ERGONOMÍA OCUPACIONAL

INVESTIGACIONES Y APLICACIONES

VOL. 12

SOCIEDAD DE ERGONOMISTAS DE MÉXICO A.C. (SEMAC)
2019

ERGONOMÍA OCUPACIONAL

INVESTIGACIONES Y SOLUCIONES

VOL. 12

EDITADO POR:

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ISBN: 978-0-578-48915-5

Prefacio

Este año tenemos una doble celebracion. Por una parte, estamos cumpliendo 25 años de llevar a cabo una gran labor academica y de difusion. Hace veinticinco años inicio sus labores la Sociedad de Ergonomistas de Mexico, A.C. agrupando a los investigadores academicos, medicos de empresas, ingenieros industriales, enfermeras laborales y a todos aquellos que les preocupe el trabajador que hace su labor diaria y debe hacerlo de forma segura y saludable, sin olvidar el otro lado que es la ejecucion del sistema productivo, es decir la calidad y productividad. Uno de los grandes logros de estos veiticinco años es la difucion de los avances que se hacen en la academia o en las empresas con la publicacion de nuestra doceava edicion del libro "ERGONOMIA OCUPACIONAL, INVESTIGACIONES Y APLICACIONES" que desde su volumen inicial se ha puesto para su consulta en la pagina de nuestra Sociedad sin costo para la persona que quiera consulta esta obra. Un gran esfuerzo de todos que hacemos posible esta obra.

El otro motivo que tenemos para celebrar es la doble publicacion en el Diario Oficial de la Federacion de las nuevas Normas Oficiales Mexicanas por parte de la Secretaria de Trabajo y Prevision Social. El 23 de Ocubre del año pasado se publicó la NOM-035-STPS-2018, Factores de riesgo psicosocial en el trabajo-Identificación, análisis y prevención. Exactamente un mes después se publicó la NOM-036-1-STPS-2017, Factores de riesgo ergonómico en el trabajo-Identificación, análisis, prevención y control. Parte 1-Manejo manual de cargas. SEMAC, en su momento, ha participado desde su redacción de esta Norma, además reviso el proyecto de la misma y presento en tiempo y forma ante la STPS las observaciones que creyo necesarias para un cambio en la redacción de la NOM-036 y que fuera mas accesible a todos los involucrados en el proceso ergonómico dentro de los centros de trabajo. La mayoría de estas observaciones fueron tomadas en cuenta y estamos seguros que somos parte importante para su publicación.

Aunque no son de aplicación inmediata, con la publicación de estas normas, México se convierte en el primer país del mundo en hacer obligatorias para los centros de trabajo la identificación, evaluación y control de los factores de riesgo psicosocial y ergonómico. A diferencia de la NOM-035, la NOM-036 solo cubre el manejo manual de cargas esperamos que en el corto plazo se publique los factores de riesgo ergonómico para el trabajo repetitivo y para otros tipos de trabajo. Consideramos que esto es de suma importancia para el bienestar de nuestros trabajadores.

Los editores, árbitros y comité académico, a nombre de la Sociedad de Ergonomistas de México, A.C., agradecemos a los autores de los artículos aquí presentados su esfuerzo, e interés por participar y compartir su trabajo y conocimientos en este nuevo libro. También agradecemos a los autores provenientes de muy diversos lugares y formaciones su valiosa aportación que estamos seguros derivará en el avance de la ergonomía en las Instituciones de Educación Superior y en la planta productiva nacional y mundial.

Enrique de la Vega Bustillos

Presidente SEMAC 2002 – 2004

SOCIEDAD DE ERGONOMISTAS DE MÉXICO A.C.

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COMPARATIVE STUDY OF ANTHROPOMETRIC MEASUREMENTS FOR CHILDREN OF 5 YEARS OF AGE OF TWO REGIONS OF MÉXICO

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Resumen: Uno de los objetivos principales de la ergonomía es el diseño y/o adaptación de las estaciones de trabajo al usuario, utilizando las cartas antropométricas adecuadas a la edad del trabajador.

Al buscar aplicar el precepto anterior en un salón de clases de niños en edad preescolar encontramos solamente dos cartas antropométricas cubriendo la edad necesaria (5 años), una correspondiente a una población del área metropolitana de Guadalajara, Jalisco, Mx. y otra del Departamento de Salud de Estados Unidos que incluye solamente el peso y la estatura de niños americanos de cinco años.

Teorizando que la población de la parte norte de México es más similar a la carta de Guadalajara, este estudio valida el uso de esas tablas tomando ocho medidas antropométricas de una pequeña muestra compuesta por doce niñas y nueve niños de la población de Cuauhtemoc, Chih., comparando los resultados con la carta anteriormente mencionada.

Los datos obtenidos proveen suficiente evidencia para afirmar que no hay diferencia significativa entre las dimensiones antropométricas de los niños de Guadalajara y las obtenidas en Cuauhtemoc, por lo cual se puede utilizar todas las dimensiones de las tablas para la adaptación de las estaciones de trabajo involucradas.

Palabras clave: Ergonomía, Cartas Antropométricas, Diseño de Estaciones de trabajo, Niños en edad preescolar.

Relevancia para la ergonomía: La validación de información antropométrica de otra población de la misma edad, usando una limitada cantidad de mediciones, reafirma la confianza para usar todos los datos de las cartas antropométricas para el diseño/rediseño de estaciones de trabajo.

Abstract (Spanish/English, this order): One of the main objectives of human factors is the design and/or adaptation of workstations to the user, using anthropometric tables appropriate to the age of the worker.

In seeking to apply the previous precept in a classroom of preschool-age children we find only two anthropometric tables covering the necessary age (5 years), one corresponding to a population of the metropolitan area of Guadalajara, Jalisco, Mx. and another one from the U.S. Department of Health and Human Services that includes the weight and stature of five years old American children.

Theorizing that the population from the northern part of Mexico is more similar to the sample from Guadalajara, this study validates the use of these tables taking eight anthropometric measures of a small sample that includes twelve girls and nine children of the population of Cuauhtemoc, Chih., comparing the results obtained with the ones presented in the anthropometric tables mentioned before.

The data obtained provide enough evidence to affirm that there is no significant difference between the anthropometric dimensions of the children of Guadalajara and those obtained in Cuauhtemoc, so you can use all the dimensions of the tables for the adaptation of the work stations involved.

Keywords: Human Factors, Anthropometric tables, Workstations design, Kindergarten age children.

Relevance to Ergonomics: The validation of anthropometric information from other population of the same age, using a small quantity of measurements, endorse the use of all the data to design or redesign work spaces with an ergonomics approach.

1. INTRODUCTION

Ergonomics have as a fundamental objective to study interfaces between people, tools, products they use, the activities they perform, and the environments in which they work, study or play to mention the main activities of any human. In this manner, at early ages, infants' environments, such as school furniture must be adapted to the anthropometry and biomechanical characteristics of users, influencing the reduction of future musculoskeletal injuries and the person's performance (Fasuloa, et.al, 2019; Tunay & Melemez, 2008).

If we speak of teaching-learning spaces, ergonomics has been devoted mainly to the adaptation of furniture, especially benches based on the anthropometry of the students, and there are numerous studies and norms (INIFED SEP, 2014; INEE, 2016) that endorse and/or give us guidelines for the ergonomic optimization of these factors.

However, research of this topic addressing furniture standards have been focused on elementary students (Agha, 2010; Altaboli, et.al., 2015; Carneiro, et al., 2017; Castellucci, et al., 2015 and Chung & Wong, 2007) or degree level students (Fasuloa, et.al., 2019; Tunay & Melemez, 2008 and Wilson Taifa & Desai, 2017). Therefore, there is an important gap in studies focused on kindergarten children in a range of age of 3 to 5 years. For Arana et al. (2018), child growth is very important and poor postures due to an inadequate design of areas and furniture can affect performance and comfort. These authors present an approach to adapt teaching-learning area to the anthropometric dimensions of children under this range of age (Arana et al., 2018).

Another important aspect of the problem is the lack of anthropometric data for children of this age. As reference there is one study concerning five years old Mexican children, this work of Avila Chaurand et al. (2007) includes a sample of kindergarten individuals from the metropolitan area of Guadalajara, Mexico; another one found is from the U.S. Department of Health and Human Services that includes only weight and stature data from five years old American children (U.S. Department of Health and Human Services, 2012)

The objective of this work is to determine the adequacy of the available anthropometric data with a small sample of measurements obtained from population from Cuauhtemoc, Chih. Mx.

2. OBJETIVES

In general, to validate that the anthropometric information of another population is not significantly different compared with the infantile residents of the municipality of Cuauhtémoc, Chih., using a small sample of anthropometric measurements.

Particularly to approve the use of a larger quantity of anthropometric data for design or redesign of learning-teaching areas of kindergarten age population included furniture, spaces and learning tools among others.

2.1 Delimitation

Anthropometric measurements including weight, height, arm length, leg length, knee height while seated, elbow to hand, hand length and trunk length were taken, from preschool-age population (5 years), of the Cuauhtémoc, Chih. area; specifically, twelve girls and nine boys and the mean of each measurement was calculated.

The data obtained was compared with the same measurements of an anthropometric table of the same age of Guadalajara, Jal. population, which includes the arithmetic mean from measurements of 48 girls and 54 boys exposed in the book from Avila et al. (2007) “Anthropometric dimensions from Latin-American population: Mexico, Cuba, Colombia, Chile”. (Avila Chaurand, et al., 2007)

3. METHODOLOGY

Eight anthropometric measurements: (weight, stature, arm length, leg length, knee height, elbow to hand, hand length and trunk length) were obtained from twenty-one children. Twelve of them were female and nine were male. The data obtained was statistically compared to more broad anthropometric data (Avila Chaurand, et.al., 2007) of children of the same age, looking for validation of the use of this data for the population appraised.

First the weight was obtained following the technique presented in Ávila et al. (2018) "Weight and Height national registry in scholars 2015-2016" a study where several Mexican governmental entities where involve for example the Department of health, the Department of Public Education (SEP), the National Council of Educational foment (CONAFE), to mention some. The procedure begins putting the scale in a flat surface verifying that is calibrated, if not it must be calibrated. Next the children must take off their shoes and stand in the scale with their arms parallel to the body axis without moving, is important to verify that the subject had the minimal clothes and no extra weight in their pockets. (Ávila et al, 2018).

Height was obtained with a stadiometer, all the other measurements were taken with a portable anthropometer from the right side of the subjets while they were sitting in an erect position on a height-adjustable chair with a horizontal suface, with their legs flexed at a 90° angles, and their feet flat on the floor.

When the data antrhropometric data was obtained, a observational type study based in the statistical contrast methodology according to Devore et al. (2017) and McClave et.al. (2016) among others, which includes a t-student test for difference between means with a significance level of 0.05 was done. The procedure of this methodology includes the following segments:

1. HYPOTHESIS (Ho, Ha)
    a. Null Hypothesis (Ho): Theory written in terms of the values of population parameters. It is the theory you want to challenge.
    b. Alternative Hypothesis (Ha): Theory that opposes the null hypothesis and that it is generally desired to prove that it is true.
2. TEST STATISTIC: Sample Statistical used to decide whether the null hypothesis is rejected, in this case t-student.
3. REJECTION REGION: Set of test statistic values for which the null hypothesis is going to be rejected. The probability that the test statistician falls into the rejection region, when the null hypothesis is true, is equal to ALPHA. It Must Be accompanied by a decision rule.
4. EXPERIMENTATION, SAMPLING AND CALCULATIONS: The sampling experiment is carried out and the values of the statistic test are determined.
5. DECISION. (base point 3). It is made based on Ho.
    a. If the numerical value of the test statistic falls within the region of rejection, then it is decided to reject the null hypothesis and conclude in terms of the alternative hypothesis, which is supported by the experimental evidence.
    b. If the numerical value of the test statistic does not fall within the rejection region, then the judgment on the null hypothesis is not decided and the decision is not accepted, because the probability of committing type II error is not known.
6. CONCLUSIONS. (based on Ha). It Is concluded in accordance with the decision and in the context of the problem on which the hypothesis was extracted.
7. ASSUMPTIONS. Tests of normalcy, independence, form, etc., using non-parametric statistics.

3.1 Hypothesis

Ho: The means tabulated in anthropometric tables from kindergarten age children of Guadalajara are equal to that of the same age of Cd. Cuauhtémoc, Chih.

Ha: The means tabulated in anthropometric tables of the kindergarten age children of Guadalajara are not the same as that of the same age of Cd. Cuauhtémoc, Chih.

n=21 kids (12 girls and 9 boys, 5 years of age)
alfa= 0.05
t-student test for means difference: For (n-1) degrees of freedom (1)

$$t = \left[\frac{(\bar{x} - \mu)}{\frac{\sigma^2}{\sqrt{n}}} \right] \quad (1)$$

Data normality tests were also carried out finding that all the points are within the confidence limits, so it is concluded that they are distributed normal.

4. RESULTS

The following tables shows the calculated mean of the eight anthropometric dimensions involve in the study, from both populations, the data includes their corresponding standard deviation. The weight was measured in kilograms and all the other were in centimeters.

Also, the t-value obtained from the tables, and the one calculated, the last column mentions the result from the Comparison test (Significant or Non-Significant).

Table 1. Results for girls

	C = Cuauhtemoc G = Guadalajara					Ho: C=G Ha: C≠G, ALFA=0.05			
		ẋ	Std. Dev.	N	t-Table value	t-Calculated	P-Value	PH	Test
Weight in kilograms	C	19.37	2.96	12	1.796	0.44	0.669	C=G	NON-SIGNIFICANT
	G	17.3	2.3	48					
Stature in centimeters	C	111.18	3.88	12	1.796	0.38	0.739	C=G	NON-SIGNIFICANT
	G	110.8	7.6	48					

Arm length in centimeters	C	45.29	2.927	12	1.796	5.67	0	C=G	SIGNIFICANT
	G	40.5	2.9	48					
Leg Length in centimeters	C	58.7	4.53	12	1.796	-5.82	0	C=G	SIGNIFICANT
	G	66.3	5.6	48					
Knee Height in centimeters	C	31.55	2.83	12	1.796	-1.41	0.187	C=G	NON-SIGNIFICANT
	G	32.7	2.3	48					
Elbow to Hand in centimeters	C	28.47	2.04	12	1.796				
	G			48					
Hand length in centimeters	C	12.7	0.897	12	1.796	1.93	0.08	C=G	NON-SIGNIFICANT
	G	12.2	6	48					
Trunk length in centimeters	C	38.7	3.42	12	1.796	2.73	0.02	C=G	NON-SIGNIFICANT
	G	36	2.5	48					

Table 2. Results for boys

	C = Cuauhtemoc G = Guadalajara		Ho: C=G Ha: C≠G, ALFA=0.05						
		ẋ	Std. Des v.	N	t-Tabl e valu e	t-Calculat ed	P-Valu e	PH	Test
Weight in kilograms	C	19.95	1.66	9	2.30 6	1.00	0.34 5	C= G	NON-SIGNIFICA NT
	G	17.3	2.3	5 4					
Height in centimeters	C	125.3 1	17.6 7	9	2.30 6	2.6	0.03 2	C= G	NON-SIGNIFICA NT

	G	110.8	7.6	5 4					
Arm length in centimeters	C	46.94	2.22	9	2.30 6	8.3	0.00 0	C= G	NON-SIGNIFICA NT
	G	40.5	2.9	5 4					
Leg Length in centimeters	C	61.28	5.0	9	2.30 6	-3.001	0.01 7	C= G	NON-SIGNIFICA NT
	G	66.3	5.6	5 4					
Knee Height in centimeters	C	32.89	2.07	9	2.30 6	-0.16	0.87 6	C= G	NON-SIGNIFICA NT
	G	32.7	2.3	5 4					
Elbow to Hand in centimeters	C	30.51	1.87	9	2.30 6				
	G			5 4					
Hand length in centimeters	C	12.91	1.05	9	2.30 6	2.32	0.04 9	C= G	NON-SIGNIFICA NT
	G	12.2	6.0	5 4					
Trunk length in centimeters	C	40.7	2.25	9	2.30 6	6.23	0.00	C= G	NON-SIGNIFICA NT
	G	36.0	2.5	5 4					

Do not reject Ho in most anthropometric measurements, since the calculated test statistic, t-student, is less than the one in the tables.

4. CONCLUSIONS

The data obtained randomly for anthropometric measurements of children of preschool age in Cd. Cuauhtémoc, Chih., provide sufficient evidence to affirm that there is no significant difference between mean values of anthropometric dimensions obtained in Guadalajara, Jal. from Children of the same age, given a random sample of 21 children, with a significance level of 0.05.

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ERGONOMIC APPLICATION OF ANTHROPOMETRIC MANNEQUINS IN INDUSTRIAL ENVIRONMENTS

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Resumen: Uno de los principales problemas ergonómicos dentro del área de soldadura de una empresa metal-mecánica, es debido a tener posturas inadecuadas. Por ello, esta investigación persigue evidenciar estas posturas no ergonómicas mediante la utilización del software Blender para posteriormente poder corregirlas. Adicionalmente, se validó el uso de este software al identificar las malas posturas a través de un cuestionario, en conjunto con el uso de la escala Likert. Se encontró que, de no realizar una corrección temprana de estas posturas no ergonómicas, pueden llegar a provocar una serie de patologías y consecuencias negativas sobre la salud y bienestar de las personas, siendo las principales: lesiones musculoesqueléticas en hombros, cuello, manos y muñecas; problemas de columna; dolores en cuello y espalda; molestias y/o dolores en hombros y piernas.

Palabras clave: Maniquíes antropométricos, Salud ocupacional, Biomecánica.

Abstract: One of the main ergonomic problems within the welding area of metal-mechanic company, is due to having inadequate postures. Therefore, this research aims to detect these non-ergonomic postures by using Blender software to later correct them. Additionally, the use of this software was validated by identifying the bad postures through a questionnaire, in conjunction with the use of the Likert scale. It was found that failure to perform an early correction of these non-ergonomic postures can lead to a series of pathologies and negative consequences on the health and well-being of people, the main ones being: musculoskeletal injuries on the shoulders, neck, hands and wrists ; column problems; pains in neck and back; discomfort and/or pains in shoulders and legs.

Keywords: Anthropometric mannequins, Occupational health, Biomechanics.

Relevance to ergonomics: The application of virtual modeling in work areas will make it possible to show and clarify problems related to the postures in the work areas, when contemplating the variability in the existing population (percentiles).

Visually showing the changes required in the work areas and allowing to sustain improvement projects.

1. INTRODUCTION

Industrial safety is the area in charge of reducing the risks that exist within industries such as musculoskeletal injuries, circulatory or spinal problems, as well as aches and pains in the neck, back, shoulders and legs, among others (Bracamonte, 2012). To carry out this security it is necessary to use different tools that facilitate the evaluation of different work scenarios (Mohammad, 2007), before the risks appear in the workers, based on critical anthropometric measurements (Ávila et al 2007).

When an ergonomic assessment is made, the use of anthropometry is needed, which includes measurements of the dimensions of the human body. The knowledge and techniques to carry out the measurements, as well as their statistical treatment, are the object of anthropometry (Maradel M. et al, 2008).

Having anthropometric measures critical and interpreting them in simple and practical ergonomic models, anthropometric mannequins can be developed to visualize the impact in the different anthropometric percentiles applied to the work area.

Currently he has focused on improving the design of patterns of the virtual human body through software since the objective is always the same, "the welfare of workers and customer satisfaction", for this purpose anthropometry plays a very important role in the industrial sector, design and ergonomics (Cichocka et al., 2014).

The key factor for the effective absorption of results from virtual models is the involvement and commitment of the sector (companies) in the development of appropriate tools and spaces in the work area (Ballester A. et al, 2015).

The concept of a virtual mannequin has many applications, such as virtual commerce and design, within the design approach it must be ensured that virtual mannequins are anthropometrically correct (Paquet E., 2007).

Currently, we are developing a virtual environment that through the help of Blender software, which allows a wide range of options to modify any number of times the dimensions -anthropometric measurements- (Carmenate et al, 2014) in a virtual mannequin, seeking to detect bad ergonomic postures in the operators; being able to observe the benefits that would be achieved by changing some aspects of the workplace or furniture in a simulated environment, preventing operators from getting involved in situations that could cause different risks in companies and providing a more comfortable stay.

1.1 General objective:

Detect bad postures when assessing areas of work making use of virtual environments where parametrized anthropometric mannequins are developed and visualized that contemplate the different anthropometric percentiles; allowing to observe benefits such as reduction of discomfort and/or musculoskeletal injuries that would be achieved by changing aspects of the workplace aimed at reducing occupational risks in companies.

1.2 Specific objectives:

1. Determine the postures and critical dimensions of the human body depending on the area where you work, to have a high degree of knowledge on the subject.
2. Select a design software (Blender) that allows to develop anthropometric mannequins, and give movement to the different articulations, adjusting the virtual mannequin in anthropometric percentiles.
3. Validate virtual mannequin contrasting with the real model of a person.
4. Perform assessments in different areas of work, to visualize the positions and the appropriate or inadequate movements of the workers at the time of performing a job or an activity that has high physical requirements.

2. DELIMITATION

Application of anthropometric measurements in a work area, to evidence required changes.

3. METHODOLOGY

An investigation was carried out on the postures and critical dimensions of the human body in standing position, to have an adequate level of understanding of the work area where the virtual environment is simulated.

We searched for relevant information on ergonomics and anthropometry, as well as information on critical anthropometric measurements.

Search of general information on ergonomics and anthropometry was sought, such as search of anthropometric measurements in various scientific articles and search of anthropometric critical measures proposed by different authors in case studies.

Obtaining anthropometric critical measures for the case study area (Industrial environment).

Afterwards, field work was carried out in a metal-mechanic company where a work area was studied - applying an ergonomic survey - to know what positions the workers adopt and what level of fatigue they currently have in those areas of work and how they could to get well.

Additionally, results of field work previously carried out were obtained

Subsequently, the anthropometric mannequins were developed in the Blender software, as well as the angles of inclination of the back -through calculation of vectors- that were presented by the workers.

Additionally, the most appropriate recommendations were made.

4. RESULTS

The research project shows the results obtained from take anthropometric measures with critical measures –to develop the mannequin in blender software- and ergonomic survey applied to workers of the metal-mechanics Industry of the welding area tob, located in Mexicali city; The applied survey helps us determine the level of fatigue in workers using the Likert scale as a measuring instrument. Figure 1 show critical measures.

Critical Measures		
3	Head-height_Z.	
4	Neck-height_Z.	
14	Torso-height_Z.	
15	Buttock-height_Z.	
23	Upperleg-length.	
24	Lowerleg-length.	
31	Feet-height_Z.	
33	Height_Z.	

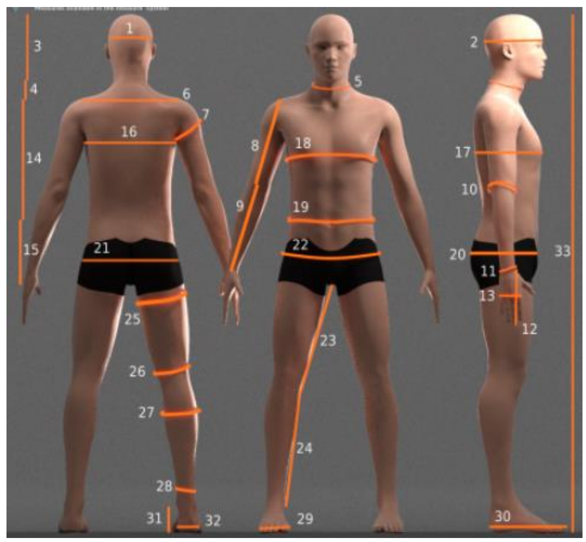

Figure 1: Critical measures

Then figure 2 shows the results of the main survey data.

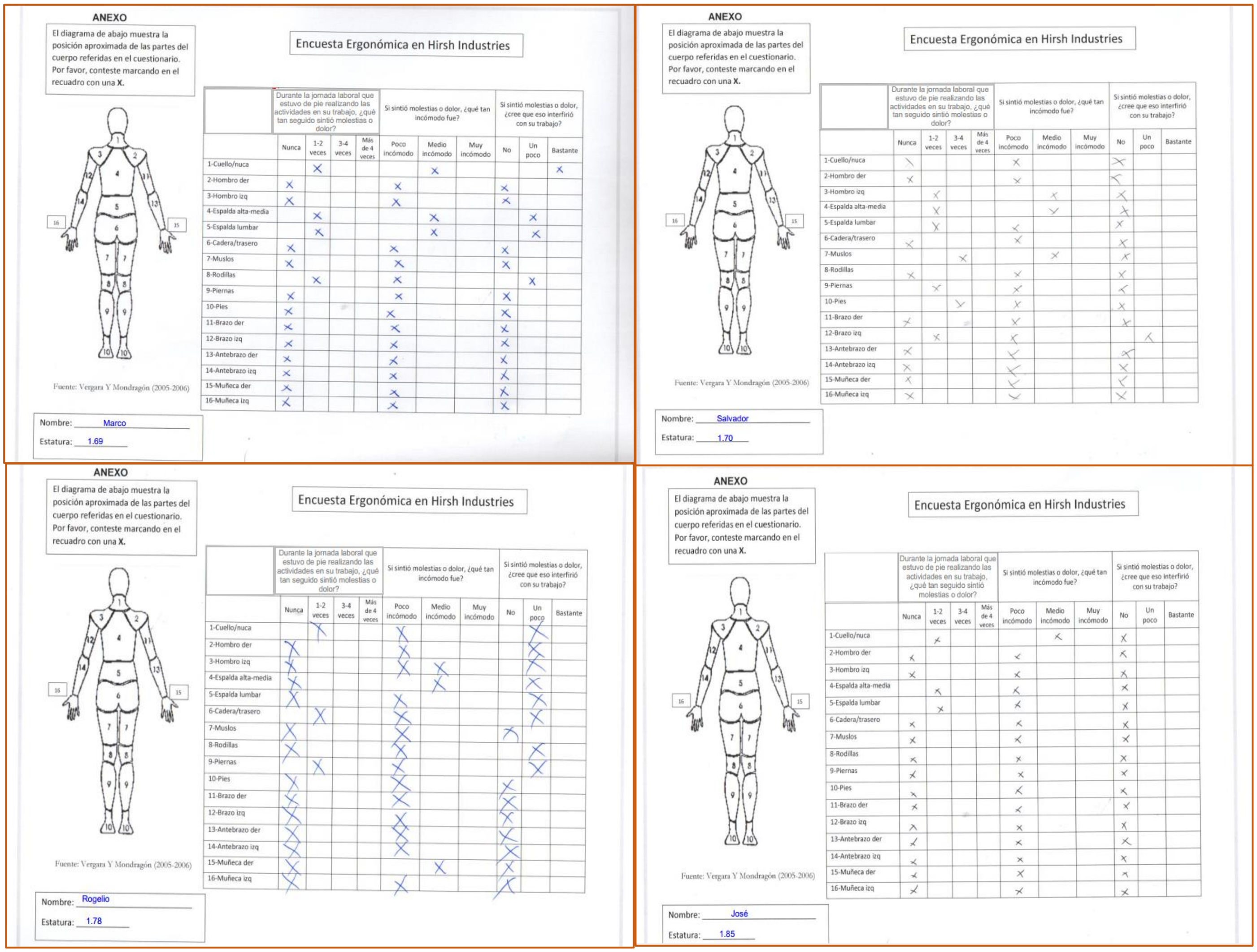

Figure 2: Data of fatigue level survey.

Then table 1 shows the fatigue level felt by workers.

Table 1: Fatigue level in workers.

body dimensions	Worker 1 Marco (1.69m P<50)	Worker 2 Salvador (1.70m P<50)	Worker 3 Rogelio (1.76m P>50)	Worker 4 José (1.85m P>50)	Sum	Likert scale
1-Neck/nape	18	2	8	6	34	3
2-Right shoulder	2	2	4	2	10	1
3-Left shoulder	2	6	12	2	22	2
4-Back	12	6	6	4	28	3
5-Lumbar Back	12	4	4	4	24	2
6-Hip	2	2	8	2	14	2
7-Thighs	2	9	2	2	15	2
8-Knees	8	2	4	2	16	2
9-Legs	2	4	8	2	16	2
10-Feet	2	6	2	2	12	1
11-Right arm	2	2	2	2	8	1
12-Left arm	2	8	2	2	14	2
13-Right forearm	2	2	2	2	8	1
14-Left forearm	2	2	2	2	8	1
15-Right wrist	2	2	3	2	9	1
16-Left wrist	2	2	2	2	8	1

Likert scale
1. Nothing uncomfortable
2. Little uncomfortable
3. More uncomfortable
4. Very uncomfortable

order of the score obtained in the survey	Assigned value (Likert scale)
01 al 12	1
13 al 24	2
25 al 36	3
37 al 48	4

The percentiles (height) of the workers are put into the blender software as well as an image of the work environment; obtaining the positions that the workers adopt during their working day in their work space; and calculate the angles of the back when resting each worker to perform their activities within the work.
The figures 3 and 4 show the worker with their percentile and their work space.

Figure 3: Percentil 1.69 m.

3

Figure 4: Percentil 1.85 m.

As you can see in the table 1 and figure 2, the fatigue level could be related with anthropometric measurements. Tus taller people could be more propends to injuries related with spinal inclination because the worker with percentile 5 could be calculate an inclination angle of 57° and the worker with percentile 95 could be calculate an inclination angle of 66°;

The angle of inclination arises due to the activity that the worker performs which is to lean on a platform to place sides and weld them with a welding machine, this action is very repetitive since they perform around 10 welding points in each cabinet thus completing approximately 45 to 50 cabinets a day.

This work pretends to put in perspective this situation showing different between percentiles variation from anthropometric dimensions.

5. CONCLUSIONS AND RECOMMENDATIONS

Through the use of the Blender software, a proposal of improvement in the positions of the workers is observed, observing the angles of inclination of the back to determine the inadequate positions (non-ergonomic) in the work environments, correcting the non-ergonomic positions of the workers, changing the work environment.

As recommendations, the following is presented: You could adjust the working height to each worker, placing it at the level of the elbows or slightly lower (the height of the hand could be about 10-15 cm below the elbows).

• the tool used to weld the points on the sides is contemplated, so the working height is proposed that it could be about 13 cm extra over the height that is currently (27 cm).

• An adjustable table could be also placed for different heights.

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SCOPE OF ANTHROPOMETRIC ANALYSIS IN UNIVERSITY POPULATION TO DETERMINE TENDENCY TO OBESITY

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Resumen: El exceso de peso y la inactividad física son considerados factores de estilos de vida que afectan la carga global de enfermedad. LA presente investigación se realizo con el objetivo de determinar la asociación entre el exceso de peso y la actividad física en estudiantes universitarios. Es un estudio de corte transversal analítico en una universidad publica del Estado de México; se incluyeron 200 estudiantes entre 19 y 26 años a través de un muestreo aleatorio simple. Se aplicó el Cuestionario Internacional de Actividad Física (IPAQ), y se realizó la valoración de la composición corporal (talla, peso, índice de masa corporal IMC y circunferencia cintura). se solicitó el consentimiento informado por escrito. Se realizó un análisis descriptivo de las características de la población estudiada. Al analizar la obesidad central en la población universitaria se encontró que en el caso de los hombres entre 20-26 años el 50% presentan valores mayores o iguales a 90 cm de cintura. En el caso de mujeres, la prevalencia de un valor arriba del recomendado (≥80 cm) fue mayor al 55% desde los 19 años. Este resultado nos indica que la mayoría de las mujeres presentan un mayor riesgo desde una edad temprana. La CC es un marcador principalmente de tejido graso abdominal, mientras que en el caso de la medición del IMC se considera a todo el tejido graso corporal. Los resultados con respecto al IMC de los hombres de 19 a 26 años encontraron prevalencias de sobrepeso (IMC ≥ 25 kg/m2) y obesidad (IMC ≥ 30 kg/m2) de 55.5% y 5.6%, respectivamente, en el caso de las mujeres de las mujeres de 19 a 26 años encontraron prevalencias de sobrepeso (IMC ≥ 25 kg/m2) y obesidad (IMC ≥ 30 kg/m2) de 36.4% y 18.2%, respectivamente. Estos resultados preliminares, muestran como la población universitaria es un reflejo de los altos índices de sobrepeso y obesidad en nuestro país.Teniendo en cuenta los patrones de actividad física de la población universitaria, es necesario establecer su asociación con el exceso de peso, con el fin de prevenir y disminuir la prevalencia de enfermedades crónicas en un future.

Palabras clave: Antropometría, IMC (Índice de masa corporal), actividad física.

Relevancia para la ergonomía: Es muy importante dar a conocer los resultados de los estudios antropométricos, por su impacto y trascendencia de riesgo potencial a la salud a corto, mediano o largo plazo, el cual se puede evitar si se cuenta con información documentada de forma objetiva.

Abstract: Excess weight and physical inactivity are considered lifestyle factors that affect the overall burden of disease. The present investigation was carried out with the objective of determining the association between excess weight and physical activity in university students. It is an analytical cross-sectional study in a public university of the State of Mexico; 200 students between 19 and 26 years old were included through simple random sampling. The International Physical Activity Questionnaire (IPAQ) was applied, and the assessment of body composition (height, weight, IMC and waist circumference) was performed. Written informed consent was requested. A descriptive analysis of the characteristics of the studied population was carried out. When analyzing the central obesity in the university population, it was found that in the case of men between 20-26 years 50% present values greater than or equal to 90 cm waist. In the case of women, the prevalence of a value above the recommended (≥80 cm) was greater than 55% from 19 years. This result indicates that the majority of women present a higher risk from an early age. The CC is a marker primarily of abdominal fat tissue, while in the case of the measurement of IMC, the whole body fat tissue is considered. The results regarding the IMC of men aged 19 to 26 years found prevalences of overweight (IMC ≥ 25 kg / m2) and obesity (IMC ≥ 30 kg / m2) of 55.5% and 5.6%, respectively, in the case of women from 19 to 26 years of age found prevalences of overweight (IMC ≥ 25 kg / m2) and obesity (IMC ≥ 30 kg / m2) of 36.4% and 18.2%, respectively. These preliminary results show how the university population is a reflection of the high rates of overweight and obesity in our country. Taking into account the physical activity patterns of the university population, it is necessary to establish their association with excess weight, with the to prevent and reduce the prevalence of chronic diseases in the future.

Key words: Anthropometry, IMC (Body Mass Index), physical activity.

Relevance to Ergonomics: It is very important to publicize the results of anthropometric studies, due to their impact and transcendence of potential risk to health in the short, medium or long term, which can be avoided if information is documented objectively.

1. INTRODUCTION

Mexico belongs to the nations with the highest adult obesity in the world, according to the Organization for Economic Cooperation and Development (OECD) which is composed of 35 countries around the world, with representation from each continent. In addition to Mexico, some of its member countries are Brazil, Chile, Turkey, the United Kingdom, Australia, Greece, Portugal and South Africa. (OECD, 2016)

By 2015, according to the Obesity Update report, more than half of adults and almost 1 in 6 children are overweight or obese in countries associated with the OECD. 19.5% of adults in countries belonging to the OECD suffer from obesity (a body mass index greater than 30 kg / m^2), in a first analysis, using the body mass index, a measure that indirectly suggests how much body fat a person has person based on their weight and height as an indicator to identify overweight and obesity), the countries with the highest prevalence are: the United States, with 38.2%, Mexico, with 32.4% and New Zealand, with 30.7%. (Rangel, 2015)

The countries with the lowest prevalence of obesity in adults are Japan (3.7%) and South Korea (5.3%). It is projected that obesity in Mexico will increase to 39% and in the United States to 47% by 2030. Women and men with a lower educational level have a higher risk of obesity in most countries. Educational and socioeconomic inequality influences that there is more obesity, addressing obesity in the educational and work environment could contribute to better living conditions. (Martínez 2019)

The United Nations Food and Agriculture Organization (FAO), in its report The state of food security and nutrition in the world 2018, warned that worldwide obesity in adults is on the increase, given that one of every eight are obese, which is equivalent to 672 million people and that in Mexico obesity in the population over 18 years increased 3.8 million between 2012 and 2018 (in preliminary results), going from 20.5 to 24.3 million people, with what occupies the sixth place of 150 countries in the world. (Echegaray, 2016)

In Mexico, the National Health and Nutrition Survey 2018 indicated that the combined percentage of overweight and obesity, considering the population over 20 years old, was 75.6% in women and 69.4% in men. According to the, overweight and obesity are defined as an excessive accumulation of fatty tissue that results in various health effects. In an alarming way, obesity has almost tripled worldwide from 1975 to 2018. (Rodríguez, 2017)

Obesity and overweight in the population are associated with an increase in morbidity and a decrease in life expectancy; however, for a long time it was considered as a sign of good health and even as an index of economic and social well-being. Obesity is a key risk factor for the development of chronic non communicable diseases, because excess weight is associated with morbidities such as cardiovascular disease, hypertension, diabetes mellitus, infertility, breast, endometrial, colon and prostate. Consequently, obesity is a public health problem that requires timely attention and multi sectorial actions to improve prevention and control in the population. However, long ago the integral treatment of this disease, not only in Mexico but in the world, has been underestimated because a high percentage of the impact of obesity on mortality is exerted indirectly. In the context of the population of university students in Mexico, some studies conducted on students aged 19 to 26 years have found prevalence's of overweight (IMC $\geq$ 25 kg / m^2) and obesity (IMC $\geq$ 30 kg / m^2) of 21.6% and 4.9 %, respectively, also found that, 35% of women and 40% of men between 20 and 30 years old are already overweight or obese and this figure increases to affect 70% of the university population in the decade of 40-49 years. (Rangel 2015)

It is important to note that the greatest proportion of weight gain occurs between 20 and 30 years, which points to this decade as a period of particular risk where a timely diagnosis could help prevent the development of obesity. The prevalence of overweight and obesity among young people of both sexes should be seen as a multifactorial phenomenon associated with major changes in lifestyle.

Despite the fact that the body mass index is an accepted measure for the diagnosis of overweight and obesity, today the measurement of waist circumference (CC) is increasingly common in the clinic due to its close relationship with the diagnosis of central obesity. Central obesity is one of the types of obesity where the greatest amount of fatty tissue is located in the abdominal or visceral part. The International Diabetes Federation (IDF) has established values for the maximum waist circumference recommended for different populations. (Kain.2016)

In Asian populations, a waist circumference greater than or equal to 90 cm in men, or greater than or equal to 80 cm in women, increases the risk of developing cardiovascular diseases and type II diabetes even when the IMC is not very high. Due to the lack of studies dedicated exclusively to the Mexican population, the IDF recommends using these same thresholds for the Mesoamerican population.

2. OBJECTIVES

To determine the association between excess weight and physical activity in university students.

3. METHODOLOGY

3.1 Materials and methods

An analytical cross-sectional study was carried out. The sample was conformed by undergraduate university students in ages between 19 and 25 years of a public university in the State of Mexico.

The sample was 200 students. This sample size calculation was made taking into account a total population of 2500 students, prevalence of physical activity in university students of 33.8%, a level of significance of 0.05 and a level of confidence of 80%. For the selection of the sample, a simple random sampling was used.

Once the sample was selected, the students were located through social networks, email and cell phones in order to arrange an appointment to make the informed consent and the data collection.

Initially, an anthropometric variables and questions related to the International Physical Activity Questionnaire (IPAQ) were investigated. Then, the assessment of the body composition was made. These measurements were made with light clothing and without shoes, all of them made in the laboratory of work study of the university. A medical professional was in charge of collecting the information and carrying out the measurements, who was duly trained and trained. (Echegaray, 2016)

3.1.1 Dependent Variables

Excess weight (overweight and obesity) defined by the percentage of total body fat and body mass index (IMC) was considered dependent variable.

Percentage of total body fat: defined according to the SEEDO 2000 consensus. The percentage of total body fat ≤ 20% and for women ≤ 30% was considered as a reference value for men, and the obesity and obesity limit categories were grouped as a factor risk> 20% of total body fat for men and> 30%.

Body Mass Index (IMC): overweight or obesity was established with a body mass index ≥ 25 kg / m2. To determine the weight, a BAME scale with a capacity of 140 Kg. Of accuracy was used with a pedestal stadiometer with a precision of one millimeter.

3.1.2 Main Independent Variables

Sedentary behavior: number of hours per day at rest (sitting or lying down

Physical activity: defined by the International Physical Activity Questionnaire (IPAQ) in its short version. This questionnaire has been validated in several countries and its use is recommended in national and regional contexts for monitoring and research purposes. This instrument evaluates the frequency (days), duration (time of completion per day), and intensity (moderate, vigorous physical activities, walking) of the physical activity performed in a week. (Echegaray, 2016)

This study evaluated total physical activity per week (total METs per week), physical activity of weekly vigorous total intensity (METs of vigorous activity per week), weekly total moderate physical activity (METs of moderate activity per week) and physical activity product of walking per week (METs of walking per week).

The physical activity levels of the population were categorized into: high, moderate and low taking into account the intensity of aerobic physical activity, in absolute scale, classified as intensity physical activity.

In this way, it was considered: *Low level of physical activity*: who does not report any type of physical activity or reports some activity but is not sufficient to reach the criteria of the moderate and high levels.

Moderate physical activity level: any of the following three criteria: Three or more days of vigorous physical activity of at least 20 minutes per day, five or more days of moderate or intense physical activity and / or walking for at least 30 minutes per day and five or more days of any combination of walking, moderate or intense physical activity reaching a minimum of 600 MET-minute / week.

Hi*gh physical activity level:* Any of the following two criteria: Intense physical activity in at least 3 days and accumulating a minimum of 1500, minute / week and seven or more days of any combination of walking, moderate or intense physical activity accumulating a minimum of 3000 minute / week.(Flegal, 2013)

3.1.3 Other Variables

Variables such as sex, age and study area to which the students belong were analyzed. Study variables. Anthropometry. Measurements of weight, height and waist circumference were obtained by trained personnel.

3.2 Statistic analysis

The variables are described through frequencies and 95% confidence intervals. The 95% CIs for the sum of the categories are presented in the figures.

4. RESULTS

We analyzed the information of 200 university students aged between 19 and 26 years, from the degree in Industrial Engineering, constituted the sample by 95 women and 105 men. When analyzing the central obesity in the university population, it was found that in the case of men between 20-26 years 50% present values greater than or equal to 90 cm waist. In the case of women, the prevalence of a value above the recommended (≥80 cm) was greater than 55% from 19 years.

This result indicates that the majority of women present a higher risk from an early age. It is undeniable that the average waist circumference has increased in recent years. In the US, England, Mexico and China, waist circumference has increased disproportionately in recent times relative to IMC, particularly among young women, with the highest increase observed in middle-income countries such as Mexico and China, study authors write. published by researchers from the University of North Carolina, United States, corroborating the observations of the present study. (Tremblay, 2017)

The CC is a marker primarily of abdominal fat tissue, while in the case of the measurement of IMC, the whole body fat tissue is considered. The results regarding the IMC of men aged 19 to 26 years found prevalence's rate of overweight (IMC ≥ 25 kg / m2) and obesity (IMC ≥ 30 kg / m2) of 55.5% and 5.6%, respectively, in the case of women from 19 to 26 years of age found prevalence's rate of overweight (IMC ≥ 25 kg / m2) and obesity (IMC ≥ 30 kg / m^2) of 36.4% and 18.2%, respectively.

Each of the measurements has advantages and disadvantages when estimating the risk of developing metabolic diseases, so the estimation of both is important at the time of diagnosis. Although the reason why young women have higher values than recommended in the measurement of CC compared to men is unknown. (Della, 2016)

These preliminary results, carried out with the participation of workers from the Public University of the State of Mexico, show how the university population is a reflection of the high rates of overweight and obesity in our country. Unfortunately, the average age of diagnosis for obesity is delayed if we consider that the majority developed overweight much earlier. It would be important to continue working with the group of young adults to find preventive measures to reduce the high prevalence of overweight and obesity with which Mexico lives.

Another relevant observation is that only 26% of people with overweight and obesity self-reported that they had already been diagnosed by medical personnel. Obesity is a disease that may not produce symptoms or discomfort in the person who suffers it, but it increases considerably the probability of developing other diseases, so early diagnosis is of vital importance. An advantage of IMC and CC is

that people themselves can track their weight and identify risks working together with health personnel.
In addition to the above, the evidence also shows that coronary risk factors (hyperlipidemia, sedentary lifestyle, obesity and smoking) that promote atherosclerosis and coronary heart disease are increasing in adult life, increasing the chances of developing diseases cardio-degenerative.

The International Physical Activity Questionnaire (IPAQ) in its short version. This questionnaire has been validated in several countries and its use is recommended in national and regional contexts for monitoring and research purposes. This instrument evaluates the frequency (days), duration (time of completion per day), and intensity (moderate, vigorous physical activities, walking) of the physical activity performed in a week. Table 1.

Table 1. average values

Age range Years	Genus	Contour Waist cm.	Height (meters))	Weight kg
19-26	FEMENINO	81,59	1,61	66,81
	MASCULINO	91,47	1,75	78,47

The results of the time that the students dedicate to physical activity, to walk and how long they are seated is shown in the following Tables, 1 Physical activity in women,2 Physical activity in men and 3 Physical activity in global:

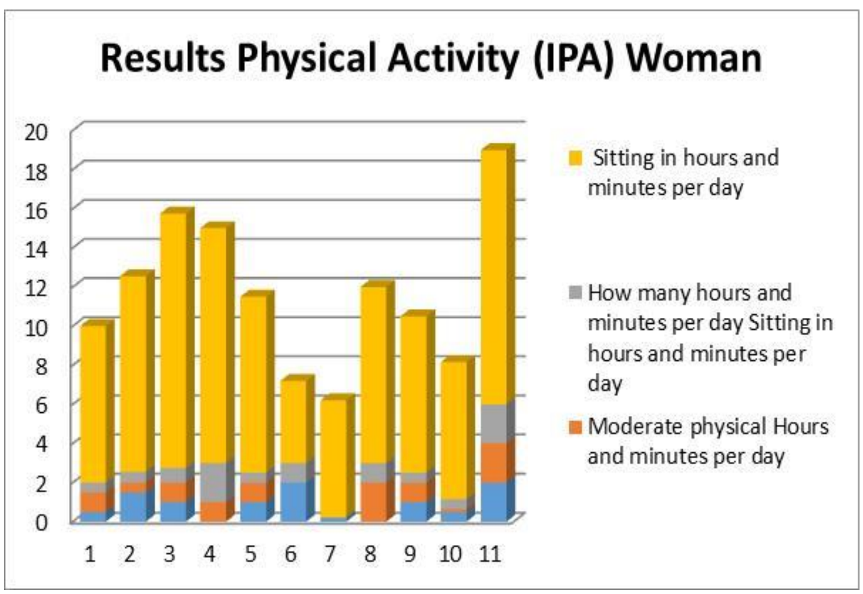

Figure 1 shows the results of physical activity in women.

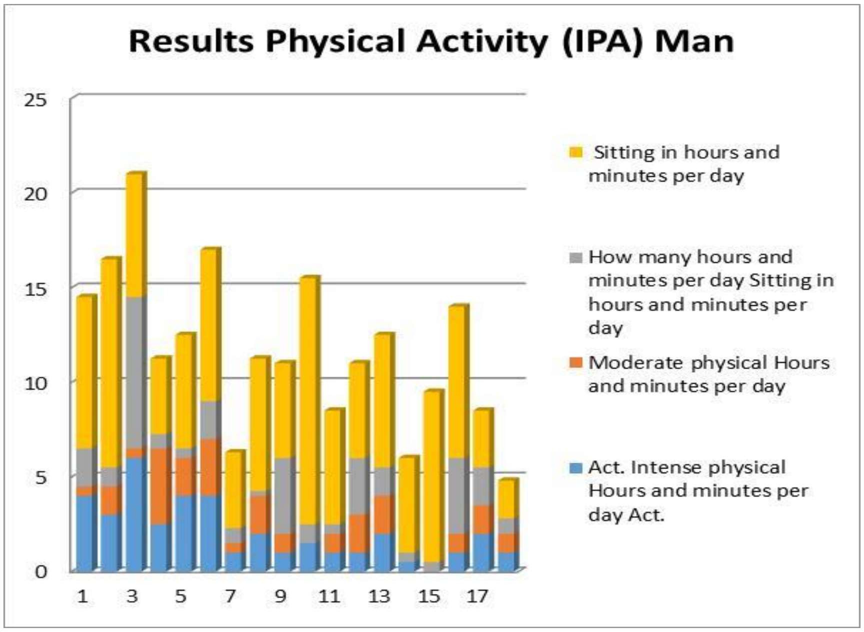

Figure 2 shows the results of physical activity in men.

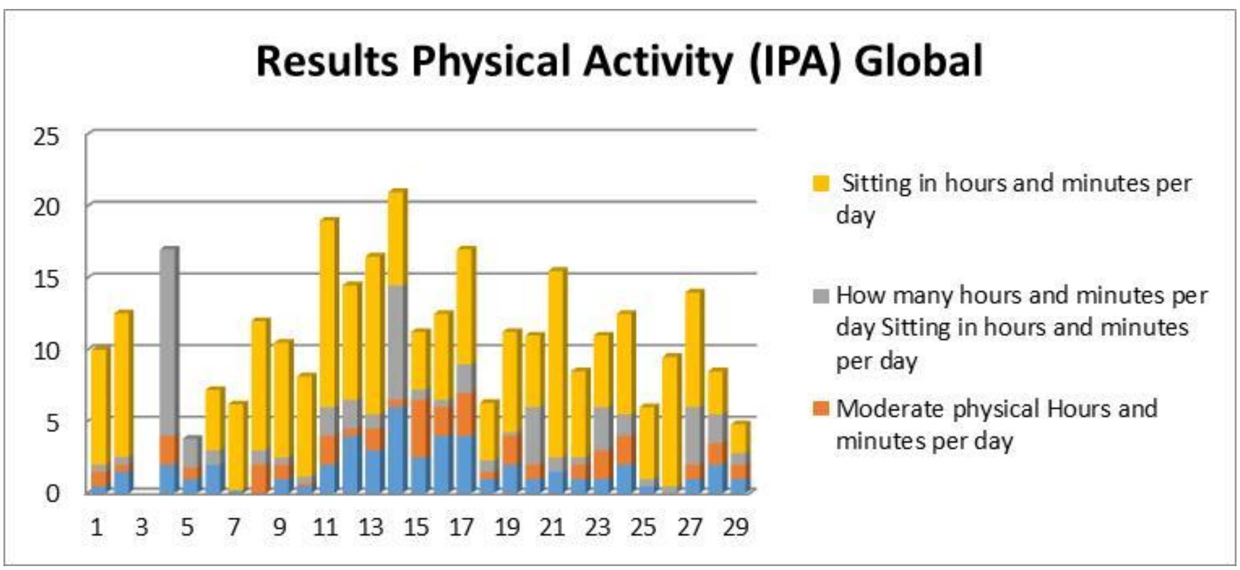

Figure 3 shows the results of physical activity in women and men.

5. DISCUSSION

A large variety of studies have shown the effectiveness of physical activity in adolescents with obesity. On the other hand, physical activity in university students has also been studied. It has been found that in countries such as Germany, nursing students, 28.5% perform less than once a week. For the Latin American area, some studies have reported prevalences of sedentary lifestyle in university students from 85% to 90% 18. A study carried out in Colombian university students found that 77% of them performed little or no physical exercise for at least 30 minutes, often three times a week. (OECD, 2016)

Taking into account the importance of physical exercise for health and the importance of implementing strategies to promote healthy lifestyles, the objective of this study was to determine the association between excess weight and physical activity in undergraduate university students.

The most relevant findings of this study show a heterogeneous Mexico in relation to overweight and obesity in the prevalence of overweight and obesity.

In the context of the university student, there is a high availability of processed foods and beverages, with high content of salt, refined sugars and fats, and low availability of vitamins, minerals and fiber, together with a decrease in physical activity and low consumption of water due to the lack of availability of this or the preference for other drinks, favors obesity.

Each country specifically presents its transition from the obesity epidemic, although, in general, it has been presented initially in groups of greater socioeconomic stratum and, later, it tends to be concentrated in poorer strata.

In this regard, in Mexico it has been documented that in the last decades, overweight and obesity in men is more prevalent than in women.

In Mexico, government policies and programs have been established in order to reduce and contain overweight and obesity in accordance with the different realities of the country, under a common and concerted vision, which generate patterns change in the consumption of food, beverages and physical activity. Within the limitations are the cross-sectional nature of the surveys, which although they do not allow to establish causality, if they allow to visualize the magnitude and their behavior for the planning of policies and programs of adequate nutrition in the immediate future. Even though several efforts have been made to reverse the increase in overweight and obesity in Mexico, high rates are still observed.

Its success depends on integrated actions between the government and society, with the aim of guaranteeing spaces and laws that protect health and promote healthy lifestyles throughout the life cycle, to protect the future of future generations against the start of obesity and its consequences.

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ASSESSMENT OF MENTAL WORKLOAD IN SETTING UP FUSED FILAMENT FABRICATION EQUIPMENT

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Resumen. El objetivo del presente capitulo fue evaluar la carga mental generada por la tarea de puesta a punto de los equipos de impresión de Fabricación por Filamento Fundido (FFF) previo al proceso de impresión. La razón de la evaluación se debe a la proporción de recursos demandados por la tarea. Estos recursos resultan en la degradación del desempeño, si la ejecución de las tareas no se realizan adecuadamente, generando como resultado problemas tangibles en el proceso de impresión y por consecuencia repetición de las tareas de preparación del equipo. La tarea analizada consistió en la puesta a punto de quipo de impresión 3d (MDF o FFF). Las actividades de la tarea fueron, conexión del equipo a terminal eléctrica, encendido del equipo, nivelación de la cama de impresión, precalentamiento del equipo y alimentación de material. Se integró un grupo de diez participantes, los cuales demostraron tener experiencia en el manejo de los equipos de FFF ya que participan como ayudantes de investigación en los laboratorios de prototipado y diseño ergonómico de la UACJ. La metodología empleada se integró en tres fases; 1) análisis jerárquico de la tarea, 2) evaluación de la carga mental con NASA-TLX, y 3) análisis de resultados. Los resultados obtenidos describen que la demanda mental, la demanda temporal y el esfuerzo fueron las sub-escalas con puntuación promedio más altas (79, 59, 57). Lo cual significa que los participantes manifestaron un nivel alto de carga mental debida a la demanda mental (generada por pensar en la secuencia de actividades, decidir el tipo de ajuste, observar los resultados de las pruebas de ajuste y buscar soluciones a problemas con el equipo), demanda temporal (presión del tiempo producida por el tiempo de ajuste máximo requerido) y el esfuerzo (el cual se debe principalmente a actividades mentales). Con base en los resultados se concluye que el uso de metodologías de evaluación de carga mental facilita la identificación de elementos generadores de carga mental asociados a una tarea específica, lo que permite proponer modificaciones a los equipos para reducir el efecto de carga mental en los usuarios de las tecnologías de MA.

Palabras clave: Carga mental, NASA-TLX, equipos de Fabricación por Filamento Fundido.

Relevancia para la ergonomía: La información obtenida presenta un escenario de desempeño del factor humano ante el uso de la Manufactura Aditiva desde el punto de vista de carga mental.

Abstract: The objective of this chapter was to assess the mental load generated by the task of setting up an FFF printer, before the printing process. The reason for this evaluation is due to the portion of the resources demanded by the task. These resources result in the degradation of performance if the execution of the task is not carried out correctly, resulting in real problems in the printing process, and as a consequence the repetition of the setting up tasks. The task analyzed consisted of setting up 3d printing equipment. The activities that integrate the task were: connection of the equipment of electrical terminal, turn on the equipment, leveling of the printing bed, preheating of the equipment, and feeding of material. A group of ten participants was integrated; each participant had experience in the handle of FFF equipment. The participants develop activities of prototyping in FFF as their activities of researcher assistants in prototyping lab and ergonomic design lab in UACJ. Three phases integrated the methodology; 1) Hierarchical Task Analysis (HTA), 2) assessment workload with NASA-TLX and 3) analysis results. The results describe that mental demand, temporal demand, and effort were the sub-scales with higher punctuation (79, 59, and 57). That means that participants manifest workload due the mental demand (generated by thinking about the sequence of activities developed and for develop, deciding the type of equipment adjustments, observing the results of the fit tests, and looking for solution to problems with the equipment), temporal demand (pressure of the time produced by the maximum time allowed by the setting up), and effort (generated firstly by mental activities). Based on the results, it is concluded that the use of mental load assessment methodology facilitates the identification of mental load generating elements associated with a specific task, which allows proposing a modification to the equipment focused on reducing the effect of mental load over users of AM technologies.

Keywords: Mental workload, NASA-TLX, Fused Filament Fabrication equipment.

Relevance to Ergonomics: The information obtained presents a performance scenario of a human factor during the use of Additive Manufacturing from the workload.

1. INTRODUCTION

Additive manufacturing (AM) is a manufacturing system that has been changing the paradigm of traditional manufacturing since it appeared in 1980. As a complement of subtractive manufacturing, AM has changed the way in how the resources are used in production or service processes. These changes involve the integration of new technologies, development of different materials, alternative methods of pre-processing, process and post-process, new abilities and knowledge of people involved in the process, and also a different work environment (Kalpakjian y Schmid 2014).

3D printing has been used as a tool to support a great diversity of research, micro productions, prototyping, and also hobbies. Even this technology represents a small market today, it will be a further alternative of employment with more than 133 million jobs for 2022 (Polli, 2018). This projection not only represents more opportunities to increase capital and develop of technologies, but this projection also represents an approximate number of people involved directly or indirectly with AM for 2022 (Wagner, Dainty, Hague, Tuck, & Ong, 2008).

As a consequence of this projected demand, ergonomics will play an essential role in the protection of users across the analysis of workstations, ergonomic design, cognitive ergonomics, human errors, workload, among others. All of them associated with the human-machine interaction.

There are seven AM technologies. FDM or FFF technology is the most AM technology used with 46% of all AM technologies (Statista, 2019). Besides that, the setup task is typical for most of the equipment, regardless of the brand. Activities associated with FFF could be synthesized in preprocess (design, settings properties of the design, setup of equipment, and preprinting), process (printing of the element), and post process (finishing of the component). It is important to declare that setup correctly allows to reduce the waste time generated by the correction of mistakes generates during the setup of the equipment.

Due the importance of setup activities, this research is focused on asses the workload; NASA-TLX was selected because it has been used widely to measure the workload of many tasks. In AM, NASA-TLX was used as a determining criterion for the choice of a new assembly method, in which the mental load has been a critical factor of the operator's performance (Al-ahmari, Ameen, & Haider, 2018). In many cases of manufacture and health procedures, NASA-TLX has been used to determine workload in repetitive activities as a reference point to affect the decisions taken in a long period of the task execution, achieving with the results of the analysis and improving task a significant level of workload (Buchert et al., 2019, Dodou, Fan, Sc, Jelı, & Breedveld, 2015).

2. OBJECTIVES

The objectives of the present study were two:

- Identify the group of activities that integrate the task of setting up 3D printing of FFF.

- Assessment of the mental load generated by the task of setting up FFF equipment using NASA-TLX.

3. METHODOLOGY

3.1 Study design

The first part of the study consisted of explaining to the participants the objective of the research, the methodology considered and the technology available for the study and for the development of the activity. Once the first part was covered, the task to be executed was explained as well as the evaluation method that would be carried out using the NASA-TLX. For the evaluation, the free software resource was used participants captured their evaluations on a PC with the NASA-TLX software. Once the participants made their evaluation, the research group proceeded to synthesize and analyze the results obtained.

3.2 Sample

The sample was integrated by a group of ten volunteers, eight men and two women. Four of them were students of graduate programs, and six were students of undergrad. All individuals had at least one year of experience working with FFF equipment at the moment of the evaluation. All participants receive training over how to use the NASA-TLX.

3.3 Methods

The methodology used in the present chapter was developed in three phases. The first one was the development of the Hierarchical Task Analysis (HTA); the second one was the workload assessment using NASA-TLX method; and finally, the third phase was to analyze the results obtained by the NASA-TLX. Figure 1 presents a flow chart of the methodology used in the present research. Because HTA and NASA-TLX have their methodology, those methodologies are described after Figure 1.

To achieve the objectives of the present chapter was necessary before define the characteristics of the volunteer's group, the task under analysis, the results obtained by the application of the NASA-TLX and finally the description of the findings.

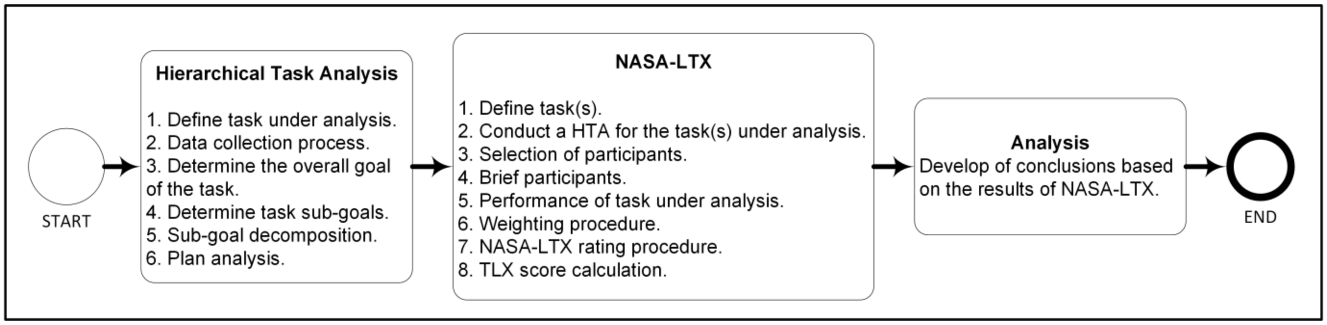

Figure 1. Flowchart of the methodology used to assess the workload in setting up FFF equipment.

3.3.1 Hierarchical Task Analysis (HTA)
According to Stanton, Hedge, Brookhuis, Salas, & Hendrick (2005), for Hierarchical Task Analysis (HTA), the description of each step that integrates the methodology is defined as follows is presented:

Step 1. Define task under analysis. This step is focused on define the task(s) under analysis. As well as the purpose of the task.

Step 2. Data collection process. Data regarding the task steps involved, the technology used, the interaction between man and machine and team members, decision making and tasks constraints.

Step 3. Determine the overall goal of the task. This should be specified at the top of the hierarchy. This enouncement describes the task in general.

Step 4. Determine task sub-goals. In this step, the goal should be broken down into meaningful sub-goals, which work together for the tasks required achieving the overall goal.

Step 5. Sub-goal decomposition. The analyst breaks down the sub-goals identified in the last step; this process should go until an appropriate operation is reached.

Step 6. Plans analysis. Plans analyses dictate how the goals are achieved. Sequences of activities are deployed in this step.

3.3.2 NASA-TLX

NASA-TLX uses six sub-scales: mental demand, physical demand, temporal demand, effort, performance, and frustration level (Hart & Staveland, 1988; Stanton et al., 2005). The procedure is described below:

Step 1. Define the task(s). It refers to define the tasks that are to be subject to analysis.

Step 2. Conduct an HTA for the task under analysis. This allows the analyst and participants to understand the task(s) entirely.

Step 3. Selection of participants. This step refers to select the participants that are involved in the analysis.

Step 4. Brief participants. Before the task(s) under analysis are performed, all participants should be briefed regarding the purpose of the study and the NASA-TLX technique.

Step 5. Performance the task under analysis. The participant(s) should perform the task under analysis. NASA-TLX can be administered either during or post-trial.

Step 6. Weighting procedure. The weighting procedure is 15 pair-wise comparisons of the six sub-scales make it by the participant. Each scale is rated by the software based upon the number of times it is selected by the participant. This is done using a scale of 0 (no relevant) to 5 (more important than any other factor).

Step 7. NASA-TLX rating procedure. Participants are asked to give a rating for each sub-scale, between 1 (low) and 20 (high), in response to the associated sub-scale questions.

Step 8. TLX score calculation. TLX software is used to compute an overall workload score. This is calculated by multiplying each rating by the weight given to that sub-scale by the participant. The sum of the weighted ratings for each task is then divided by 15 (sum of the weights). A workload score of between 0 and 100 is derived for the task under analysis.

With the aim to get standardized results an open software of NASA-TLX is used, this source is available in https://www.keithv.com/software/nasatlx/ (Vertanen, 2010).

4. RESULTS

4.1 Tasks description

The task under analysis consists of setting up Fused Filament Fabrication equipment. Most of FFF 3D printers have the same principles of operation. The first step was to verify that the equipment was plugged to the electrical terminal, and it turns on pushing the power button or turning the knob (depending on the model) (see Figure 1). Once that the equipment has been turned on, the next step was to verify that the printing bed was leveled. A leveling bed is one of the most complicated tasks of the equipment, due that an uneven bed is the principal cause of fails during the printing process. Even many of the models of FFF have electronic futures for leveling; these features work only to determinate an adjust the distance between bed leveling and extruder. The leveling bed consists of making a precisely adjust of the printing bed using the screws leveling located under the printing bed (see Figure 2).

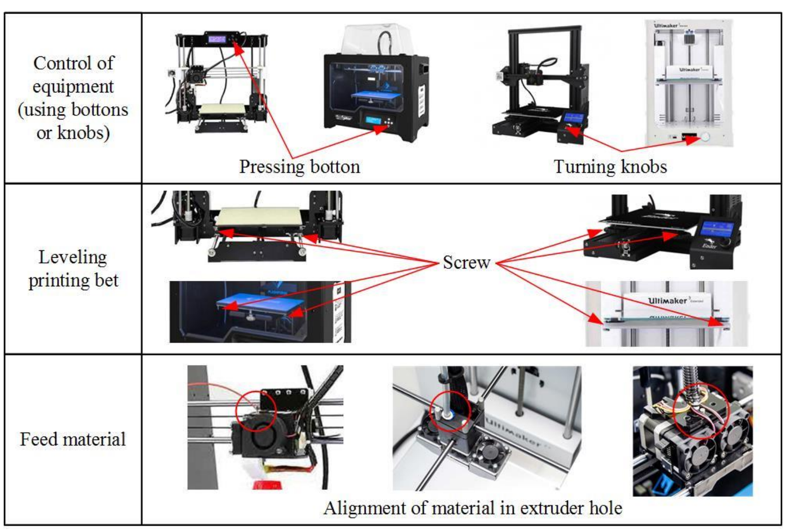

Figure 2. General elements for setting up FFF equipment.

The perfect adjust will allow that the material adheres perfectly to the surface of the printing bed. After the leveling, the next step was to verify that the motors of the equipment were working correctly. If they were working, the next step was to preheat the extruder and the printing bed to evaluate the capacity of the equipment to get the ideal temperatures. When the equipment is ready, the next step is to feed wit material the extruder. This activity consists in punt the filament inside the extruder and lines up it across the equipment. Feed the material correctly allows to get a flow material without problems during the printing process. The setting up process ends when the equipment is ready to receive information about the model to print.

3.2 Hierarchical Task Analysis (HTA)

Following the methodology proposed in this chapter, the HTA is presented in a tabular form. Table 1 presents the information on the HTA.

Table 1. HTA for setting up FFF equipment.

0. Set up FFF equipment. Plan 0: Do 1, then 2, then 3, then 4, then 5, then 6.
1. Plug in FFF equipment to an electric terminal.
2. Turn on equipment (pressing on the start button).
3. Leveling printing bed. Plan 3: Do 1, then 2, then 3 (if wrong, then 4, otherwise 5), then 5 (if wrong, then 6, otherwise 7), then 7 (if wrong, then 8, otherwise 9), then 9 (if wrong, then 10, otherwise 11), then 11 (if wrong, then 12, otherwise 13), then 13 (if wrong, then 14, otherwise 15), then 15 (if wrong, then 16, otherwise 17), then 17 (if wrong, then 18, otherwise 19), then 19 (if wrong, then 20).
3.1 Disable engines. 3.2 Move the printing bed to the front of the equipment. 3.3 Check GAP between extruder and printing bed on the left rear corner. 3.4 Make level adjustments by left rear leveling screw (turn clockwise to go up, turn counterclockwise to go down). 3.5 Check GAP between extruder and printing bed on the back center. 3.6 Make level adjustments by the left and right rear leveling screws (turn clockwise to go up, turn counterclockwise to go down). 3.7 Check GAP between extruder and printing bed on the right rear corner. 3.8 Make level adjustments by right rear leveling screw (turn clockwise to go up, turn counterclockwise to go down). 3.9 Check GAP between extruder and printing bed on the center right side. 3.10 Make level adjustments by front and rear right leveling screws (turn clockwise to go up, turn counterclockwise to go down). 3.11 Check GAP between extruder and printing bed on the center. 3.12 Make level adjustments by four leveling screws (turn clockwise to go up, turn counterclockwise to go down). 3.13 Check GAP between extruder and printing bed on the center left side. 3.14 Make level adjustments by front and rear left leveling screws (turn clockwise to go up, turn counterclockwise to go down).

3.15 Check GAP between extruder and printing bed on the left front corner. 3.16 Make level adjustments by the front left leveling screw (turn clockwise to go up, turn counterclockwise to go down). 3.17 Check GAP between extruder and printing bed on the center front. 3.18 Make level adjustments by front leveling screws (turn clockwise to go up, turn counterclockwise to go down). 3.19 Check GAP between extruder and printing bed on the right front corner. 3.20 Make level adjustments by front right leveling screw (turn clockwise to go up, turn counterclockwise to go down).
4. Enable engines. Plan 4: Do 1, then 2, then 3, then 4.
4.1 Press the central button or knob. 4.2 Select QUICK SETTINGS. 4.3 Press the central button or knob. 4.4 Select HOME ALL.
5. Preheat equipment. Plan 5: Do1, then 2, then 3, then 4, then 5, then 6.
5.1 Press the central button or knob. 5.2 Select QUICK SETTINGS. 5.3 Press the central button or knob. 5.4 Select (type of material) PREHEAT. 5.5 Check the temperature increase in LCD. 5.6 Verify the temperature with an infrared thermometer.
6. Feed and line up filament. Plan 6: Do 1, then 2, then 3, then 4, then 5, then 6, then 7, then 8, then 9, then 10, then 11.
6.1 Check the date of manufacture of the material. 6.2 Take out packing material. 6.3 Place roll of material in roll holder. 6.4 Cut 60 degrees at the tip of the material. 6.5 Press the central button or knob. 6.6 Select QUIT SETTINGS. 6.7 Press the central button or knob. 6.8 Select CHANGE FILAMENT 6.9 Insert filament in extruder feed. 6.10 Press top button or knob until the filament comes out of the nozzle. 6.11 Push the middle button or knob.

3.3 Workload assessment

After the HTA, the workload was assessed using the NASA-TLA method. The individuals of the group received training over the use of the method. After the performance of the task, participants used open source software. The results are shown in Table 1. These results expose that mental demand was the subscale with higher punctuation with an average of 79. Even the participants were familiar with the task; they expressed that the task was demanding and complex. The level of complexity is due to the adjusting of the bed requires a high grade of precision that is different between the participants. This adjust is the most important of all the setting process due that a bad adjust result in future process problems.

The second sub-scale with higher punctuation was temporal demand with an average of 59. As it had mentioned, temporal demand was associated with time pressure. During the task, participants had the restriction of time. Twenty-three minutes is the standard time of setting up for FFF 3D printing (The models used in this research were Prusa I3 and Ultimaker). Even the participants were familiar with the procedure, components, and tools used in the setup; they feel pressure for the time before starting with the task.

Table 1. NASA-TLX scores for setting up FFF equipment.

Individual	MD	PD	TD	P	E	F	Score	Workload level
1	95	45	70	80	65	30	76.00	Very High
2	90	30	60	70	55	30	65.66	High
3	80	25	75	70	70	35	69.66	High
4	75	30	80	70	80	40	72.33	High
5	75	25	40	25	30	20	45.66	Low
6	75	5	70	35	50	15	55.66	High
7	70	5	40	25	40	20	46.66	Low
8	70	25	55	25	35	25	50.00	Low
9	80	25	45	60	70	35	65.66	High
10	80	25	55	65	75	45	70.00	High
Average	79.00	24.00	59.00	52.50	57.00	29.50		

MD (Mental Demand); PD (Physical Demand); TD (Temporal Demand); P (Performance); E (Effort); and F (Frustration).

The effort was the third subscale with important average punctuation. As a result of the mental demand and temporal demand, it is possible to assimilate that individuals perceive specific grade of mental demand associated with the development of the task. In this point and due that physical demand was the lowest average punctuation, it is possible to ensure that the effort is represented firstly by activities as a thinking (about the correct adjust or the correct gap used), deciding (if the adjust was correct or incorrect, if the tool used was appropriate or inappropriate, if turn the screw clockwise or in the opposite direction, etc.), and remembering (the sequence displayed by the software, even they were familiar with the commands and the sequence).

Finally, it is necessary to declare that the task was developed using Prusa I3 and Ultimaker equipment. The importance of this research is evident, for 2022 the setting up of equipment will be developed in more than one equipment (mostly in companies), the projection is that industrial companies will have their prototyping area with many types of equipment's as is showed in Figure 2. As a consequence, the workload could increase significantly because the tasks required in the pre-processing, process, and post-process of 3D printing will increase in quantity.

Figure 2. Industrial prototyping areas, FFF 3D printers.

5. CONCLUSIONS

Additive manufacturing is an alternative manufacturing of production, emerging from industrial production systems. The inclusion of the human factor in this new technology represents a challenge for researchers in the ergonomics field. The objective of this chapter was to assess the workload of setting up FFF equipment. Although the task was developed in just one equipment, it is essential to expose the potential of this technology. Today, Figure 2 is a reality inside companies with many types of equipment's demanding the attention of the human factor.

The results inform that participants were exposed to specific workload, where NASA-TLX identified that mental demand subscale was the significant score in which researchers should propose an alternative to improve the task. The activities of setting up equipment are highly demanded, due that the perfect adjust will eliminate or reduce future problems during the. In this case, the precision activities demanded for the task are the key to reduce the effect of workload.

Finally, considering that this technology will increase its impact over the industry, it is remarkable that the workload of this task should be analyzed using other workload assessment methods to compare more results.

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HUMAN RELIABILITY: MODEL PROPOSAL FOR THE PROCESS IMPROVEMENT OF PROFESSIONAL RESIDENCES

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Resumen: Dentro del sistema que conforman las 254 instituciones del Tecnológico Nacional de México, se concibe a la Residencia Profesional como una estrategia educativa, con carácter curricular, que permite al estudiante, aun estando en proceso de formación, incorporarse profesionalmente a los sectores productivos de bienes y servicios, a través del desarrollo de un proyecto definido de trabajo. Al ser una asignatura diferente (no se realiza en un salón de clases, es una asesoría de uno a uno, exige la participación de asesores dentro de la empresa, etc.) requiere de un proceso de gestión diferente. En él se involucran varios departamentos (el Académico al cual pertenece el alumno, División de Estudios Profesionales y Vinculación) y su interacción con el alumno, es muestra de la calidad en el servicio que presta la institución educativa. Con la aplicación de un sondeo preliminar a residentes, entrevistas a los involucrados en el proceso, diagrama de flujo y jerarquización de tareas, se encontraron áreas de oportunidad para definir un modelo que simplifique el actual proceso. El modelo a proponer pretende abarcar el aspecto humano y su contribución en la ocurrencia de errores y/o retrasos, basándose en el enfoque de la ergonomía cognitiva para evaluar el comportamiento humano y su interacción con el proceso. La presente investigación pretende – a través de herramientas de confiabilidad humana – analizar puntos clave en el proceso de gestión de la asignatura de Residencias Profesionales y proponer acciones concretas para minimizar retrasos (causados por los re-trabajos y esperas). Dentro del alcance y responsabilidad del asesor interno se han establecido mejoras, sin lograr aún la pertinencia que el usuario y el entorno demandan. Este artículo presenta los avances realizados y la proyección de mejoras que pueden implementarse. Este es el avance de un trabajo de tesis de maestría en ingeniería industrial realizado en conjunto con la maestra Yolanda Frausto y revisado por nuestros asesores.

Palabras clave: Confiabilidad humana, residencias profesionales, gestión

Relevancia para la ergonomía: El mejoramiento de los procesos se considera con frecuencia como un aspecto técnico de flujos, tiempos y tareas. Sin embargo, los procesos de servicio (de atención, de gestión) deben estudiarse de una perspectiva diferente a los productivos. Los procesos administrativos o de gestión exigen tener una mejor comprensión del significado del aspecto humano y su contribución en la ocurrencia de errores. Para ello se requieren emplear enfoques que abarquen la ergonomía cognitiva conjuntamente con las herramientas convencionales de ingeniería de métodos, para evaluar el comportamiento en los procesos. Este proyecto es uno de ellos, y espera contribuir con su análisis a puntos de vista que enriquezcan este enfoque y mejoren el servicio, evitándole al usuario esperas innecesarias, repetición de tareas, así como la frustración al percibir un proceso lento, moroso y poco entendible.

Abstract: Within the system that make up the 254 institutions of the National Technological Institute of Mexico, the Professional Residence is conceived as an educational strategy, with curricular character, which allows the student, even in the process of being trained, to enter professionally into the productive sectors of goods and services, through the development of a defined work project. As it is a different subject (it is not done in a classroom, it is a one-on-one assessment, it requires the participation of advisors within the company, etc.) it requires a different management process. It involves several departments (the Academic to which the student belongs, Division of Professional Studies and Bonding) and their interaction with the student, is a sign of the quality of the service provided by the educational institution. With the application of a preliminary survey, to residents, interviews to those involved in the process, flow chart and hierarchy of tasks, areas of opportunity were found to define a model that simplifies the current process. The proposed model aims to cover the human aspect and its contribution to the occurrence of errors and delays, based on the cognitive ergonomics approach to evaluated human behavior and its interaction with the process. The present research intends - through human reliability tools - to analyze key points in the management process of the Professional Residency subject and propose concrete actions to minimize delays (caused by re-work and waiting). Within the scope and responsibility of the internal consultant, improvements have been established, without yet achieving the pertinence that the user and the environment demand. This article presents the progress made and the projection of improvements that can be implemented. This is the progress of a master's thesis work in industrial engineering conducted in conjunction with teacher Yolanda Frausto and reviewed by our advisors.

Key words: Human reliability, professional residences, management.

Contributions to Ergonomics: The improvement of processes is often considered as a technical aspect of flows, times and tasks. However, the service processes (attention, management) should be studied from a different perspective to the productive ones. The administrative or management processes require a better understanding of the meaning of the human aspect and its contribution to the occurrence of errors. This requires employing approaches that encompass cognitive ergonomics in conjunction with conventional methods engineering tools, to assess the behavior in the processes. This project is one of them, and it hopes to contribute with its analysis to points of view that enrich this approach and improve the service, avoiding unnecessary waits for the user, repetition of tasks, as well as frustration when perceiving a slow, slow and understandable process.

1. INTRODUCTION

In order for the Higher Education Institutions (HEIs) to respond to the needs of the productive sector, especially the business sector, some policies emerged almost twenty years ago in order to establish or reinforce the linkage programs between HEIs and said sector. "Within the framework of the Reform of Higher Technological Education and in response to the need to strengthen the link between higher education and the productive sectors of goods and services, professional residencies were incorporated into curricula of current careers in this System "(SEP-SEIT, 1997).

According to the background of this program, there are few studies conducted to know its achievements, advances, strengths, limitations and, weaknesses. (Quispe, Atriano 2014)

Within the National Technological Institute of Mexico - constituted by 254 institutions, of which 126 are Federal Technological Institutes and 128 Decentralized Technological Institutes, among others -, the curricular value for the Professional Residence (RP) is 10 credits, and its duration is determined for a period of at least four months and six months maximum. (National Technological Institute of Mexico, 2015).

The Technological Institute of Ciudad Juárez (ITCJ) belongs to the National Technological System of Mexico (TecNM) and therefore is obliged to follow the current regulations of the same.

Currently, the student population of the ITCJ is approximately 7319 students, of which 1604 study the Industrial Engineering degree: 169 in the semi-face-to-face mode, 1435 in the face-to-face modality (Accountability, Lagarda, 2018).

Each semester about 80 young people (only in Industrial Engineering) carries out the process of professional residency since this is a compulsory subject from the ninth semester and has the purpose that the future professional reaches the labor field with the experience of having developed - at least - a project in your area.

It is necessary to consider that resident students not only study the subject, they also have to handle procedures, information, the relationship with the internal and external advisor, and sometimes with the lack of sensitivity of those who interact with them in the process. (Rodríguez, Cisterna, Gallegos, 2011)

Seeking the opinion of the users of the process in the area of Industrial Engineering, regarding their perception as the main client in the processing of the subject of professional residences, a survey was conducted, finding - among other things - that more than 50 % of those who studied the subject, state that the most accurate description of the process is "There is difficulty in knowing the specific activities to be carried out and whom to contact", and they mention that the most complicated part of the process is "The investment of unnecessary time in the search and/or waiting for attention from the personnel involved in said process "

Given these data, the need arises to perform a more detailed analysis of the process, conducting interviews with those involved in the process and applying method engineering tools to determine tasks, operation flows, hierarchy of tasks, most common errors that are mentioned , cause and consequences of them, as well as times for the completion of each task,

The data emerges. These are discussed and shared.

Even demonstrating quantitatively and qualitatively evidence of the alert that the process points to, it is difficult to achieve actions that focus on a re-engineering of processes, since in the vast majority of government institutions, there is justification (valid or invalid, real or fictitious) of the limitation of resources (human, infrastructure, time and budget) for planning and improvement of services. In addition, as an internal advisor to an academy, participation in the process is limited.

However, within this limited responsibility and framework of action, work options to positively impact the process arise, such as:

1. Sensitize internal advisers, and
2. The need to analyze, from the perspective of the student, errors, and circumstances of the same in the process, in order to prevent them.

It should not be forgotten that the analysis of human error, of the reliability of the human act, is a subject in which it is convenient to keep in mind that human beings always act under the action of a large number of personal variables, organizations, situational and environmental factors, which often make it impossible to definitively determine the causes. (Elsayed, 1999)

2. OBJECTIVES

This project focuses in the prevention of human error in the administrative process to control the performance of the professionals residences in the Industrial Engineering career in a prestigious educational institution, with a scope that start with the submitting of the project by the alumni, and finishing with the verification of the student´s score in the Integral Information System of the institution. Not included is the payment process to the resident.

2.1 General objective:

This project aims to establish clear strategies for the prevention of errors in the activities under the responsibility of the student in the process of managing the subject of Professional Residences, as well as forming the basis for a proposal for a new operating model that increases the efficiency and communication of the departments involved, and provide added value to the institution.

2.2 Specific objectives:

a. Evaluate the crucial points that need to be addressed regarding the areas of opportunity to improve the current process of Professional Residences

b. Apply human reliability tools, to optimize resources and improve the results of the process in analysis.
c. Develop a proposal with the goal of systematizing the process in study.

3. METHODOLOGY

This analysis included the detailed observation of the evidence gathered throughout the process (dated trades, receipt of documents, controls of those involved, etc.).
It was found that not all the tasks are documented and that many of the data do not reflect with certainty the real process carried out by residents in the management of the subject since there is no control of each step.
The study was completed with interviews in focus group of residents, who -despite the fact that each one went through different management processes -supported the identification/ validation of the hierarchy of tasks, key activities where they are committed
errors, causing delays and delays in the process, as well as their suggestions to improve the process.To prevent these errors, these actions are analyzed under the SHERPA method.

4. RESULTS

4.1 Data colecction.

In the survey applied to students performing professional practices and graduates alumni it was obtained:

- 52.73% mentioned that the most complicated part of the process, is the time spent in the search and / or the waiting time to receive attention by the institutional personnel in charge of the task.
- 50.91 % consider that, the most accurate picture of the process, is the fact that there is difficulty to know the specific activities to be performed and with whom to go to solve the issue.

4.2 Flowchart.

The flowchart is applied in the process analysis. The summary thereof is presented in Fig. 1

Technological Institute of Ciudad Juárez	Summary	
Activity: Management process of Professional Residences	Activity	Time
Date: 19 / May/ 2018.	Operation	25
Operator: Student	Transfer	6
Analyst: Y. Frausto	Delay	
JPVC = Project manager career linkage	Inspection	
CC = Career coordinator	Storage	
AI = Internal advisor	Time	50 días
	Distance	583.49 mts
	Cost	

Fig. 1. Summary obtained by applying a flowchart to the residential process carried out by Y. Frausto.

Explanatory notes on process flow diagram:
• The estimated time is in days
• The estimated time is considered when the response to an application is given (signature, trade, etc.) and it is done the day after being requested.
• To consider the standard time, it is necessary to add 15% (7.5 days) to the estimated time. From this operation, the management cycle time is obtained in 57.5 days. Approximately.
• In the ideal process conditions, it is estimated that from the total time devoted to the residencies, 27 to 41%, is spent in bureaucratic procedures, either 6 or 4 months the time dedicated to the subject.

4.3 HTA (Hierarchical Analysis of the Task)

The HTA implies a description of the activity as an analysis objective in terms of a hierarchy of objectives, sub-objectives, operations and plans.

The final result is an exhaustive description of the activity of the task.

In the present case, it was complicated to establish the hierarchy of tasks in some activities of the process, since there was not a single flow for all the cases. The perception of the residents was considered as the primary basis to determine it, independently of the flows that each department commented.

The HTA served as background for the analysis of human error through the SHERPA method.

With the application of HTA it was determined, that from the 35 tasks involved in the process, 18 are the student responsibility.

0. Management Process of the Professional Residency Course
Plan 0: Do correctly 1-2-3-4-5-6 End
1. Obtain appointment as an internal advisor.
Plan 1: Do 1.1-1.2 -1.3-1.4-1.5-1.6-1.7-1.8-1.9-1.10
1.1 Student - Prepare draft of professional residences
1.2 Student - Delivery of preliminary draft to Career Coordinator (CC)
1.3 CC - Delivery of the preliminary project to the Project Director of Career Linking (JPVC)

1.4 JPVC - Assigns internal advisor (AI)
1.5 AI - Check the draft according to guidelines
1.6 AI - Informs JPVC and Student of preliminary project observations
1.7 JPVC - Generate advisor assignment office
1.8 JPVC - Inform CC of the acceptance of the project and the assigned advisor
1.9 CC - Publish the acceptance of the project and the advisor's assignment
1.10 Student - Receive assignment of assignment of internal advisor from the CC

2. Pre-registration
Plan 2: Make 2, the student pre-enrolls.

3. Registration in the subject.
Plan 3: Do 3, 3.1-3.2 If it is not done within THREE WORKING DAYS after issuing the assignment document, it is returned to 1.7. If this is the term, continue with 3.3-3.4-3.5-3.6-3.7-3.8-3.9
3.1 CC - Complete information on the project in the SII (Comprehensive Information System) for the student to request registration to the subject
3.2 Student - Carry assignment of internal advisor to Liaison (Only THREE WORKING DAYS AFTER ISSUING THE INTERNAL ADVISOR ASSIGNMENT OFFICE) If this does not happen, you will have to go to activity 1.7 to request an office with a new date and be generated again by JPVC.
3.3 Student - Apply in Liaison cover letter to the company
3.4 Bonding - Generates the presentation of the resident before the company where the professional residences will take place
3.5 Student - Gathering cover letter and take the company
3.6 Company - Generates acceptance of the resident in the company
3.7 Student - Official submission of acceptance of the company to Link
3.8 Student - delivery to CC copy of preliminary project, cardex, request of the subject and NSS
3.9 CC - Inform student of the process, key procedures, formats and delivery times.

4. Follow-up through monthly reports
Plan 4: Do 4.1-4.2-4.3-4.4 in a cycle of 4 to 6 times adhering to the term indicated in the office of assignment of the internal advisor.
4.1 Student - Interview with Internal Advisor
4.2 AI - Verify and give observations to correct in the residences report
4.3 Student - Make corrections indicated by the IA in the report
4.4 Student - Submit monthly reports to Career Coordinator
This cycle of activities can occur from 4 to 6 times MONTHLY.

5. Close with departments involved in the process.
Plan 5: Do 5.1-5.2-5.3-5.4-5.5-5.6-5.7-5.8 If this activity is NOT performed within a period NOT GREATER THAN THREE DAYS after the termination document has been issued, you must return to item 5.4. If so, continue with activity 5.9
5.1 Student - Manage visit of the Internal Consultant to the Company to review the project and contact the External Advisor of the Company
5.2 AI - Visit company and review project application. Find the opinion of the External Advisor regarding the work done by the resident
5.3 Student - Compiles in evaluation format the qualifications granted by External Advisor and Internal Advisor, as well as the seal of the company and the stamp of the Dept. Academic to which the student belongs.
5.4 Company - Issue Office of Termination of Professional Residences
5.5 Student - Final report of professional residences approved by the Internal Advisor
5.6 Student - Prepares digital file (CD) of the final report of the subject and presents for the signature of the Internal Advisor
5.7 AI - Issue proof of release of the subject
5.8 Student - Compiles the formats of: Evaluation, Letter of Release, Letter of Completion and takes them to Link for your signature
5.9 Student - Delivery of Evaluation forms, Letter of Release, Letter of Completion and CD with CC

6. Qualification of the subject
Plan 6: Do 6.1-6.2
6.1 AI - Document qualification in the SII and print qualification certificate.
6.2 JPVC - Verify the documentation of the resident's qualification in the SII

Fig. 2. HTA of the process of management of the subject of Professional Residencies.

4.4 SHERPA

After HTA development, each task was analyzed individually and classified into action, retrieval, selection, checking and information, finding in the 35 tasks

analyzed: 17 actions, 8 retrieval, 0 selection, 4 checking and 6 information / communication.
According to the interviews carried out with those involved in the process, as well as the testimonies of residents and the evidences obtained in the analysis of 79 cases, the errors were classified. The result of the analysis of the error in the task of "Obtaining assignment of internal advisor assignment" is presented in the following table.

Tabla No. 1. Identification of errors found in the management process of Professional Residences. It shows only the analysis of "Get assignment of internal advisor assignment"

Step of the Task	Type of Error	Description of Error	Consequence	Recovery	P	C	Suggestions
1.1	**A3**	Student prepares preliminary proyect out of guidelines	Process does not start	1.5	L		Campaigns to inform students coming to study
1.2	**A5**	Student delivers the preliminary project outside the established time period	Delay in the process	1.3	M		Training - Verification early in the process of data required
1.3	**A2**	CC - Project delivery out of time	Delay in the process	1.4	L		New communication channels
1.4	**A2 A5**	JPVC - Late delivery for review - no profile assignment advisor for the project	Delay in the process–Difficulty in the process, problems with the company	1.5	L	¡!	New communication channels
1.5	**C1-C2 C4-C5**	AI - No verification is done - is done incompletely - verification is under a list of incorrect or outdated collation - check is carried out of time	The process is not carried out according to guidelines	1.6	M	¡!	Training and awareness of the process
1.6	**I1 – I3**	AI - The observations are not reported or are reported incompletely	Delays in the process - Process does not conform to guidelines (PROJECT TITLE)	1.7	M	¡!	Training and awareness of the process
1.7	**R2**	JPVC - Generates the office with incorrect information	To do again and delays in process	1.10	H	¡!	Verification by the student

1.8	**I1**	JPVC - Does not communicate the allocation of internal adviser CC	Delays in the process	1.9	L	¡!	New communication channels
1.9	**I1**	CC - NO informs the allocation of student advisor	Delays in the process	1.10	L	¡!	New communication channels
1.10	**C1**	Student receives a letter from CC to continue the process		1.7	M	¡!	Training and awareness of the process

5. DISCUSSION / CONCLUSIONS

If the Professional Residence is conceived as an educational strategy, with curricular character, that will be the student to be incorporated to the productive sectors, through the development of a defined work project, it should be managed with clear, accessible, controlled and safe processes, and in that way, the student will prioritize their academic performance, rather than the bureaucratic activities management, that for various reasons in many cases, they involve delays and rework, lengthening the process and contributing to perceive it as complex.

The training of the internal advisors on the process and the previous instruction of the residents, both in the research protocol and in the management process, would help to understand the tasks and prevent errors.

More and better channels and forms of information-communication with the residents should be implemented on the sequence of tasks, filling of forms, periods of reception-delivery of documents, schedules of the departments involved, etc. noticing the consequences of errors in the process, and the use of interactive platforms would help a lot in this.

Within the responsibility of the internal advisor, have been designed and implemented awareness and information courses about the process, and great results have been obtained in the exchange of good practices; an electronic template has been designed and disseminated, making it easier for the resident to prepare his report; However, the lack of a criteria of the various academic departments, the lack of clarity in the flow of activities and work instructions to be performed, as well as the lack of updated IT tools, have made difficult the understanding of the efficiency of the process

It is necessary to keep in mind that the lack of systematization in the processes means that the academies and the people involved in the processes use their criteria to carry out the tasks, and it also makes it difficult to visualize priorities to implement improvements.

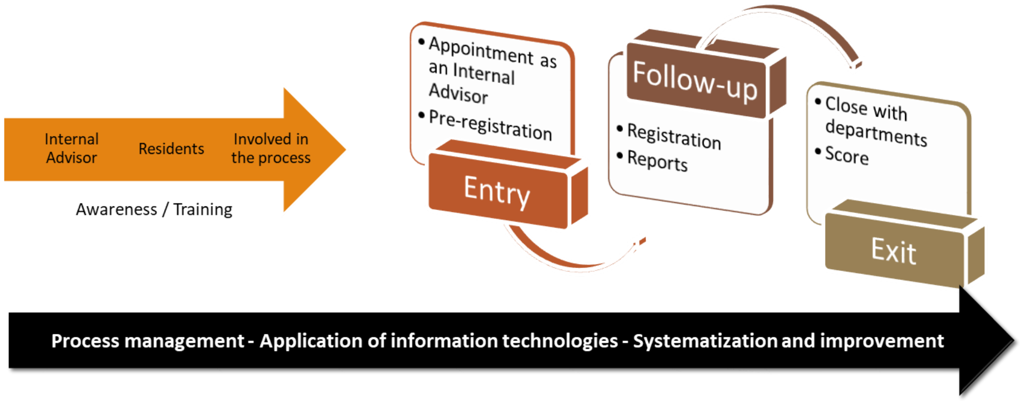

Fig. 3: Proposed model for the process of Professional Residencies

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SHERPA AND TAFEI, COMPARISON OF TWO HUMAN ERROR IDENTIFICATION TECHNIQUES: A CASE STUDY

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Resumen: El siguiente trabajo, presenta un estudio de caso de análisis del error humano en una tarea ejecutada en un centro de reparación de equipos de cómputo. Por lo que se realizó un Análisis Jerárquico de Tareas, así como aplicación de dos técnicas de identificación del error humano, TAFEI y SHERPA. Como resultado, en TAFEI se elaboraron 11 SSD que ayudaron a identificar 5 transiciones ilegales y 5 modos de error, siendo uno de ellos catastrófico. Una vez analizados y comparados los resultados de TAFEI y SHERPA, se pudieron encontrar errores debido a la mala ejecución de la tarea, mal identificación de los equipos en reparación, daños por mal manejo de los materiales y errores en la colocación de los componentes.

Palabras clave: Ergonomía cognitiva, error humano, análisis jerárquico de tareas, TAFEI, SHERPA.

Relevancia para la ergonomía: Por medio de este trabajo se presenta un caso de estudio en donde se hacen uso de técnicas de identificación de error humano (SHERPA y TAFEI), las cuales a pesar de ser de gran importancia han sido muy poco aplicada en campo, por lo que se presenta como una posible referencia para todos aquellos que deseen implantar dichas técnicas.

Abstract: The following paper presents a case study of the analysis of human error in a task performed in a computer equipment repair center. Therefore, a Hierarchical Task Analysis was performed, as well as the application of two human error identification techniques, TAFEI and SHERPA. As a result, TAFEI developed 11 SSDs that helped identify 5 illegal transitions and 5 error modes, one of which was catastrophic. Once the results of TAFEI and SHERPA were analyzed and compared, errors could be found due to the bad execution of the task, bad identification of the equipment being repaired, damages due to bad handling of the materials and errors in the placement of the components.

Keywords: Cognitive ergonomics, human error, hierarchical task analysis, TAFEI, SHERPA.

Relevance to Ergonomics: This work presents a case study in which human error identification techniques are used (SHERPA and TAFEI), which despite being of great importance have been very little applied in the field, so it is presented as a possible reference for all those who wish to implement such techniques.

1. Introduction

The use of personal computers (PCs) has now become more ordinary, it's common to find them in homes, workplaces, schools, etc., resulting in PC repair facilities installed everywhere. One of the problems that have been generated within these facilities has been that of economic losses that have been caused by human errors. The analysis of human error is currently one of the main topics of study of cognitive ergonomics. According to Casares-Li, Rodríguez-Hernández, & Viña-Brito (2016), human error has been increasing due to the complex dynamics of current production and service systems. Due to the above, the use of techniques for the identification of human error (HEI) has been increasing. As to Reason (1990) state, not all possible faults are caused by human error, in order to be considered as a consequence of human error, these should not be the consequences of causal agents.
According to Mohammadian, Choobineh, Mostafavi Nave, & Hashemi Nejad (2012), virtually all human error identification techniques follow a common procedure: what acts can be done and how these acts cause human error, in addiction, Stanton, Salmon, & Rafferty (2013) recommend developing a Hierarchical Task Analysis before the application of any HEI technique. Hierarchical task analysis (HTA) is a powerful tool that gives the analyst an overview of how a process works, since HTA provides an analytical description of a process or activity, including the realization of a hierarchy of objectives, sub-objectives, operations, and task plans. The HTA was originally developed as a method for determining training requirements and is the oldest and best-known task analysis technique (Lorés & Granollers, 2017).
According to Stanton et al. (2013), one of the best HEI techniques is SHERPA, (Systematic Human Error Reduction And Prediction Approach), developed by D.E. Embrey in 1986, which has the objective of qualitatively and quantitatively evaluate human reliability and elaborate concrete recommendations to reduce the probability of human errors, especially as regards procedures, personnel preparation and equipment design (de Arquer & Nogareda, 1994). SHERPA has been used to identify pilot errors, errors during laparoscopic or keyhole surgery and errors that occur during the use of consumer products such as ticket machines.
We also have that TAFEI (Task Analysis For Human Error Identification) technique is one of the easiest HEI techniques to implement, in which an analyst can be quickly trained (Kuang, Hu, Zhang, & Gao, 2009; Stanton et al., 2013). TAFEI was developed by Baber & Stanton, (1994), and allows analysts to predict errors with the use of a device (artifact) by modeling the interaction between the user and the device analyzed.

1.1. Objetive

The objective of this work is: analyze human error, through TAFEI and SHERPA, in a task performed in a PC repair center, in order to compare both HEI techniques and provide suggestions in order to reduce human error in the task evaluated.

1.2. Delimitation

Only the analysis of human error in the selected task was performed, so the analysis of the entire operation was not performed, hierarchical analysis of tasks (HTA) was developed as a preliminary step in the application of the TAFEI and SHERPA techniques.

2. Metodology

In the elaboration of this work, the following methodology was used:

2.1. Selection of the task for analysis and elaboration of HTA

For the selection of the task to be analyzed, a survey was carried out among the personnel of the support center to determine the task whose consequences would have a greater impact and which, due to its poor execution, would cause irreparable damage to the equipment under reparation, as well as the workflow in the area and based on the results obtained, to proceed with the elaboration of the HTA.
In order to elaborated the HTA 6 steps should be observed (Stanton et al., 2013):

1. Define the task for analysis.
2. Data collection process.
3. Determination of sub-goals of the task.
4. Sub-goal decomposition.
5. Plan analysis

Once all sub-goals and operations have been fully described, plans need to be added. Plans dictate how goals are achieved. A simple plan would be: Do 1, then 2 and then 3. Plans do not have to be linear and exist in many forms, some examples are shown in Table 1.

Table 1. Types of plans for the HTA.

Plan	Example
Linear	Do 1, then 2, then 3
Nonlinear	Do 1, 2 and 3 in any order
Simultaneously	Do 1, then 2 and 3 at the same time
Bifurcation	Do 1, if X is present make 2, then 3, if X is not present Exit
Cyclic	Do 1, then 2 and then 3 and repeat until X
Select	Do 1, then 2 or 3

2.2. Analysis of human error by using of TAFEI.

In order to develop the TAFEI, three steps are necessary (Baber & Stanton, 1994):
1. Develop a Hierarchical Task Analysis (prepared in the previous stage).
2. Create a space-time diagrams (SSD).
3. Make a transition matrix.

SSD is the list of states which may happen in a machine. Each list has a common list under which is a list of output states (feedback) (Mohammadian et al., 2012) and, according to (Stanton et al., 2013) the Space-state Diagrams (SSDs) are constructions that represent the behavior of the device or product. Each of them represents one of the possible task states, listing the initial and final status, this is based on the HTA.

The transition matrix is an important step in TAFEI because all possible transitions in the execution of the task or the use of artifacts are introduced. These transitions are the change from one SSD to another. Three approaches are adopted to complete the matrix (Mohammadian et al., 2012):
- If the given transition is impossible, a dash is placed in the respective cell.
- If a given transition is possible and desirable (I. e., the user is moving towards the target), it's a legal transition represented by L in the table.
- If a given transition is possible but undesirable (deviation from the desired action), it's an illegal transition shown in the table, it's represented by an I.

When all possible intersections have been analyzed, the situations in which an illegal transition occurs (I) are analyzed.

2.3. Analysis of human error through SHERPA.

SHERPA human error identification technique consists of common questions and answers that distinguish similar errors at each step of task analysis. (Embrey, 1986; Stanton et al., 2013). The application of SHERPA is done in eight steps:
1. Elaboration of HTA, prepared in the first stage
2. Classification of tasks: Each step of the work is considered for the classification of errors from the lowest level of analysis:
    - Action: Press a switch or press a button to open a door;
    - Recovery: receiving information from a monitor or guide, etc.;
    - Verification: directing and managing a verification process;
    - Selection: select another strategy based on orders from higher authorities;
    - Communication of information: talking to other departments or groups

The following errors can be studied with this method:
- Action: this error is in fact related to the actions of individuals, i.e. individuals do not do their task properly or promptly;
- Recovery: the immediate action after an error to return the system to its original state;
- Verification: an error in which people do not perform verification in a timely or proper manner;

- Communication: an error in the process of communicating with other sections, that is, incorrect information is received;
- Selection: the operator selects the wrong option or forgets to select a step in the system control process.

In this step, and using a special checklist, shown in Table 2, the error code is determined and recorded in the error mode column, shown in Table 3.

3. Identification of human error: The classification of task steps leads the analyzer to verify action errors by classifying lower level errors. A description of the occurrence of each error is presented.
4. Consequence Analysis: Examining the consequences of each error for the system is the next critical step, which produces the applied consequences of the critical error. It is necessary for the analyst to provide a full description of the results together with the identification of the error.
5. Recovery analysis: The analyst must determine the recovery of possible errors identified in this step, i.e. the scanner decides what action is necessary to avoid this type of error. First, this action, obtained in the hierarchical analysis of tasks, is determined and the following step is entered.
6. Ordinal probability analysis: The necessary results and recovery have been obtained to estimate the probability of the error. Then the error probability is determined with respect to Table 4.
7. Criticality analysis: In this step, the severity of damage caused by human error is determined based on Table 4. After combining it with the probability of error, the relevant risk level is determined and recorded in the seventh column of Table 3.
8. Analysis of solutions: The final step in this method consists of strategies to reduce human error. They take the form of changes and modifications suggested in the system to prevent human error and are divided into four categories:
   - Equipment (redesign or modification of existing equipment).
   - Training (development of new curricula or educational and training programs, modification of training course).
   - Guidelines (providing new guidelines and instructions or revising old guidelines and instructions).
   - Organizational and management modifications.

Table 2. SHERPA Error Mode Checklist

Type of Error	Code	Error category
Operation too short / long	A1	Action
Untimely operation	A2	
Operation in the wrong direction	A3	
Too little / much work	A4	
Misalignment	A5	
Right operation on the wrong object	A6	
Wrong operation on the right object	A7	
Omitted operation	A8	
Incomplete operation	A9	

Incorrect operation on the wrong object	A10	
Omitted revision	C1	Verification
Incomplete revision	C2	
Correct revision of wrong object	C3	
Incorrect revision of right object	C4	
Untimely revision	C5	
Incorrect revision of wrong object	C6	
Unattained information	R1	Recovery
Wrong information obtained	R2	
Incomplete recovery of information	R3	
Non-relayed information	I1	Information communication
Incorrectly relayed information	I2	
Relay of incomplete information	I3	
Omitted selection	S1	Selection
Incorrectly made selection	S2	

Table 3. Information which must be included in the table of results

Step in the HTA	Type of Task	Type of Error	Description	Consequence	Reco-very	Risk Level	Corrective Measure
(HTA-Obtained)	Write the name of task	(Obtained from the error verification list, Table 1)	Description of the possible error	Consequence when error does not occur		(Obtained during the ordinal probability analysis and the criticalness analysis step of the methodology)	Propose corrective measures to prevent error from reoccurring.

Table 4. Risk evaluation range.

		Catastrophic	Critical	Marginal	Insignificant
Risk		1	2	3	4
Frequent	A	1A	2A	3A	4A
Probable	B	1B	2B	3B	4B
Occasional	C	1C	2C	3C	4C
Remote	D	1D	2D	3D	4D
Improbable	E	1E	2E	3E	4E

3. Results

3.1. Selection of the task for analysis and elaboration of HTA

The task selected for analysis, based on interviews between technicians, is to change and test the power supply (PS) of the PC, this is because the PS is responsible for providing the proper electrical current to all elements of the PC, so that in case of error and/or failure during this task all equipment is affected. According to the comments of the participants, the failures of the PS represent 16% of the total failures of the reviewed computer equipment. 13 participants were observed performing this task during different days and hours.

For the elaboration of the HTA, which is shown in Table 5, and following the steps described in the methodology, the following points were observed:

1. Task definition for analysis: The task determined to analyze in this work is: change and test the PS.
2. Data collection process: Data were collected through interviews and direct observation of the work done by the participants.
3. Determine the overall goal of the task: The main goal of the analysis is: Change of PS
4. Determination of sub-goals of the task: Test the PS, disconnect the PS, selection of the new PS, install a new PS, Test the equipment.
5. Sub-goal decomposition: each of the sub-goals was broken down into simple elements detailing the process of the task.
6. Plan analysis: a linear and selective plan was used to deploy 4 hierarchical levels for subtasks.

Table 5. Hierarchical Task Analysis pertaining to the task analyzed.

0. Change and Test of PS		
Plan 0: 1 if necessary: 2, 3, 4 and 5		
	1. Determine if PS change is required	
	Plan 1: 1, 2 and 3	
		1.1 Open the PC
		1.2 Place the tester in the PS
		1.3 Determine the condition of the PS
	2. Remove the PS	
	Plan 2: 1, 2	
		2.1 Remove the screws, ties and connectors from the PS
		2.2 Remove the PS from the PC chassis
	3. Selection of the PS	
	Plan 3: 1, 2	
		3.1 Check the specs of the defective PS
		3.2 Find the right PS from the spare parts
	4. Install new PS	
	Plan 4: 1, 2	
		4.1 Place the new PS into the PC chassis
		4.2 Place the screws, ties and connectors of the PS
	5. Test the PC	
	Plan 5: 1, 2 and 3	
		5.1 Attach the PC accessories
		5.2 Verify PC functionality
		5.3 Close the PC

3.1. Analysis of human error by using of TAFEI

From the HTA developed in the previous step, the SSD were developed and are shown in Figure 1. In this case, we had 11 different states. The SSD showed the possible state of the equipment under repair at different times during the execution of the task. Changes between states are indicated by a black line. The red arrows

show the state where it is possible to generate an illegal transition and the number inside shows the state towards which it would be done, they are showed in the transition matrix in the Table 6.
Based on the transition matrix, the following illegal conditions, red arrows, were detected:

- From status 1 to 8.
- From state 2.2 to 7 and 8.
- From state 3 to state 8.
- From state 4 to state 6.

These errors occur when the equipment to be repaired is not correctly identified, so the technician confuses the state of the repair and sends it to the next process without having performed the task correctly. It can also happen that when the technician is reviewing the PC, he is distracted, skipping steps of the operation.

Table 6. Transition matrix

		To state										
		1	2.1	2.2	3	4	5	6	7	8	9	10
From state	1	-	L	L	-	-	-	-	-	I	-	-
	2.1	-	-	-	-	-	-	-	-	-	-	-
	2.2	-	-	-	L	-	-	-	I	I	-	-
	3	-	-	-	-	L	-	-	-	I	-	-
	4	-	-	-	-	-	L	I	-	-	-	-
	5	-	-	-	-	-	-	L	-	-	-	-
	6	-	-	-	-	-	-	-	L	-	-	-
	7	-	-	-	-	-	-	-	-	L	-	-
	8	-	-	-	-	-	-	-	-	-	L	-
	9	-	-	-	-	-	-	-	-	-	-	L
	10	-	-	-	-	-	-	-	-	-	-	-

3.2. Analysis of human error through SHERPA

In the case of the SHERPA analysis, the results obtained from the interviews with the technicians are shown in Table 7. From the SHERPA results, the highest risk error that can occur in the PS selection. Since it is a selection type error (S2, from Table 2) and probable and catastrophic (1B, from Table 4) , its necessary that the technician has the necessary capacity, during this stage, to carefully select the piece that will be placed in the equipment, due to the consequences that such action may have, the most serious of which would ultimately be the total loss of the equipment.

4. Conclusions and Recommendations.

The use of two HEI techniques in the same case study, not only assist to identify the same error, for example, thanks to TAFEI was detected that the lack of identification of the state of the PC under repair was important, while SHERPA helped to identify

the importance of the correct execution of the task, so together it was possible to identify the following situations where there would be an error: poor execution of the task, misidentification of equipment in repair, damage by improper handling of materials and errors in the placement of components. In order to avoid them, the following actions are recommended: elaboration of visual aids that indicate the due process to follow, adding an identification label that shows the state of the PC under repair, training technicians on the importance of having the proper handling of materials as well as their correct placement.
Finally, thanks to the use of the best HEI technique (SHERPA), as well as the easiest to implement (TAFEI) it was possible to detect the errors shown above, so it is recommended that the analyst consider the different HEI techniques that are available and apply the one that the analyst considers most suitable for their needs.

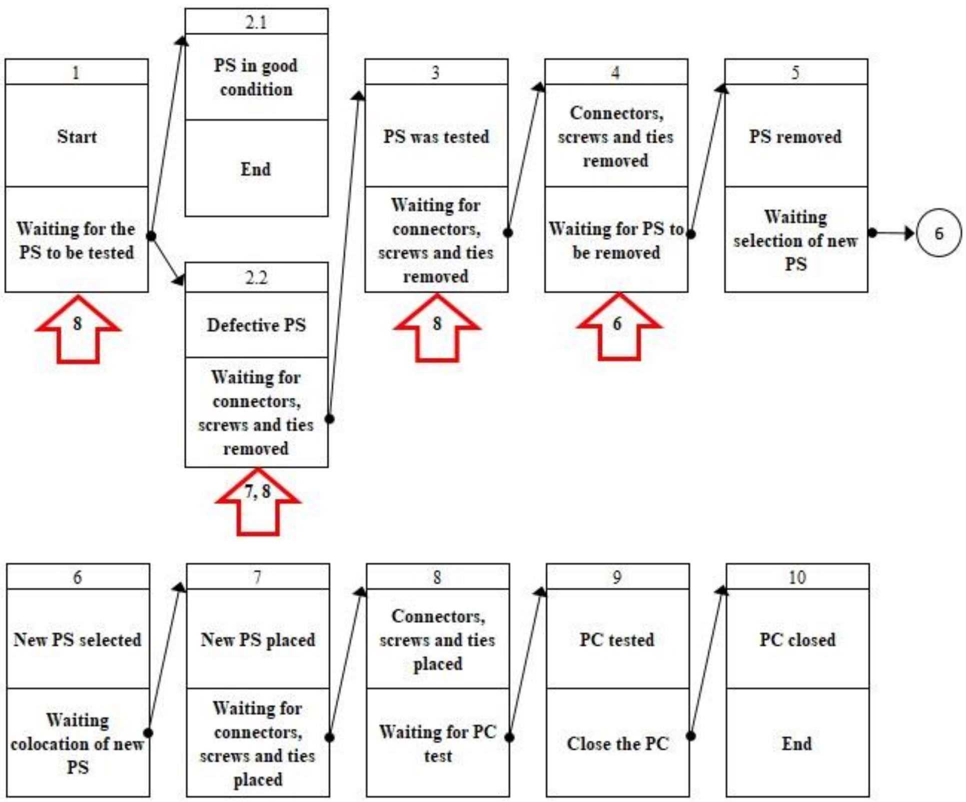

Figure 1. SSD developed from the HTA.

Table 7. SHERPA Results in the task analyzed.

Step in the HTA	Type of Task	Type of Error	Description	Consequence	Reco-very	Risk Level	Corrective Measure
1.3	Determine the condition of the PS	C4	PS verification is not performed correctly	Source can create a power overload and cause a short circuit,		1D	Perform the verification of the condition of the PS

				thus damaging the equipment entirely.			without omitting any steps.
2.3	Remove the screws, ties and connectors from the PS	A7	Action is performed carelessly	Component parts may get damaged, when this could have been avoided.		3D	Perform the action handling the object with greater care.
2.4	Remove the PS from the PC chassis	A7	Action is performed carelessly.	Component parts may get damaged, when this could have been avoided.		3D	Perform the action handling the object with greater care.
3	Selection of the PS	S2	The selection of the replacing part is performed incorrectly	Source can create a power overload and cause a short circuit, thus damaging the equipment entirely.		1B	Study carefully the characteristics of the part to be replaced.
4	Install new PS	A7	Connectors are installed incorrectly	The part doesn't work correctly, which may result in poor diagnosis or in another expense.		3C	Follow the directions included in the part. Study the power outlets and the cables available carefully. Understand thoroughly how the part works before installing it.

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DEVELOPMENT OF AN APP FOR THE LEARNING PROCESS OF CHILDREN WITH ADHD

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Resumen: Se desarrolló una Aplicación para dispositivos móviles Android que nos permitiera medir la carga mental, frustración y desempeño en niños con TDAH, evaluando la aplicación por medio del método NASA TLX, en esta primera etapa del proyecto solo se evaluó la actividad de reconocimiento auditivo y visual para el aprendizaje de los niños.

Con los resultados obtenidos, pudimos darnos cuenta que el nivel de carga mental es demasiado alto para los niños con TDAH, y que existe una correlación muy estrecha con su nivel de frustración debido a sus capacidades diferentes. Los resultados cualitativos en la utilización de esta aplicación son buenos, ya que refuerzan el aprendizaje dentro de su aula, así como el tener un mayor interés por las actividades de la App.

Palabras Claves: Ergonomía Cognitiva, Diseño, App, TDAH

Aportes a la Ergonomía: Provee información sobre el aprendizaje cognitivo, lo cual nos permite estimar la carga mental, así como conocer las variantes en la percepción visual y auditiva de conocimiento, aprendizaje, y limitaciones en la ejecución de tareas, para niños con TDAH.

Abstract: An application was developed for Android mobile devices that allows to measure the mental demand, frustration and performance of children with ADHD, assessing the application with NASA TLX method; at this first stage of the project the activities of auditory and visual recognition were evaluated for the learning process of the children.

With the gathered results, it was noticed that the mental demand is too high for children with ADHD and that there exists a tight correlation with the frustration grade due to their different abilities. The qualitative results in the usability of the application are good since they reinforce learning in the classroom, but also creates a greater interest for the activities of the application.

Key words: Cognitive Ergonomics, Design, App, ADHD

Contributions to Ergonomics: Providing information about the cognitive learning process, which allows to estimate the mental demand, then knowing the variables in visual and auditory perception of knowledge, learning, and limitations when performing the tasks, for children with ADHD.

1. INTRODUCTION

In the present project a cognitive ergonomics study aimed at describing the mental demand in the use of an educational application (App) for Android was carry out, which has eight activities where children with ADHD (Attention Deficit Hyperactivity Disorder) problems can interact and acquire knowledge through simple games and lessons of an initial level. This application will facilitate the activities carried out within the CAME study centers, in particular the one located in Moctezuma, Sonora.

For the evaluation of this study, the NASA TLX Method (Hart & Staveland, 1988) was used as a diagnostic tool for evaluating the mental demand factors during the completion of a task or manipulation of a system, since it is a multidimensional valuation procedure that gives an overall score of such mental demand.

Due to the characteristics that the children present, we found ourselves in a situation in which the performance of work demands a high level of attention and generates a level of frustration from the user (Arquer & Nogareda, 2000); it is important to highlight that children do not retain long-term information and their learning process consists in the repetition of knowledge.

GENERAL OBJECTIVE

Help in development and learning process of the educational programs of the Specialized Multiple Care Centers (CAME) though software with which children with different abilities, especially ADHD, can interact, acquire and reinforce their learning through games and ergonomic activities.

Scope:

Directed at children with different abilities, focused on ADHD, which in general include low attention, hyperactivity and impulsivity; therefore, this application aims to provide the child with content of their liking, adapted to their cognitive abilities to make learning easier by applying usability techniques from mental demand studies.

2. METHODOLOGY

For being an exploratory project it was defined to use the methodology of Rapid Prototyping of Applications (Ponce Mendoza, Yánez Moreno, & Soto Bernal, 2014) for the development of the application, since this will allow us to analyze in each iteration the new requirements of the projects. In this first iteration, it was agreed with CAME managers to develop a rapid intervention prototype that allows obtaining acceptance data in a short time. The requirements analysis was done through

surveys of the teachers working in the Multiple Care Center (CAME #18) of Moctezuma, Sonora, who defined the type, degree of difficulty and content of the activities. The architecture of the application is based on the model-view-controller (MVC), based on the Ionic Framework project structure, which is a platform for designing hybrid applications. Also, the interface design was made following the indications of colors, distribution and iconography suggested by CAME staff. The development of the application was made with the Ionic framework in a total period of a month.

The first study was carried out by applying the NASA TLX assessment to six children of CAME #18, in order to identify the levels of effort, performance and frustration when using the application. The NASA TLX evaluation table used is known as the **Raw Table**, since the weight of the demanding activities is not established by the participants in the study, but by an expert in the area (Sebastián Cárdenas, 2016). In our case, the person in charge of the group of children. Subsequently, the results were integrated into individual tables to generate the index that shows the correlation. The activities evaluated were “Identify Animals” which consists in the visual identification of the image of an animal and related in an auditory way with a representative sound. Likewise, a second activity (task) was evaluated with the association of vowel spellings and words that begin with it.

3. RESULTS

In interview with the Teacher in charge of the group of students under observation, the following qualitative results were obtained: a) Interest in the use of the App in the afternoon in the form of a reward at home was positive for all the students; b) The activities of the App positively reinforce the learning of the students in the CAME to favor the repetition of the activities seen in the classroom; and c) This application supports children with intellectual disabilities to improve the recognition of sounds as with images and identify figures, colors and letters.

The individual results of the application of the NASA TLX (Hart S. G., 2006) yielded the following measurement:

Table 1. Diego level of total mental demand: Medium

Variable	(a) Weight	(b) Grade	(c) Converted Grade (b x 5)	(d) Weighted Grade (c x a)
Mental Demand	5	2	10	50
Physical Demand	1	0	0	0
Temporal Demand	1	1	5	5
Performance	2	5	25	50
Effort	3	3	15	45
Frustration	3	1	5	15
TOTAL	15	12	60	**900**

Table 2. Francisco level of total mental demand: Medium

Variable	(a) Weight	(b) Grade	(c) Converted Grade (b x 5)	(d) Weighted Grade (c x a)
Mental Demand	5	3	15	75
Physical Demand	1	0	0	0
Temporal Demand	1	1	5	5
Performance	2	4	20	40
Effort	3	3	15	45
Frustration	3	0	0	0
TOTAL	15	11	55	825

Table 3. Brayan level of total mental demand: High

Variable	(a) Weight	(b) Grade	(c) Converted Grade (b x 5)	(d) Weighted Grade (c x a)
Mental Demand	5	2	10	50
Physical Demand	1	4	20	20
Temporal Demand	1	1	5	5
Performance	2	3	15	30
Effort	3	4	20	60
Frustration	3	0	0	0
TOTAL	15	14	70	1050

Table 4. Gabriel level of total mental demand: High

Variable	(a) Weight	(b) Grade	(c) Converted Grade (b x 5)	(d) Weighted Grade (c x a)
Mental Demand	5	4	20	100
Physical Demand	1	5	25	25
Temporal Demand	1	1	5	5
Performance	2	2	10	20
Effort	3	5	25	75
Frustration	3	4	20	60
TOTAL	15	21	105	1575

Table 5. Allison level of total mental demand: High

Variable	(a) Weight	(b) Grade	(c) Converted Grade (b x 5)	(d) Weighted Grade (c x a)
Mental Demand	5	4	20	100
Physical Demand	1	5	25	25
Temporal Demand	1	1	5	5
Performance	2	2	10	20
Effort	3	5	25	75
Frustration	3	1	5	15
TOTAL	15	18	90	1350

Table 6. Jesús level of total mental demand: Medium

Variable	(a) Weight	(b) Grade	(c) Converted Grade (b x 5)	(d) Weighted Grade (c x a)
Mental Demand	5	5	25	125
Physical Demand	1	1	5	5
Temporal Demand	1	5	25	25
Performance	2	5	25	50
Effort	3	2	10	30
Frustration	3	1	5	15
TOTAL	15	19	95	1425

The delivery of the prototype was made in APK installation file to perform the acceptance and improvement tests of the same application, staying as future work to redesign the application based on the results of the tests indicated in this document. The App interface has eight categories using sounds, figures, and colors, which allow the level of stress of the user to decrease significantly, obtaining learning while having fun.

4. **CONCLUSIONS**

a) For the heterogeneous characteristics of the children evaluated, it is not possible to perform general statistics.

b) It is possible that there is a direct relationship between the condition that presents the child and the mental demand that can be tolerated in the use of the App.

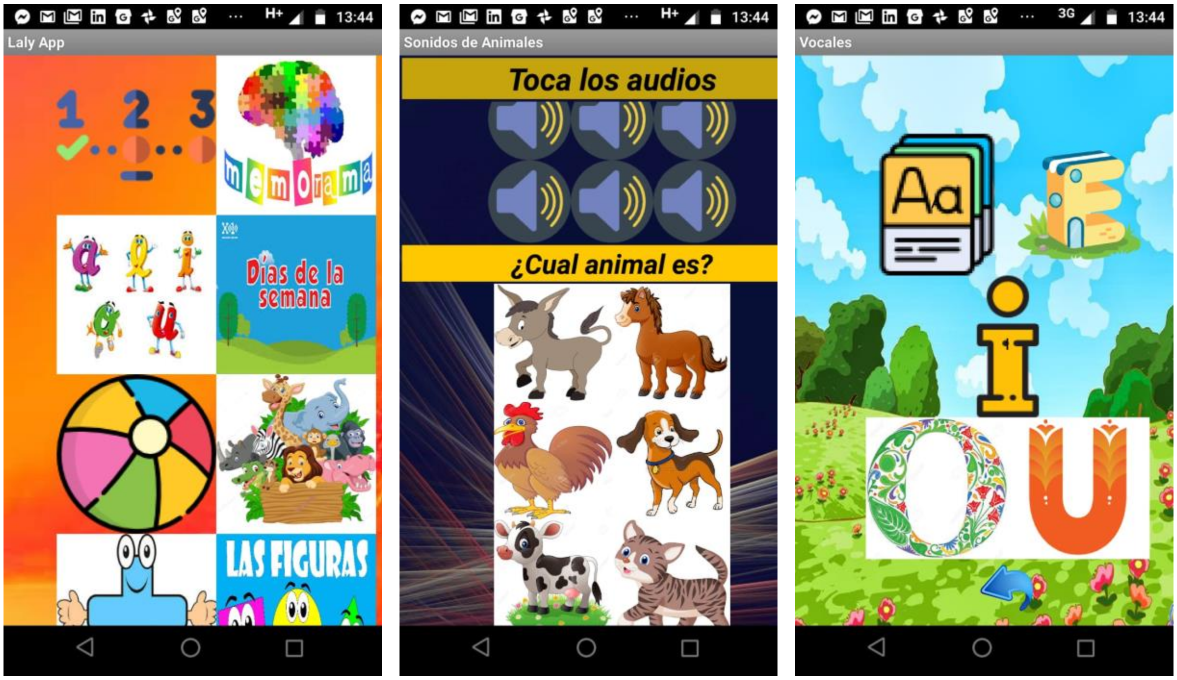

Figure 1. Screenshots of the App, from Left to Right the a) main menu is shown, b) auditory and visual recognition activity and c) Graphic recognition activity.

c) The application requires the addition of visual examples in each of the activities to reduce the initial frustration of not knowing the operation of the selected activity.

d) The NASA TLX tool (Sebastián Cárdenas, 2016) is suitable for the mental demand measurement. It is necessary to increase the size of the simple to identify particularities between each disability or discard differences among them.

e) According to the recommendations issued by the person in charge of the group and the results of the measurements, modifications will be made to the App to favor a low level of cognitive demand in its operation.

f) The use of an App to reinforce learning in children with different abilities supports their retention capacity and eases teaching, by being included as a tool based on cognitive ergonomics and providing an alternative that does not require learning new skills for its use.

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HUMAN ERROR REDUCTION IN SETTING UP FUSED FILAMENT FABRICATION EQUIPMENT

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Resumen: El Modelado por Deposición Fundida (MDF) o Fabricación por Filamento Fundido (FFF) es una de las tecnologías la Manufactura Aditiva (MA) con mayor demanda. FFF presenta un inminente crecimiento en su uso debido a la disponibilidad de diversos modelos en el mercado, el bajo costo, y el bajo nivel de complejidad de operación. Con el incremento de usuarios asociados a la FFF, surge la necesidad de evaluar el impacto del uso de esta por el ser humano durante actividades de preparación de equipo o pre procesos, procesos, y pos procesos. El objetivo del presente capitulo fue evaluar el error humano generado por la tarea de preparación de equipo de impresión FFF. Las actividades que integraron la tarea fueron, conexión del equipo a terminal eléctrica, encendido del equipo, nivelación de la cama de impresión, precalentamiento del equipo y alimentación de material. Se integró un grupo de diez participantes, los cuales demostraron tener experiencia en el manejo de los equipos de FFF ya que participan como ayudantes de investigación en los laboratorios de prototipado y diseño ergonómico de la UACJ. La metodología empleada se integró en cuatro fases; 1) análisis jerárquico de la tarea, 2) predicción del error humano por medio del enfoque SHERPA, 3) Cuantificación de los errores, y 4) análisis de resultados. En enfoque SHERPA permitió clasificar 59 errores humanos, de los cuales el 32 fueron errores de acción, 11 errores relacionados al proceso de revisión, se identificaron 3 errores más del tipo de retroalimentación, así como 13 errores de selección. Con base en los resultados obtenidos, se concluye que el enfoque SHERPA facilita la identificación de errores durante la ejecución de una tarea, esto permite proponer modificaciones a los equipos para reducir los errores y mejorar los equipos o sistemas de FFF.

Palabras clave: SHERPA, equipos de Fabricación por Filamento Fundido, preparación de equipo.

Relevancia para la ergonomía: La información obtenida presenta un análisis del conjunto de errores humanos asociados al uso de FFF desde la perspectiva del método de identificación de error humano.

Abstract: Fused Deposition Modeling (FDM) or Fused Filament Fabrication (FFF) is one of the most popular Additive Manufacturing (AM) technologies. FFF is increasing because it is a low-cost technology, has low complex operation level, and exists a vast variety of models in the market. Whit the increase of users of FFF, emerges the necessity to evaluate the impact of the human factor in pre-process, process and post-process tasks. The objective of this chapter was to evaluate the human error generated by the tasks of setting up FFF equipment before the printing process. The activities associated with the task were; connection of the equipment to the electrical terminal, turn on the equipment, leveling of printing bed, preheating of the equipment, and feeding of material. A group of ten participants was integrated. Each participant had experience using FFF printers, due that they develop activities of prototyping in ergonomic design lab and prototyping lab in UACJ. The methodology integrates four stages: 1) hierarchical analysis task (HTA), 2) Systematic Human Error Reduction and Prediction Approach (SHERPA), 3) error quantification, and 4) analysis results. The SHERPA approach allowed to classify 59 human errors, of which 32 were of action type, 11 associated with checking errors, 13 classified as a selection. SHERPA approach is a useful methodology to classify and identify human errors generated during a task(s); this approach allows to propose changes in equipment focused on reducer human error and improve FFF equipment.

Keywords: SHERPA, Fused Filament Fabrication equipment, setting up equipment task.

Relevance to Ergonomics: The information obtained presents an analysis of human error linked with FFF, from the perspective of SHERPA methodology.

1. INTRODUCTION

Additive Manufacturing (AM) or 3D printing, have been changing the manufacturing world. This change has been affecting technologies, materials, process, abilities, and knowledge of people involved in the process, and also it has changed the environment of work (Kalpakjian y Schmid 2014). AM printing has been used as an alternative to developing research, to generate production in low scale, and prototyping (Aguilar-Duque, Hernandez-Arellano, Avelar-Sosa, Amaya-Parra, & Tamayo-Perez, 2019). AM is a further alternative of employment with more than 133 million jobs for 2022 (Polli, 2018). This projection represents the opportunity to develop strategies of protection for the people that will be, directly or indirectly, involved with AM for 2022 (Wagner, Dainty, Hague, Tuck, & Ong, 2008). As a consequence of AM projected demand, ergonomics should play an essential role in the protection of users, across the analysis of workstations, ergonomic design, cognitive ergonomics, human errors, workload, etc., all of them associated with the human-machine interaction.

Due that the interest of the research exposed in this chapter is focused on the human error; Systematic Human Error Reduction and Prediction Approach (SHERPA) was selected because it has been used widely to approach the human error of many tasks. SHERPA has been considered as a generic approach and can be applied in any domain involving human activity (Neville Stanton, Hedge, Brookhuis, Salas, & Hendrick, 2005). There are many success cases of SHERPA analysis. For example, Murphy et al. (2018) analyses a medical procedure in Kenia were medical personnel and mothers of family were include to determine the human error that participants (mothers) generate during their participation, allowing propose training strategies to eliminate or minimize these errors. In industry, Di Pasquale, Miranda, Iannone, & Riemma (2015) present an analysis of simulation tools based on SHERPA to determinate and classify the human error. The relevance of this analysis radicates in the integration of simulation tools to evaluate human performance in real environments.

Because this technology will increase significantly in the next years, the opportunity to improve designs and reduce human error is open. The relevance of this study radicates in the Systematic Human Error Reduction and the Prediction Approach over setting up FFF equipment.

2. OBJECTIVES

The objectives of the present chapter were three:

- Identify the set of tasks and sub-tasks related to the setup of FFF equipment.
- Qualitatively and quantitatively evaluate the reliability of users of basic filament printers during the start-up of the equipment.
- Define the set of errors and their effect on the preparation process of FFF printing equipment.

3. METHODOLOGY

3.1 Study design

The study considered as a first phase, the selection of participants under the only restriction of experience (at least one year working with FFF equipment). The second activity was the training over the task to develop. Using the observational method, the analyst registers all the human errors presented during the development of the task. SHERPA was used to classify the human errors identified.

3.2 Sample

For the study, there were used two models of FFF equipment (Prusa I3 and Ultimaker). Eight men and two women integrated the group of participants.

3.3 Methods

The methodology used in the present chapter was developed in four phases. The first one was the Hierarchical Task Analysis (HTA); the second one was an approach with SHERPA, the third was error quantification, and the fourth was to analyze the results obtained by the SHERPA. Figure 1 presents a flow chart of the methodology used in the present research. HTA and SHERPA have their methodology; those methodologies are described after Figure 1.

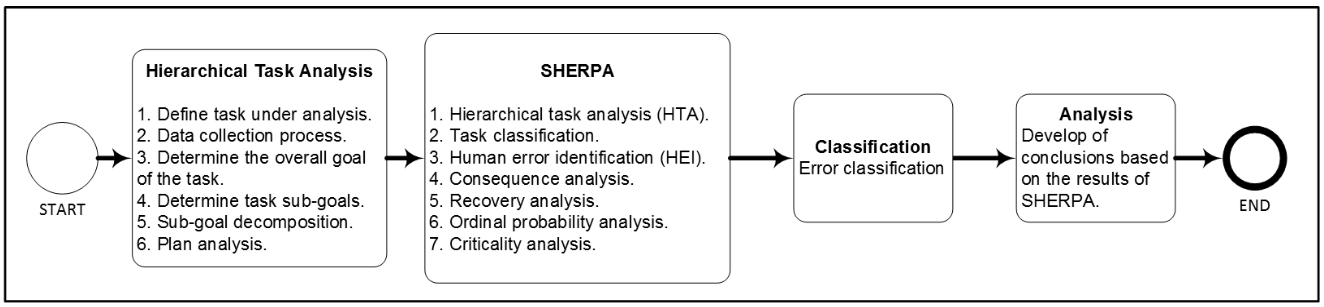

Figure 1. Flowchart of the methodology used approach the human error in setting up FDM or FFF equipment.

3.3.1 Hierarchical Analysis Task (HTA) is a task analysis method that describes the activity under analysis in terms of a hierarchy of goals, sub-goals, operations and plans (Stanton, 2006). The description of each step that integrates the methodology is defined as follows is presented:

Step 1. Define task under analysis. This step is focused on clearly define the task(s) under analysis. As well as the purpose of the task.

Step 2. Data collection process. Data regarding the task steps involved, the technology used, the interaction between man and machine and team members, decision making and tasks constraints.

Step 3. Determine the overall goal of the task. The goal should be specified at the top of the hierarchy; this enouncement describes the task in general.

Step 4. Determine task sub-goals. In this step, the goal should be broken down into meaningful sub-goals, which together for the tasks required achieving the overall goal.

Step 5. Sub-goal decomposition. The analyst breaks down the sub-goals identified in the last step; this process should go until an appropriate operation is reached.

Step 6. Plans analysis. Plans analyses dictate how the goals are achieved. Sequences of activities are deployed in this step.

3.3.2 Systematic Human Error Reduction and Prediction Approach (SHERPA) comprises of an error mode taxonomy linked to a behavioral taxonomy and is applied to an HTA of a task under analysis in order to predict potential human or design induced error (Neville Stanton, Hedge, Brookhuis, Salas, & Hendrick, 2005). The procedure is described below:

Step 1. Hierarchical Task Analysis. This step describes the task or scenario under analysis.

Step 2. Task classification. The analysis should take the first (or next) bottom level task step in HTA and classify it according to SHERPA behavior taxonomy. Action (A), retrieval (R), checking (C), selection (S), and communication (I).

Step 3. Human error identification. In this step, it is necessary to use the associated error mode taxonomy and domain expertise to determine any credible error makes for the task in question.

Step 4.Consequence analysis. This step involves determining and describing the consequences associated with the errors identified in step 3.

Step 5. Recovery analysis. The analysis should determine the recovery potential of the identified error.

Step 6. Ordinal probability analysis. Once de consequence and recovery potential of the error has been identified, the analysis should rate the probability of the error occurring.

Step 7. Criticality analysis. In this step, the analyst rates the criticality of the error in question. A scale of low, medium and high is also used to rate error criticality. Usually, if the error would lead to a critical incident, then it is rated as a highly critical error.

Step 8. Remedy analysis. The final stage in the process is to propose error reduction strategies. Those strategies propose remedial measures to changes the design of the process or system.

The task under analysis consists of setting up Fused Filament Fabrication equipment. Most of the FFF have the same principles of operation. For this reason, it is possible to generalize the procedure of setup. The first step was to verify that the equipment was plugged to the electrical terminal and turned on pressing the power button or turning the knob (depending on the model). Figure 2 shows the position of the button and knob of the two models of FFF equipment. Once that the equipment is turned on, the next step was to verify that the printing bed was leveled. A leveling bed is essential for the correct printing process; an uneven bed is the principal cause of defects and waste of time.

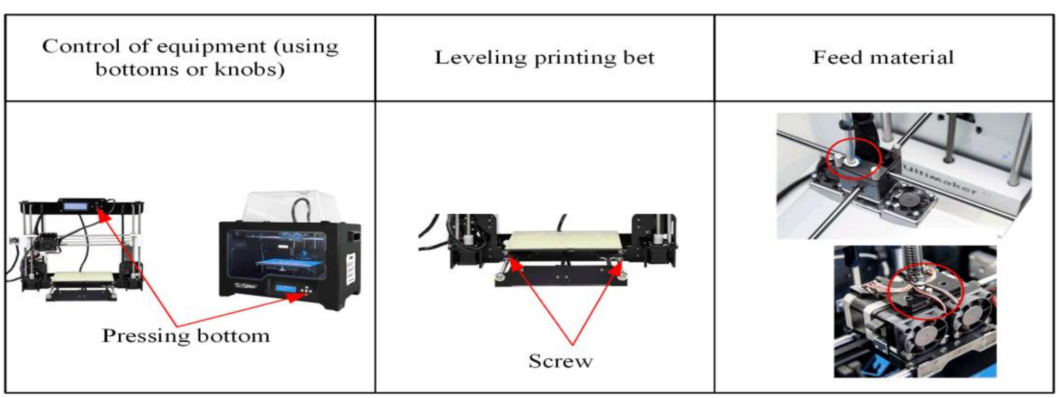

Figure 2. Characteristics of some FFF equipment

4. RESULTS

To achieve the objectives of the present chapter was necessary to define the characteristics of the volunteer's group, the task under analysis, the results obtained by SHERPA approach, and finally the description of the findings.

Many of the models of FFF have electronic futures for leveling; these features only work to determinate and adjust the distance between bed leveling and extruder, so the leveling of the bed should be done by hand. The leveling bed consists of making a precisely adjust of the printing bed using the screws leveling located under the printing bed (see Figure 2). Once the leveling was achieved, the next step was to verify that the motors of the equipment were working correctly. If motors were working, the next step was to preheat the extruder and the printing bed to evaluate the capacity of the equipment to get the ideal temperatures. When the equipment was ready, the next step was to feed with material the extruder. This activity consisted of insert the filament inside the extruder and lined up it across the equipment. Feed the material correctly, allows to material flow without problems during the printing process. The setting up process ends, when the equipment is ready to receive information about the model to print. Following the methodology proposed in this chapter, the HTA is presented in Figure 3.

The information of Table 1 synthesizes the number and type of errors identified. From 59 errors, 32 of them were action errors, 11 were of classified as checking errors, three were classified as retrieval and 13 were of selection errors.

The most critical action error was associated with the right operation on the wrong object. This error is generated by the design of the device because the operation is developed when the user presses one bottom. This moment is when the confusion happens due that the user has to decide between five options. The second most important action error is type A6; these errors were generated by doing the right operation on the wrong object. This error was defined when the participants try to leveling the printing bed from a specific side using the wrong screw.

From the selection error class, it is remarkable that 12 errors were of the type of wrong selection made (S2). This error is linked with the action error, where the options to operate the equipment makes confuse at the moment to operate it. FFF bottom models have five operation bottoms, in almost all the cases, participants press the wrong bottom, thinking that it was the bottom that allows executing the operation desired.

5. CONCLUSIONS

AM is a fast-growing technology, this evolution opens the opportunity to create objects and products that already exist in the market. This technology uses a principle of control via different interfaces. The interaction of humans with this technology is associated with the control of the equipment, the interchange of information, and the high possibility to generate human errors during the operation.

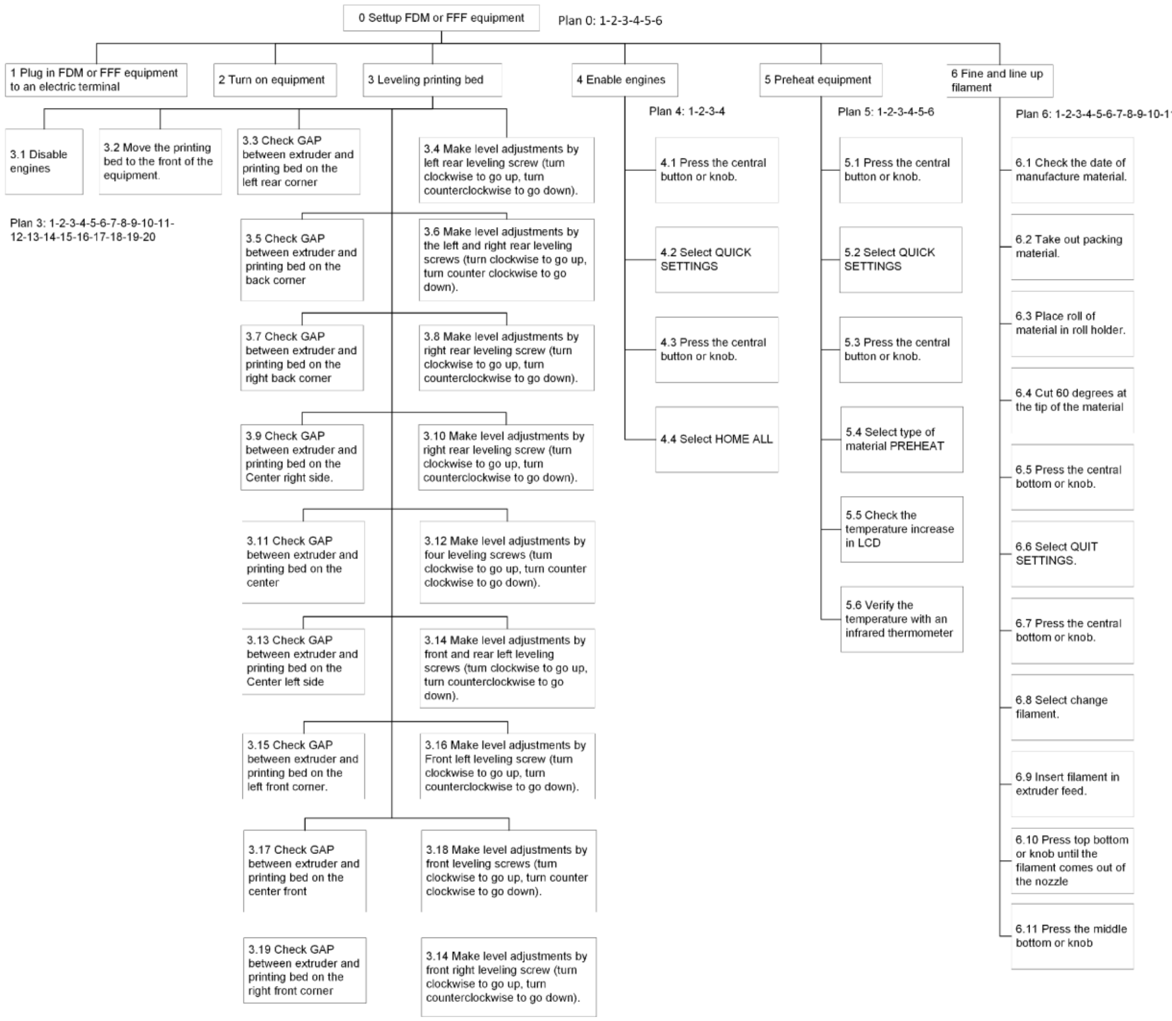

Figure 3. HTA for setting up FFF equipment.

Table 1. SHERPA for setting up FDM or FFF 3d printers.

TS	EM	Error description	Consequence	R	P	C	Remedial strategy
3.1	A8	Fail to disable engines.	The printing bed is blocked.	I	M	L	Display in LCD engines enable.
3.2	A9	Printing bed away from the front edge.	The printing bed is under extruder.	I	L	L	Display green light when the bed is in position.
3.3, 3.5, 3.7, 3.9, 3.11,	A1	Displacement of the tool between printing bed and extruder.	Incorrect GAP	I	M	M	Establish a repetition procedure.

3.13, 3.15, 3.17, and 3.19	A8	It does not perform the displacement operation correctly.	Incorrect GAP	I	L	L	Make verification test.
	C2	Check the adjustment incomplete.	Incorrect height	I	M	M	Establish a repetition procedure.
	C5	Check a different point than indicated.	Bed not leveled	I	H	H	Define the sequence of checkpoints.
	R2	Think that the GAP is correct	Bed not leveled	I	L	L	Tool calibration.
3.4, 3.6, 3.8, 3.10, 3.12, 3.14, 3.16, 3.18, and 3.20	A1	Screw or unscrew.	Improper curling	N	H	H	Print bed adjustment training.
	A3	Wrong turn for adjustment.	Wrong leveled	N	H	H	Develop visual help.
	A6	Adjustment of other screw leveling.	Wrong leveled	N	L	L	Print bed adjustment training.
4.1	A4	Inconsistent number of times that pressure the button or knob	Disable erroneous menu	I	H	H	Software management.
	A6	Push the wrong button, or option.	Disable erroneous menu	I	H	H	Software management.
	S2	Wrong selection on the menu option	Disable erroneous menu	I	H	H	Software management.
4.2	C5	Select the wrong option.	Access to other apps.	I	L	L	Software management.
	S2	Wrong option	Menu error	I	L	L	Software management.
4.3	A4	Inconsistent number of times that pressure the button or knob	Disable erroneous menu	I	H	H	Software management.
	A6	Push the wrong button, or option.	Disable erroneous menu	I	H	H	Software management.
	S2	Wrong selection on the menu option	Disable erroneous menu	I	H	H	Software management.
4.4	A4	Inconsistent number of times that pressure the button or knob	Disable erroneous menu	I	H	H	Software management.
	A6	Push the wrong button, or option.	Disable erroneous menu	I	H	H	Software management.
5.1	A4	Inconsistent number of times that pressure the button or knob	Disable erroneous menu	I	H	H	Software management.
	A6	Push the wrong button, or option.	Disable erroneous menu	I	H	H	Software management.
	S2	Wrong selection on the menu option	Disable erroneous menu	I	H	H	Software management.
5.2	C5	Select the wrong option.	Access to other apps.	I	L	L	Software management.
	S2	Wrong option	Menu error	I	L	L	Software management.
5.3	A4	Inconsistent number of times that pressure the button or knob	Disable erroneous menu	I	H	H	Software management.
	A6	Push the wrong button, or option.	Disable erroneous menu	I	H	H	Software management.
	S2	Wrong selection on the menu option	Disable erroneous menu	I	H	H	Software management.
5.4	A2	Select the wrong option of preheating material.	It is overheating of material or material clogging due to lack of heating.	N	M	H	Double check of material selection.
	C1	Check of temperatures specified in the pack, omitted.	It is overheating of material or material clogging due to lack of heating.	N	L	L	Software management.
	S2	Selection of the wrong option.	It is overheating of material or material clogging due to lack of heating.	N	L	L	Software management.
5.5	A2	Does not remember the specification of material.	It is overheating of material or material clogging due to lack of heating.	N	L	L	Tracking the temperature increase in LCD

	C1	Does not check the LCD	The temperature does not increase	I	M	M	Poka-Yoke of LCD check.
	R3	The information display by the LCD is wrong	The temperature of printing bed and extruder do not change.	I	L	L	Ensure equipment operation by TPM register.
5.6	A2	Does not where to point the light of thermometer	The user does not assure the temperature for operation.	N	M	M	Procedure training
	A5	Misalign temperature between extruder and printing bed.	A wrong check of temperature	N	L	L	Procedure training
	A6	The user does not point on the object.	Measure the temperature of another object	N	L	L	Procedure training
	A8	Forgot to measure the temperature of extruder and printing bed.	The user does not validate temperature of elemental parts of equipment.	N	L	L	Procedure training
	C2	Check incomplete	Check only extruder or printing bed.	N	L	L	Procedure training
6.1	R2	Wrong information obtained	Use of material in adverse conditions.	N	M	M	Assure that material is packing and repacking correctly.
6.3	A3	Wrong placement of coil.	Increase traction during unwinding of material	I	M	M	Poka-Yoke of coil placement.
6.4	A1	Wrong cut	Difficulty inserting material in the extruder	I	M	M	Procedure training
	A8	Does not cut material	Difficulty inserting material in the extruder	I	M	M	Procedure training
6.5	A4	Inconsistent number of times that pressure the button or knob	Disable erroneous menu	I	H	H	Software management.
	A6	Push the wrong button, or option.	Disable erroneous menu	I	H	H	Software management.
	S2	Wrong selection on the menu option	Disable erroneous menu	I	H	H	Software management.
6.6	C5	Select the wrong option.	Access to other apps.	I	L	L	Software management.
	S2	Wrong option	Menu error	I	L	L	Software management.
6.7	A4	Inconsistent number of times that pressure the button or knob	Disable erroneous menu	I	H	H	Software management.
	A6	Push the wrong button, or option.	Disable erroneous menu	I	H	H	Software management.
	S2	Wrong selection on the menu option	Disable erroneous menu	I	H	H	Software management.
6.8	C5	Select the wrong option.	Access to other apps.	I	L	L	Software management.
	S2	Wrong option	Menu error	I	L	L	Software management.
6.9	A6	Wrong placement of the filament	Cannot insert the filament into the extruder	I	M	M	Poka-Yoke for hole extruder
	A9	Does not entirely insert the filament	Filament does not advance	I	H	H	Procedure training
6.10	C5	Select the wrong option.	Access to other apps.	I	L	L	Software management.
	S2	Wrong option	Menu error	I	L	L	Software management.
6.11	C5	Select the wrong option.	Access to other apps.	I	L	L	Software management.
	S2	Wrong option	Menu error	I	L	L	Software management.

This chapter aimed to approach the human error generated by the task of setting up FFF equipment. This type of equipment is the most common technology of AM, as a consequence is available in the market. Although the operation is not as smooth as the users suppose, the use of SHERPA enables us to identify 59 human errors. It is remarkable that these errors have a potential effect during the printing process, and could be identified until the process began, producing a significant waste of time during the printing process.

The highest number of errors were action errors. It supposes that the design of the equipment, the design of the procedure, and the design of the software represents an opportunity to improve the equipment. Many of the equipment available for users do not have manuals of operations. For this reason, many of the users make the same mistakes during the setup of the equipment.

Finally, it is essential to mention that the use of SHERPA allows to identify and classify the human errors of the setting up the task. Let it open the opportunity to use other human error methods to evaluate this task, and create a robust evaluation of the task associated with the 3D printing process.

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DIFFERENT EQUATIONS USED DURING THE MENTAL WORKLOAD EVALUATION APPLYING THE NASA-TLX METHOD

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Resumen: Los objetivos de la investigación fueron identificar las diferentes ecuaciones utilizadas durante la evaluación de la carga de trabajo mental con el Índice de carga de tareas de la NASA (TLX) y comparar los resultados obtenidos con las diferentes ecuaciones. Se realizó una encuesta de 21 preguntas a 30 estudiantes de la Universidad Autónoma de Ciudad Juárez. Se encontraron cuatro ecuaciones diferentes. Las puntuaciones de las dimensiones y el Índice de carga de trabajo global (ICTG) mostraron diferencias aparentes en los resultados entre las ecuaciones empleadas en esta investigación.

Abstract: The objectives of the research were to identify the different equations used during the evaluation of mental workload with the NASA Task Load Index (TLX) and to compare the results achieved with the different equations. A survey consisted of 21 questions was administered to 120 students from the Autonomous University of Ciudad Juarez using the four different equations identified. The scores of the dimensions and the Global Workload Index (GWI) showed differences in the results between the equations employed in this research.

Keywords: Ergonomics, workload, mental, method, NASA-TLX.

Relevance for ergonomics: This research showed a comparison of different equations used in mental workload evaluation when the NASA-TLX method is used. which serves to other people for obtaining results when performing evaluations with the method used. The publication of this article would help future investigations where the NASA-TLX method is used for the use of different equations depending on the case to apply it.

1. INTRODUCTION

Modern technology has involved changes in industrial work, especially in decision making involving mental workload (Demands & De, 2018). Mental workload is investigated in ergonomics and human factors and represents a topic of increasing importance (Ayaz et al., 2012). In working environments, high cognitive demands are imposed on operators, while physical demands have decreased. Understand how the mental workload impacts on performance is becoming more critical (Young, Brookhuis, Wickens, & Hancock, 2015).

Due to high levels of mental charge, stress levels are generated that in addition to affecting the worker's performance, affect productivity and these effects can be causes of occupational stress, as well as health problems (Arce & Silvia, 2012). This stress is shown in the physiological plane altering indexes such as the reactivity of the heart rate and the increase in blood pressure. At the behavioral level, the effects of stress are revealed in problems of smoking, alcoholism, drug abuse, antisocial and aggressive acts, which leads to a possible tendency to accidents and errors, as well as problems of relationships at work (González Muños & Gutiérrez Martinez, 2006).

During the assessment of mental workload using the method NASA-TLX, there are equations that can be used to facilitate the use of this method, allowing software supported a quick evaluation. The equations explained in this research was from the following authors: Şeker (2014), NASA (1986), and Enríquez (2018). The equations that can be used have differences between them, from a variety of scales used in scores, using the amount resulting from multiplications of data and equations that with non-stop results.

This article will explain the different equations employed with the method NASA-TLX, showing the scores and comparing the results of the Global Workload Index obtained with the different equations.

2. OBJECTIVES

The objectives of this research are 1) through a literature review, identify the different equations used to determine the global workload index, and 2) compare the results of the Global Workload Index obtained with the different equations.

3. METHODOLOGY

3.1 Study design

This research is a longitudinal study, using a sample of 120 students from the Autonomous University of Ciudad Juárez in the Institute of Engineering and Technology.

3.1 Identification of Equations

The identification of the equations used in the method NASA-TLX arises from a bibliographic review in scientific databases such as SciFinder, ScienceDirect, SciELO, Dialnet, Sage Journals, Research Gate, MDPI, etc. The keywords used were: "Method, ergonomics, mental, cognitive, study, workload, evaluation, NASA-

TLX" during the search of methods selecting the area of knowledge of ergonomics – human factor, where different publications were found, as well quotations used in useful articles for this research.

3.2 NASA TLX METHOD

NASA-Task Load Index (TLX). This procedure developed by Hart & Staveland (1988) distinguishes six dimensions of mental load (mental demand, physical demand, temporal demand, yield, effort, and level of frustration), from which it calculates a global index of mental load. In various laboratory investigations, it has been proven that it is sensitive to a variety of tasks and that each of the six subscales provides independent information about its structure.

The application of this instrument is carried out in two phases: a weighting phase, at the time prior to the execution of the task and another phase immediately after the execution, called the scoring phase. It Is part of the base that the specific sources of load imposed by the different tasks are determinant in the experience of load and the subjective feeling of load, therefore the prerequisite is that the subjects themselves make a weighting in order to determinate the extent to which each of the six factors contributes to the burden on each specific task or subtask.

The objective of this phase is to define the load sources. It consists in presenting to the people the definitions of each one of the dimensions in order to compare them by pairs (binary compares) and choose for each pair, which is the element that is perceived as a greater source of the load. From this election you get a weight for each dimension, depending on the number of times you have been chosen.

These weights can take values between 0 (for the dimension that has not been chosen on any occasion and therefore is not considered relevant) and 5 (for the dimension that has always been chosen and therefore is the most important source of charge). The same set of weights can be used for variations of the same task or for a group of subtasks. In Addition, the weights give diagnostic information about the nature of the workload imposed by the task as they provide data about two sources of interpersonal variability:

A. The interpersonal differences in the definition of the workload in each task considered.

B. Differences in workload sources between different tasks. The second requirement is to award value for each factor, which represents the magnitude of each factor in a given task.

In this scoring phase, people value the task or subtask they have just done in each of the dimensions, marking a point on the scale presented to them. Each factor is presented in a line divided into 20 equal intervals (a score that is reconverted to a scale over 100) and bipolarly limited by some descriptors (for example: high/low and bearing in mind the definitions of the dimensions.

One of the main advantages of this method is its applicability in the real labor framework as people can directly and quickly rate the task done either right after its execution or retrospectively. A video recording can be useful to improve the memory of the activity, stop if necessary, in each segment of the task. In experiences carried out on retrospective valuations, it has been found that there is a high correlation between the data obtained and the scores obtained in a way Immediate (from Archer & Nogare, 2001).

3.2 Data Collection

The data were obtained with the application of a survey for the assessment of workload and school fatigue applied to students of the Autonomous University of Ciudad Juárez in the Institute of Engineering and Technology. A mental load questionnaire consisting of 21 items was applied in two stages. This research carried out in Ciudad Juárez, Chihuahua, México, is limited the evaluation of tasks where there is a mental workload of through, Hypothetical cases where equations will be used exclusively for the NASA-TLX method and as a support for research in articles, conference reports and book chapters.

3.3 Obtaining the Different Global Workload Indexes

The survey evaluates the 6 dimensions of the NASA-TLX method (mental demand, physical demand, temporary pressure, effort, performance, frustration), where people evaluate and get a score. Continue to ask the evaluated person the 15 binary combinations where the weight is obtained for each dimension evaluated. It performs the multiplication of the score x 100 and divided by 20 to obtain a score converted from the dimensions, to multiply the weight of each dimension by the score converted resulting in the weighted score. Finally, the sum of the values of the weighted score is made, divided by 15 and the value obtained is the global index of workload, which depending on its value will tell us the level of mental load of the evaluation performed.

3.4 Data Analysis

To Verify the reliability of the NASA-TLX method, the Alpha coefficient of Cronbach was calculated for the total scale. For the deep analysis of data and to be able to find differences between the profiles of mental load, an Analysis of Variance (ANOVA) was elaborated with the 6 dimensions evaluated of the method (Barbara G. Tabachnick, 2001).

4. RESULTS

4.1 Equations

Table 1 shows four different formulas identified, the author and the year of use.

Table 1. Equations identified

Author	Year	Equation
(Hart & Staveland, 1988)	1988	Equation 1 - 2

Alper Şeker	2014	Equation 3
Enríquez	2018	Equation 4

Equation 1 NASA-TLX

$$\frac{\sum_{i=1}^{6} Ci}{15} = \frac{\sum_{i=1}^{6}(a\ x\ b)}{15} \qquad (1)$$

Where
Ci: Weighted score
a: Weight
b: Raw rating
15 Number of binaries comparisons

Equation 2 NASA-TLX

$$IC = \frac{(\sum pi\ x\ Xi)}{15} \qquad (2)$$

Where:

- IC Load Index
- Pi Weight obtained for each dimension in the binary table (weighting)
- Xi Score obtained by the dimension in the evaluation stage

Equation 3 Unweighted Score

$$IC = \frac{(\sum pi\ x\ 100\ )}{30} \qquad (3)$$

Where:

- IC Load Index
- Pi Weight obtained for each dimension in the binary table (weighting)

Equation 4 Scale assessment (Scale 5) NASA-TLX

$$IC = \frac{(\sum pi\ x\ Xi\ x\ 5)}{15} \qquad (4)$$

Where:

- IC Load Index
- Pi Weight obtained for each dimension in the binary table (weighting)
- Xi Score obtained by the dimension in the evaluation stage multiplied by five

4.2 Comparative

Table 2 presents the results of the application of the four equations using data from 30 students.

Table 2. Results of the Global Workload Index among 30 students.

Global Workload Index			
Equation 1	**Equation 2**	**Equation 3**	**Equation 4**
92.00	80	160	23.00
82.67	76.66	153.33	20.67
80.00	70	140	20.00
49.33	46.66	93.33	12.33
76.00	66.66	133.33	19.00
68.00	66.66	133.33	17.00
64.00	53.33	106.66	16.00
80.00	70	140	20.00
76.00	66.66	133.33	19.00
50.67	46.66	93.33	12.67
84.00	73.33	146.66	21.00
62.67	60	120	15.67
80.00	76.6	153.33	20.00
84.00	70	140	21.00
50.67	56.66	113.33	12.67
86.67	73.33	146.66	21.67
74.67	63.33	126.66	18.67
81.33	80	160	20.33
70.67	60	120	17.67
88.00	80	160	22.00
77.33	66.66	133.33	19.33
82.67	76.66	153.33	20.67
74.67	73.33	146.66	18.67
66.67	63.33	126.66	16.67
85.33	73.33	146.66	21.33
65.33	56.66	113.33	16.33
90.67	80	160	22.67
86.67	80	160	21.67
57.33	63.33	126.66	14.33
80.00	60	120	20.00

5. CONCLUSIONS

Visual comparison of the results from the four different formulas identified showed apparent differences. Because the results are not deployed on the same scale, a statistical comparison is not possible without the development of data transformation. The use of data from students allowed to get a first approach to explore more about a gold standard method to evaluate workload among different work environments.

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CONTRIBUTIONS OF METHODOLOGY TO ERGONOMICS APPLIED TO INDUSTRIAL DESIGN.

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Resumen. Este artículo presenta el inicio de una investigación cuyo propósito es destacar que en la mayor parte de la práctica profesional en nuestro país no se consideran los factores ergonómicos tan importantes como los aspectos de creatividad, originalidad o crear valor en los productos. La Ergonomía no se considera como un elemento central en el desarrollo de los proyectos ni se menciona abiertamente como un factor esencial. Por otra parte, se reflexiona sobre el interés que ha surgido, desde hace varios años, entre los diseñadores por conocer nuevos métodos de diseño para obtener resultados diferentes y novedosos; sin embargo, se manifiesta la falta de conocimiento pertinente sobre la Ergonomía aunque se menciona el propósito de atender los aspectos funcionales de los productos, su relación con los usuarios y la evaluación con modelos intermedios y/o prototipos rápidos. Por otro lado, se sabe del ambiente de presión que afrontan los diseñadores para ofrecer respuesta rápida a las continuas exigencias que se presentan en el mercado laboral lo cual les impide conocer los métodos recientes para actualizarse y poder encontrar la solución a los problemas relacionados con las nuevas inquietudes y necesidades de grupos específicos, y para ello recurren a información difundida en diversos medios. Actualmente es notorio que en la promoción de muchos productos en el mercado ya no se destacan los factores ergonómicos, sino que predominan expresiones sobre la experiencia, la emoción y otros atributos ambiguos como comodidad y seguridad que un producto puede ofrecer al usuario. Por ello, en el ámbito académico se debe despertar el interés de los estudiantes de diseño para que se acerquen y profundicen en temas relacionados con la ergonomía sustentados en métodos y/o técnicas que faciliten su comprensión y aplicación sin demeritar el rigor requerido para lograrlo.

Esta es una investigación de naturaleza académica que tiene como antecedente la investigación ergonómica aplicada al diseño industrial, tomando en consideración que la ergonomía es multidisciplinaria cuyos fundamentos derivan de ciencias y técnicas diversas. De ahí que se requiere organizarlos con base en las etapas del proceso de diseño, que se explica en los planes de estudio de la licenciatura en Diseño Industrial. Se8 presenta una revisión documental de diferentes métodos y técnicas de diseño y de ergonomía aplicada organizados en categorías, así como las sugerencias para aplicarlos en cada una de las etapas del proceso de diseño.

Se pretende generar un compendio de los métodos y técnicas de ergonomía aplicada al diseño industrial, con ejemplos que correspondan con las diferentes etapas del proceso proyectual: Análisis, Síntesis, Realización y Evaluación (Plan de Estudios de Diseño Industrial, 2002). Como meta final se propone la difusión de este documento entre la comunidad de diseño, en diferentes foros.

Palabras clave: Ergonomía, Diseño industrial, métodos.

Relevancia para la ergonomía: Al proponer ejemplos de algunos métodos idóneos como base para formular requerimientos ergonómicos en el diseño de objetos, sistemas y/o servicios, en los cuales se destaque la importancia de esta disciplina y su relación con el logro de resultados originales que se difundirán entre la comunidad de diseñadores. La importancia que adquiere el resultado de esta investigación documental es de interés para estudiantes, académicos y profesionistas ya que se requiere una actualización sistematizada, constante y estructurada para alcanzar las metas deseadas en los proyectos, ya que la complejidad de los problemas de diseño requiere de soluciones creativas. Para los estudiantes servirá como apoyo en su formación, para los académicos podrá ser un manual para coadyuvar en la formación de los diseñadores y en el caso de los profesionistas será una guía y referente para respaldar su proceso de diseño (Delft Design Guide, 2016).

Abstract: This paper presents the beginning of a research whose interest is to highlight that in Mexico, some innovative design approaches do not consider ergonomic factors as important as others concerning originality, creativity or creating value. Ergonomics is no longer the center of many projects; human factors seem unnoticed because they are not explicitly mentioned. On the other hand, designers are looking for new design methods to allow them to discover creative problem solving. However, suitable knowledge on Ergonomics is not available for designers although the purpose of attending the functional characteristics of products, visualizing the interaction between user and product and evaluation with intermediate models and / or rapid prototypes. Also it is important to mention the environment of stress faced by designers between the ‘current situation’ and the ‘desired situation’ in everyday life, which inhibits them from updating; for example in the expression of requirements and to find the solution to problems related to new concerns and needs of more specific groups. Nowadays it is recognized that, Ergonomics and Human Factors are no longer highlighted in market advertising of many products, but expressions about experience, emotion and other ambiguous qualities such as comfort and safety are often mentioned.

This paper presents an academic research based on human factors applied to industrial design, considering Ergonomics and its multidisciplinary origin linked to science and techniques. Therefore it is important to organize the results based on design process thoroughly explained in Industrial Design Study Plan. This is a documentary review of different design methods and techniques and applied

ergonomics organized in different groups, as well as suggestions for relating them in each of the stages of the design process.

As a conclusion it is intended to generate a compendium of methods and techniques of ergonomics applied to industrial design, with examples related to the different stages of the design process: Analysis, Synthesis, Realization and Evaluation (Industrial Design Study Plan, 2002). The final goal is to publish this document among the design community in different opportunities.

Keywords: industrial design, methods, and ergonomics.

Relevance to ergonomics: Propose a compendium of examples of suitable methods to help express the list of industrial design requirements that must be gathered in order to be successful (Delft Design Guide, 2016). This process leads to a better quality of life, through innovative products, systems and services. Methods can help bridge the gap between creativity and problem solution with the intent of making a product, system or service better (World Design Organization, 2015). For design students this guide can be used as a reference manual in their design projects; for design tutors it is important to support students in their learning process, and for design professionals it is a reference to support their design process (Design Guide Goals, 2016).

1. INTRODUCTION

Ergonomics approach and importance have changed throughout the years. In Mexico, for example in the 80's there was a great interest in this discipline, especially applied to Industrial Design practice. In that decade and before, many students and professionals were interested in this subject, even though there were not enough textbooks or information to be used in the projects. Henry Dreyfuss published the first charts that could be found dealing with anthropometrics: *The Measure of Man. Human Factors in Design* (Dreyfuss,1967). These diagrams illustrated and showed with details how the dimensions could be applied. It was very useful but difficult to find and purchase. Some years later Panero and Zelnik (1979) prepared a complete edition also on anthropometric data and how to apply the information. It was called *Human Dimension and Interior Space.* Panero is still the reference for many Mexican designers. This book has been a success since then and Gustavo Gili has published it in Spanish for many years and different editions, maybe up to fifteen. Little by little, Mexican editors translated books published in the USA, England, France and USSR, for example.

It was in the beginning of the 21st century when a group of investigators of the University of Guadalajara published a book with Mexican anthropometric references (Ávila & cols., 2001). This data have been very important to help designers fit the objects to Mexican users. Nevertheless it's not well known among designers' consultancies.

In Sweden, in the 1969 there was a famous group of designers that began working together and became known for the ergonomic approach of their design solutions. In 1979, they were identified as Ergonomi Design Gruppen, in contrast with Italian or French design. Red Dot Design Awards recognized their work as the leaders of ergonomic proposals. Actually this group of Swedish designers changed their name to Veryday and became “one of the world’s top ranking design and innovation consultancies, taking care of what people really need”. (Veryday, 2019).

Figure 1. Pair of spoons for special users.

Many Mexican designers are working in exhibition companies where ergonomics is not considered in the everyday products and jobs. On the other hand there are designers working together with artisans trying to collaborate with them. In the recent Congress organized by the Universidad Autónoma de San Luis Potosí, only one designer Arq, Oscar Hagerman expressed his interest and achievements in ergonomic proposals applied to furniture design. He has been working for 40 years with different groups of artisans in Oaxaca, Chiapas and Puebla.

This is why the interest arose to attend these ways of contrasted thinking that have been present for several years as it can be known in the work of Esrawe, Godoy and others. Their designs are very popular for different reasons and that is the way many students and designers try to be. In academic and professional methods “Design Thinking” has been adopted as a unique method towards success forgetting or ignoring how to apply this method correctly (Tapia, 2017).

In our Faculty, Aragón UNAM, we are really interested in designing and applying Ergonomics in our investigation that has been held for more than ten years. We are working with students to interest them in this subject and using the ergonomic concepts in all our products and design proposals. We continuously refer to ergonomic expertise in books such as Bridger (2009) and Kroemer (2001).

2. OBJECTIVES

Recommend methods and techniques to help students and designers develop understanding and skills required to design products, services and systems considering knowledge and expertise based on Ergonomics in order to solve users needs, requests and desires innovative and creatively.

Emphasize the importance of Ergonomics as a very important tool for product design and development.

Select the method or technique according to personal experience and necessity, always with people in mind.

Help students clearly distinguish between qualitative and quantitative methods and techniques.

Help students, tutors and design professionals to manage their personal development, support learning and professional process. (Delft Design Guide, 2016).

Publish the results among design students, tutors and professionals.

3. METHODOLOGY

As a methodological strategy the project is divided into two phases. The first one is related to documentary research dealing with academic design study plans. Analyze bibliographic and diverse references. Also analyze professional practice dealing mainly with ergonomics and human factors subjects based on interviews with designers, attending congresses, conferences and design exhibitions, for example. Also look for important design projects, designers and design consultancies in Mexico and all over the world, to understand their results and the way they deal with people-users needs, feels and desires. Classify all the information identifying qualitative and quantitative methodology.

The second phase is the core of the research, prepare and publish the contributions of methodology to Ergonomics applied to Industrial Design. In order to achieve this purpose this work should be divided according to the design process: Analyze, synthesize, produce and evaluate (Industrial Design Study Plan, 2002) and complement or compare it with different documents as Delft Design Guide, Design Thinking Methods, and different design perspectives as emotional design, user centered design, user experience design, for example. And the most important approach is always considering the person, people and or user through ergonomics perspective. Basically all this information should guide designers, students and professionals, to describe concretely design objectives, discuss the best proposal obtaining a thorough understanding of the problem.

4. RESULTS

The results of the research will be achieved based on the methodology presented in this paper. At the end it is intended to generate a compendium of methods and techniques of ergonomics applied to industrial design, with examples related to the different stages of the design process: Analysis, Synthesis, Realization and Evaluation. The final goal is to publish the document among the design community, in different forums.

Despite the fact, a table with a sample of some methods that can be related with ergonomics and design can be discussed.

Table 1. Example of methods.
These examples are carefully cited from the book *Delft Design Guide* from the Faculty of Industrial Design Engineering. Delft University of Technology.

First Phase: **Discover**
User observations Helps to study what the intended user do in a specific situation. Observations enable to understand phenomena, influential variables or other interrelations in "real life".
Interviews Are face- to -face consultations that can be useful for understanding consumer perceptions, opinions, motivation and behavior concerning products or services, or to gather information from experts in the field.
Questionnaires Are research tools consisting of a series of questions and other prompts intended for gathering information.
Focus groups A focus group is a group in which several topics ``concerning specific group or issue are discussed.
Mind map Is a graphical representation of ideas and aspects organized around a central theme, showing how these aspects are related to each other.
Trend Analysis Methods help to identify and analyze customer needs and business opportunities in order to develop business strategies, design visions and new product ideas.
Function analysis It is a method for analyzing and developing the function structure of an existing product or new product concept.
Second phase: Define
Collage It is a visual representation of the context, user group or product category. It helps to develop visual design criteria and to communicate these criteria.
Storyboard It is a visual representation of a story or narrative about the design in its context of use over time.
Problem Definition

Designing is often referred to as problem solving. Finding and defining the real problem is a significant step towards a solution.
List of requirements This list states the important characteristics that the design must meet in order to be successful. The list of requirements describes concretely all the design objectives and can be used to select the most promising ideas and design proposals.

5. DISCUSSION/CONCLUSIONS

This project was recently started, so the conclusions have not yet been reached. However, it is intended to specify the contents that concern the design of object-products on the one hand and the design of jobs, for example. Also help to correct some misunderstandings dealing with Ergonomics and design expressions.

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IMPROVED ERGONOMIC CHISEL WITH HANDLE ADAPTATION

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Resumen: El uso del cincel se remonta a las épocas del hombre primitivo, que utilizaba burdas herramientas manuales construidas en piedra, hasta el uso en la actualidad por diversas profesiones como la construcción, plomeria, medicina, joyería, entre otras. El cincel se usa únicamente en frío y con ayuda de una herramienta de soporte como un martillo o una maza.

Siempre se ha hecho hincapié en las precauciones que se deben de tomar al momento de usar el cincel por ser esta una herramienta de altas probabilidades para ocasionar una lesión en las manos por impacto,éste debe manejarse con sumo cuidado procurando que la herramienta de soporte (martillo o maza) no resbale por el extremo del cincel y así ocasione la lesión antes mencionada. Por este motivo se propone una mejora del diseño del cincel añadiendole un mango con cubierta de goma para su mejor y mas seguro desempeño.

PALABRAS CLAVE: Diseño ergonómico, herramienta de mano, riesgo.

RELEVANCIA PARA LA ERGONOMÍA: Las herramientas de trabajo manuales deben estar diseñadas para satisfacer tanto las necesidades de la empresa como las de la persona que desempeñará su tarea con él.

Abstract: The use of the chisel goes back to the era of the primitive man, who used crude manual tools built in stone, to the present use by diverse professions like construction, plumbing, medicine, jewelry, among others. The chisel is only used cold and with help of a support tool like a hammer or a mallet.

Emphasis has always been placed on the precautions that must be taken when using the chisel because it’s a tool with a high probability to cause an injury to the hands by impact, This must be handled with great care, taking care that the support tool (hammer or mallet) does not slip down the end of the chisel and thus cause the aforementioned injury.For this reason an improvement of the design of the chisel is proposed by adding a handle with a rubber cover for its better and safer performance.

KEY WORDS: Ergonomic design, hand tool, risk.

RELEVANCE FOR ERGONOMICS: Manual work tools must be designed to meet both the needs of the company and those of the person who will perform their task with it.

1. INTRODUCTION

According to the article published by Franco SA, Preciado L, Salazar M, Vázquez JM, in the Cuban Journal of Health and Work, “ACCIDENTES DE TRABAJO EN MUÑECAS Y MANOS EN EL ESTADO DE JALISCO, MÉXICO, EN LOS AÑOS 2010, 2011 Y 2012”1, July 10, 2014," Hands are necessary tools for multiple activities of production, recreation, creativity, fine arts, and they complement us with various supports and assistances for the hygiene and health of our body. Accidents in hands generate between 40 and 55% of the days of incapacity that occur in the industrial sector in Latin America ", (Mexico), however, the prevention techniques give them little relevance due to the widespread idea oflittle seriousness of the injuries they produce, as well as the influence of the human factor, which is more difficult to tackle technically. In this sense, it is important to redesign the manual tools.

For this reason, a proposal to improve the design of the conventional chisel is presented in this document, which consists of adapting a handle perpendicular to the body of the chisel with a rubber cover to allow the user to have a better grip and handling of the tool, in addition to drastically reducing the risk of accidents by avoiding exposure of the hand to possible unforeseen impacts due to the use of this tool in any area where it is used such as plumbing, construction, mechanics, goldsmithing, among others.

1.1 Justification

Based on the article NTP 391: Herramientas manuales: Condiciones generales de seguridad, notes that annually publishes the work and social security that it can be said that approximately 9% of the total of work accidents have been produced by the tools, constituting 4% of serious accidents. However, 85% of work accidents with tools have been with the manuals.

It also points out from an ergonomic point of view manual tools must meet a series of basic requirements to be effective as: effectively perform the intended function of it, provide user dimensions, which is appropriate to the strength and endurance of the user and minimize user fatigue.

For the above, a proposal of an ergonomic chisel prototype with handle adaptation is created, in addition to adding a type of rubber, which will help the worker to avoid some type of accident or risk to which he is exposed at the moment of making the impact with any surface on which you are working.

1.3. Delimitation:

This study is specifically aimed at people working in construction, carpentry, mechanics, goldsmithing, among others, anyone who uses this type of tool.

2. OBJECTIVE

Design a prototype of improvement for the handling of the conventional chisel in a way that reduces the risk of an accident and / or injury for the person who is using this manual tool.

2.1. Specific objectives

- Identify the most functional and comfortable protection model for the use of a chisel.
- Verify and conduct a survey to identify the time of use of this tool.
- Improve the occupational health of the worker, by improving the conventional chisel (Protection and ease of handling).

3. METHODOLOGY

Due to the study that was developed, the inductive, descriptive and explanatory method was used since an improvement design for the conventional chisel was proposed, based on the observation of the use of this tool in plumbing, masonry, mechanics and goldsmithing.

For the creation of the design of the prototype of the improved chisel, it was based on the qualitative technique, since a survey was carried out to 50 people from the different areas mentioned, where they were asked a series of questions about this tool, for what from the results obtained from this survey began with the chisel improvement design. The obtained data threw us a series of proposals that could be made to the conventional chisel, of which we took into account to make the new design and translate it into a 3D format.

3.1. Process description

The user who handles this manual tool usually holds it with the palm of his hand holding it tightly when doing the action of the hammer or mallet. This procedure is done as follows:

If what is intended is to cut a piece, the chisel should be placed in a perpendicular position, at about 90º and provide a dry blow to the head. In this way you will get a cut as clean as possible. On the other hand, to extract chips, or to decorate a piece, you must place the chisel in a more angular position where the head is located closer to the surface that will receive the contact.

Next, the graphs of the survey applied in the present investigation are shown, which had the objective of obtaining information about the repercussion of the use of the conventional chisel.

Figure 1 shows that, of the 50 people surveyed, 94% have knowledge and use this tool.

Figure 2 shows that of the 50 people surveyed, 52% consider that it brings health problems, while 48% say the opposite

Figure 3 shows that 60% of the surveyed sample indicates that they only use the conventional chisel from 0 to 20 minutes, while 24% indicate that they use it from

21 to 40 minutes. 14% use it in a period of time between 41 to 60 minutes. And the remaining 2% use it in periods of 1 to 2 hours.

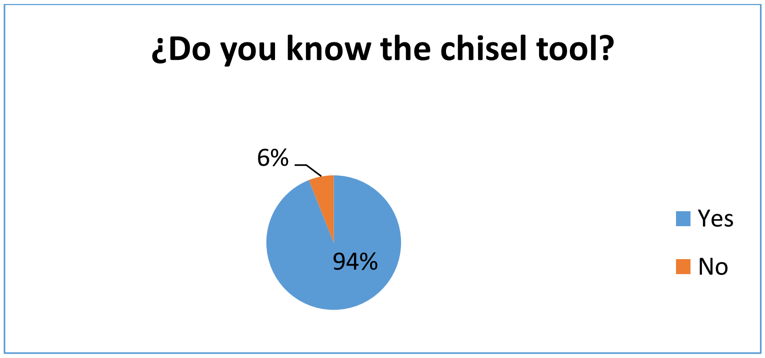

Fig. 1 Results obtained from question 1

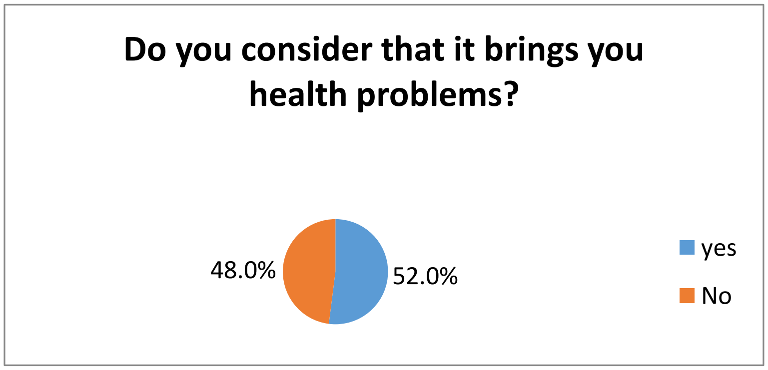

Fig. 2 Results obtained from question 2

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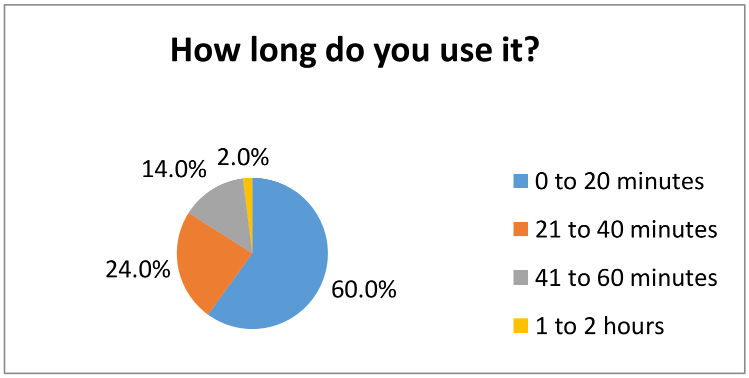

Fig. 3 Results obtained from question 3

In Figure 4 shows in terms of frequency of use, the previous graph shows that 62% use it once a week, this being the highest percentage.

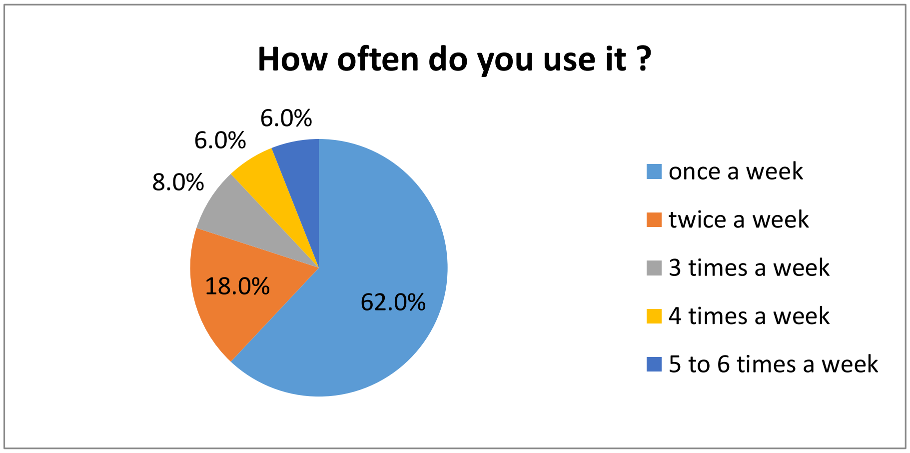

Fig. 4 Results obtained from question 4

How do you like the handling of the chisel?

In the answers we got, the most significant mentions three main aspects, the first aspect and the one that had more frequency of mention was about how the design of the chisel is anti-ergonomic, with a rustic design that when using it can be harmful and presents a certain degree of considerable risk; the second aspect that, like the first one, stood out over the other answers, talks about the frequent use of the chisel in the respective works of the interviewees and the last most significant aspect that we detected were opinions of improvement over the design of the chisel for its best use and management.

What improvements would you make to the chisel?

About the improvements to implement the two most significant opinions mention that they would add some kind of handle that provides a better grip of the tool and the second opinion suggests a rubber surface in the impact area to reduce the intensity of it in the moment of the hit.

When observing the results we can analyze that the majority is in agreement that the conventional chisel must be improved by adding a wooden handle for a better grip.

4. RESULTS.

Next, the images of the prototype of the chisel are shown from different perspectives:

In Figure 5 you can see the design of the prototype of the conventional chisel with a handle that is made of wood to have a better grip

Fig. 4 Front view of the chisel

Figure 6 shows the front view of the handle which will be the grip support of the chisel, which has a length of 7.87 inches.

Fig. 5 Front view of the handle

Figure 7 shows the side view of how the wooden handle is formed, which has a distance from the striking end of the chisel to the center of the 2.55 inches wooden handle

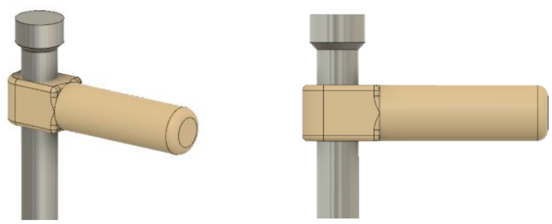

Fig. 6 Side view of the handle

In figure 8 you can see the rear view of the chisel that has a length of 12.20 inches long

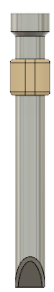

Fig. 7 Rear view of the chisel

Figure 9 shows the graph of the data collected from the different diameters in 37 people based on a 5th percentile, where we found that the diameter of 1.96 inches is the most suitable for the grip of the improved chisel prototype
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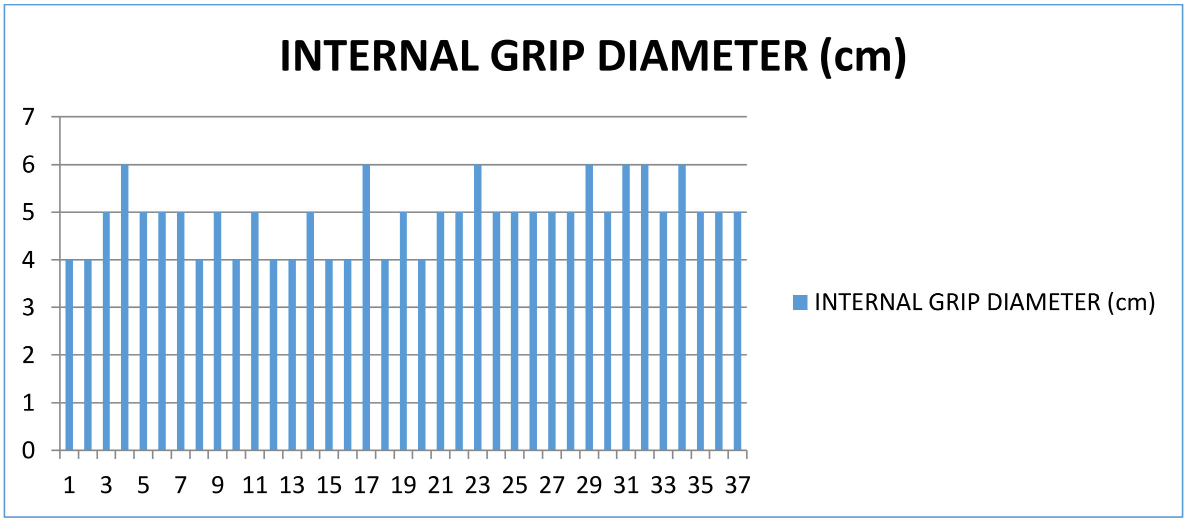

Fig. 9 Grip diameter

In Figure 10 shows how is the grip of the conventional chisel at the time of use for work, we can see that the user grabs it in a way that the hand is at a distance of 2.75 inches from the head of the chisel.

Fig. 10 Conventional chisel

In figures 11 and 12 the user is making use of the improved chisel which we add a handle that is adapted for a better grip of the conventional chisel. The users gave their own comment saying that they feel more comfortable and safe to use this type of tool already improved since they mention that the conventional chisel has its faults when not having security when using it.

Fig. 11 improved chisel handling

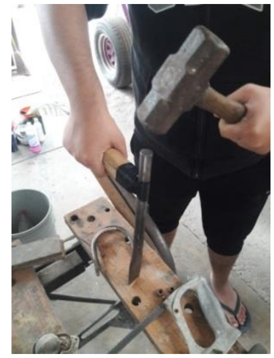

Fig. 12 improved chisel handling

For the design of the handle we took the criteria of the book "Herramientas Manuales: Criterios Ergonómicos y de Seguridad para su selección" of the National Institute of Safety and Hygiene in the workplace of Spain, which indicates that a force grip needs a handle with a diameter of 1.25-2.007 inches and a length of 3.93-5.90 inches. In addition to considering the 5th percentile according to the anthropometric measurements of the majority of users.

5. CONCLUSIONS

With the results obtained we provide the design of a tool that helped to protect the safety of the worker avoiding wounds, injuries caused by painful blows, which will be of great help to have better handling of the tool when using it at work, therefore has innovated in a tool that helps to carry out such work safely. It is considered that it will be very supportive for the plumber, mechanical sector, etc. In addition to reiterating that the objectives set at the beginning of the investigation were met, since the appropriate design was found so that any worker could use this design of the chisel based on the analyzed accounts and therefore the physical integrity of the worker was improved when handling of better form the new design of the chisel in comparison of the conventional one.

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DESIGN OF A MEASUREMENT PROTOCOL OF A MOTORCYCLE TAXI DRIVER AND HIS WORK STATION USING THE ARTEC EVA LITE 3D SCANNER

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Resumen: Actualmente se reconoce para la toma de medidas antropométricas el uso de herramientas manuales, como es el caso del antropómetro convencional; además, se cuenta con dispositivos digitales de alta precisión como el escáner 3D. En ambos casos se debe contar con un protocolo establecido para tomar las medidas de forma correcta, un nivel mínimo de conocimiento en el uso de estas herramientas y reconocer los posibles factores externos que puedan interferir o modificar el proceso de medición (Kouchi y Mochimaru, 2011). En este trabajo de investigación se describe un protocolo donde se detalla paso a paso el procedimiento para la medición de una cabina de mototaxi mediante el uso del escáner 3D modelo Artec Eva Lite. A partir de una serie de prácticas experimentales con el escáner 3D Artec Eva Lite se pudieron identificar varias tareas y subtareas en el procedimiento, las cuales ayudaron a definir los 12 pasos de los que está conformado el protocolo de medición. En este trabajo se pudo comprobar que el escáner 3D Artec Eva Lite es de utilidad para la toma de medidas en este escenario, sobre todo considerando los espacios reducidos y de poco margen de maniobra para la toma de mediciones. Por último, se pretende que el protocolo de medición sea una guía de referencia que permita al usuario disminuir los errores tanto en la ejecución y operación del hardware y software.

Palabras clave: Ergonomía, Diseño, Protocolo, Medición, Escáner.

Abstract: Currently, the use of manual tools is recognized for taking anthropometric measurements, as is the case with the conventional anthropometer; In addition, it has high-precision digital devices such as the 3D scanner. In both cases, an established protocol must be in place to take the measurements correctly, a minimum level of knowledge in the use of these tools and recognize possible external factors that may interfere with or modify the measurement process (Kouchi & Mochimaru, 2011). In this research paper we describe a protocol that details step by step the procedure to measure a motorcycle taxi cab using the Artec Eva Lite 3D scanner. From a series of experimental practices with the Artec Eva Lite 3D scanner, several tasks and subtasks could be identified in the procedure, which helped to define the 12 steps of which the measurement protocol is made. In this work it was possible to verify that the Artec Eva Lite 3D scanner is useful for taking

measurements in this scenario, especially considering the small spaces and little room for maneuver to take measurements. Finally, it is intended that the measurement protocol be a reference guide that allows the user to reduce errors in both the execution and operation of hardware and software.
Key words: Ergonomics, Design, Protocol, Measurement, Scanner.

Contribution to ergonomics: The ergonomics of work from its focus on the design of work stations, should take into account the anthropometric aspects of the user as well as the dimensions of the spaces where the person works; Although there are technical procedures on how to use the conventional anthropometer, it is convenient to have a measurement protocol using the Artec Eva Lite 3D scanner. In this way it contributes to carry out an efficient use of this device, errors are reduced during the execution and the researcher has a clearer picture of how to perform the scan. This measurement protocol contributes to the development of applied ergonomics, from anthropometric studies to evaluations of work stations and redesign of stations.

1. INTRODUCTION

Currently, the use of manual tools is recognized for taking anthropometric measurements, as is the case with the conventional anthropometer; In addition, it has high-precision digital devices such as the 3D scanner. In both cases, an established protocol must be in place to take the measurements correctly, a minimum level of knowledge in the use of these tools and recognize possible external factors that may interfere with or modify the measurement process (Kouchi & Mochimaru, 2011).

Anthropometric studies are particularly relevant in the evaluation of job positions, design and redesign of stations; having as priority those stations that may have an urgent need to be redesigned. In the local context of the metropolitan area of Guadalajara, specifically in the municipality of Tlajomulco de Zúñiga, It has been identified through the Instituto de Movilidad y Transporte de Jalisco (2016), motorcycle taxis as a means of transport with a wide demand in the region. These vehicles have design features that do not adapt specifically to the physical dimensions of the users (Zurita, 2013).

These motorized vehicles are mostly manufactured in India and exported to different countries; in the estate of Jalisco in Mexico until November 2016 there was an estimated 2,141 units of this type, which circulate every day covering working days of up to 12 hours (Instituto de Movilidad y Transporte de Jalisco, 2016). The working conditions of the motorcycle taxi driver have been studied by some researcher, in these studies have been reported the physical risk to which drivers are exposed as well as the needs of their work station (Berrones - Sanz, 2018).

One of the pressing needs in the design of a work station is the contribution of anthropometry, which allows taking measurements of the body segments of users and design based on percentiles of the population (Gómez-Conesa, 2002); In this sense, applied anthropometry has implemented in recent years the use of 3D scanners, especially in the automotive area and in the modeling of the human body

(Lacko et al., 2017); within the advantages that we find in the use of this technology is the precision in taking measurements of objects with little space or that have irregular surfaces, in addition once the objects and bodies have been scanned, they can be represented in 3D so that from a modeling can be proposed redesign of work stations.

In this study a measurement protocol is proposed using a 3D Artec Eva Lite model scanner, the scan of the workstation of a motorcycle taxi driver has been carried out, according to the literature reported, it represents a work station with several ergonomic risks, both safety and dimensions of space (Díaz Olvera, Guézéré, Plat & Pochet, 2016); however, this measurement protocol can be replicated in any other workstation that needs to be evaluated.

It is expected that, depending on the implementation of the measurement protocol designed in this study, a better interaction with the device can be achieved and errors in the scanning procedure can be reduced.

2. AIMS

To propose a design of a measurement protocol of a motorcycle taxi driver and his workstation using a 3D Artec Eva Lite Scanner.

3. DELIMITATION

A study was carried out detailing step by step the procedure for the measurement of a motorcycle cab from the use of the Artec Eva Lite 3D scanner. This in order to define a measurement protocol that could later be used for the analysis of multiple activities related to the operation of a workstation. In this study, a motorcycle taxi and the driver have been used as examples.

4. METHOD

4.1 Participants

One participant male of 45 years old, who works as a motorcycle taxi driver at the metropolitan area of Guadalajara, Jalisco.

4.2 Scenario

The design of the measurement protocol was applied inside the facilities of the *Universidad Politécnica de la Zona Metropolitana de Guadalajara.* To use the 3D scanner and to have a better access to all the motorcycle taxi structure, it was necessary to do the process outdoors. This, in order to take advantage to the space and sunlight. The procedure was carry out during the day on a schedule between 8:30 and 12:30 hrs in one day only.

4.3 Material and Equipment

A TVS Moto three wheelers, 2012 (fig. 1). This vehicle was builded in India, and it's important to mention that it didn't count with any anthropometric adaptation according to Mexican population.

Figure 1. TVS Moto three wheeleres. *Source: https://www.bicimotos.com.mx/motocarros/motocarros-de-pasajeros/motocarro-tvs-200.html*

To register the dimensions and physical details of the vehicle through a 3D software, it was necessary to use a 3D scanner model Artec Eva Lite (fig. 2).

Figure 2. 3D scanner model Artec Eva Lite. *Source: https://all3dp.com/1/artec-eva-3d-scanner-price/*

This scanner has important specifications that probably represent certain advantages when making the registration of dimensions and details of the objects. Some of this features are detailed in the table 1.

Table 1. 3D Scanner specifications. *Source: https://www.artec3d.com/portable-3d-scanners/artec-eva-lite#specifications*

GENERAL SPECIFICATIONS	PARAMETER
3D Resolution (mm)	0.5 mm

3D point accuracy (mm)	0.1 mm
Working distance (m)	0.4 to 1 m
Video rate: frames per second	16 fps
Data acquisition speed	2,000 points per second

The scanner works through photogrammetry technology. Is a 3D coordinate measurement technique, also called motion capture that uses photographs or other remote sensing systems along with reference points on the surface, as a fundamental means of measurement.

Software name: Artec Studio Projects Ver. 11
PC: Surface Tab Pro 4. RAM 16gb. 512mb video. Core i7.
All the process was video recorded using two videocameras at the moment of the data collection to analyze every stage of the protocol.

4.4 Procedure

Before the video recording and the scan of the taxi motorcycle and the driver, the procedure was explained to the participant. The scanning process included the registration of dimensions and details of the driver's cabin, passenger area, the external features of the vehicle and the participant.

The first step was to parked the vehicle in a wide courtyard inside the facilities of the university to take advantage of the space and illumination conditions. Next, the equipment was positionated and activated to start the scanning process of the external area of the motorcycle taxi. Once this phase was accomplished, the next step was to scan the passenger area and driver's cabin.

Finally, the driver was scanned in anatomic position, in every angle. All digital archives were saved in the computer. The following section presents the measurement protocol with the description of each of the steps.

5. MEASUREMENT PROTOCOL

Below is a detailed presentation of the measurement protocol obtained from the practices carried out with the Artec Eva Lite 3D scanner. This protocol consists of 12 points where the steps to be followed for a systematic scanning process are specified.

1. Define the trajectory of the scan and make a plan of previous work.

   In this stage it will be established how the strokes will be made with the scanner. For example, if they will be done in descending direction, from left to right, in how many sections the object will be divided to carry out the scan, etc.

2. Ensure a large work space, free of obstacles and with adequate lighting.
3. Prepare all the computer equipment, wiring and scanner.
4. Make required connections, USB, power, secure cable length.
5. Turn on the computer equipment.
6. Open the Artec Studio Projects software.
7. Create new project with SPROJ extension.
8. Define name of the project.
9. Make a preview to evaluate the trajectory and avoid obstacles.

    Before performing the scan, the software offers a preview option which is useful to identify if the details of the object are visible and also if the distance to which the scanner operator is located is appropriate, which should be between 40 60 centimeters from the object.

10. Scanning.

    The recommendations that will be mentioned below are intended to facilitate the technical process to save and process the files later; as well as to avoid that the operator of the scanner is exhausted and that is exposed during a prolonged time to forced positions while it realizes the procedure.

a. First, it is recommended that each scanning session be 50 seconds. This in order to avoid generating very heavy files that later are difficult to process. In addition, this can give the operator time to rest a few moments before the next session.

b. In the case of the motorcycle taxi, it is recommended to divide it into four sections: anterior, posterior, right lateral and left lateral. For each section the scan process will start from left to right and from top to bottom. In case of large units, these in turn can be divided into smaller sections so as not to exceed the time per session proposed above.

Figure 3. (Left) Scanning of the side section of the moto taxi 1. (Right) Scanning of the side section of the moto taxi 2.

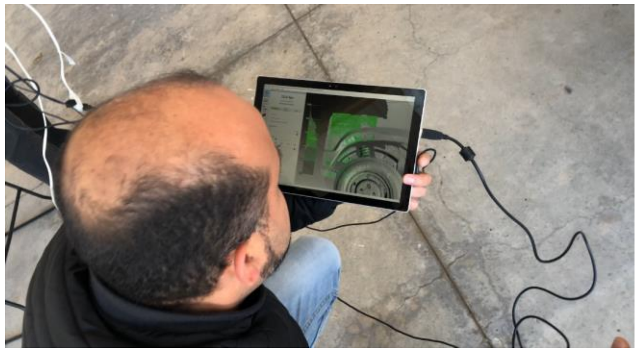

Figure 4. Artec Studio Projects software interface when scanning.

c. Previously informed of the process, the driver of the unit is asked to be located in a place with enough space, free of obstacles and in an anatomical position with closed eyes. It is recommended that the line be made from top to bottom, as in the case of the motorcycle taxi and surrounding the spiral participant.

Figure 5. Scanning process

11. Go to the post processed of the files stored in the computer equipment.
The post-processing is divided into three sections which allow, in the end, to obtain clean three-dimensional files that are easy to manipulate to obtain the required measurements. The phases of the post-processing are briefly described below:

a) Registration. This phase consists of aligning each of the scanning sessions that were generated on an area of the object to be scanned.
b) Fusion. This phase consists of joining the geometries previously generated in the registration phase,
c) Post processed. This phase consists of cleaning impurities from the scanned surface to generate the final model.

12. Obtaining and recording anthropometric measurements.
The software has different tools that allow knowing volumes, areas, perimeters, in real scale (1:1).

5.1 Linear measurement tools

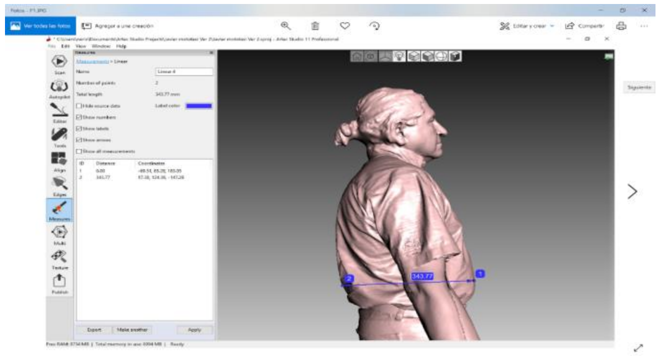

Figure 6. Linear measurement tool 1.

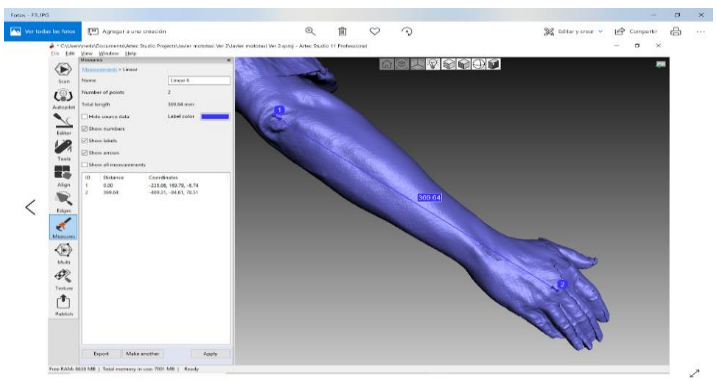

Figure 7. Linear measurement tool 2.

5.2 Perimeter measurement tools

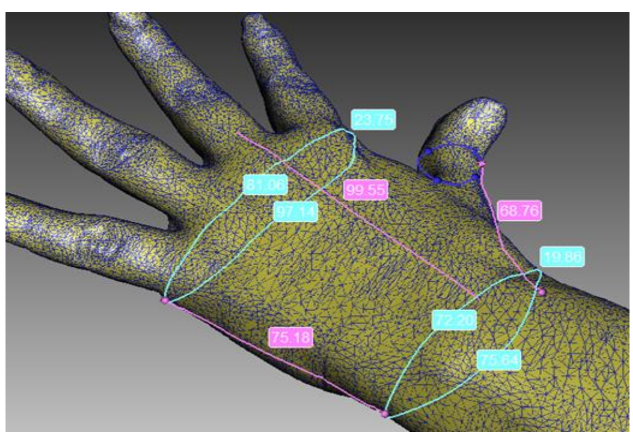

Figure 8. Perimeter measurement tool.

5.3 Area measurement tools

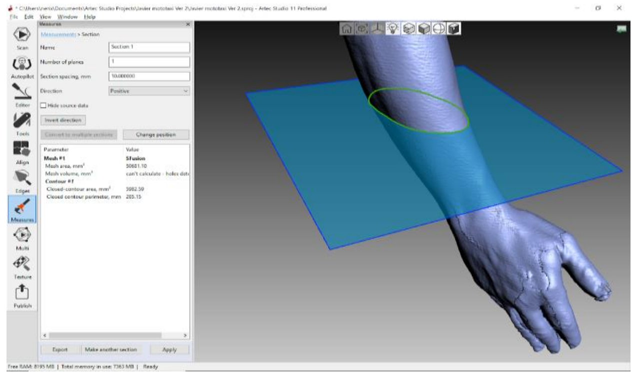

Figure 9. Area measurement tool.

5.4 Additional recommendations previous to scanning

1. To generate better results in the scanning process, it’s important to verify that the surface is not too bright and preferably avoid scanning black surfaces.
2. In case the area to be scanned is too bright or black, should be covered with a canvas cloth that fits the geometry of the surface.
3. The illumination of the area has to allow that each one of the elements of motorcycle taxi, interior and exterior are detected by the scanner.

5.5 Limitations

1. The scanner has no ability to detect color.
2. A minimum level of training is required to be able to operate the equipment.
3. The modeling process can be very slow.
4. It is a computer with a high cost, so it could be difficult to access.

6. RESULTS

From a series of experimental practices with the Artec Eva Lite 3D scanner, several tasks and subtasks could be identified in the procedure, which helped to define the 12 steps of which the measurement protocol is made. These steps included the scan of the anatomy of the motorcycle taxi driver, the cabin that represents his work station and also, a scan of the exterior of the vehicle was obtained. That said, it was found that the Artec Eva Lite 3D scanner is useful for taking measurements in this scenario, especially considering the small spaces and little room for maneuver for taking measurements. Finally, the images obtained from the measurement taking could be modeled in the Artec Studio Project software, which represents a functional tool in the design or redesign of the work stations.

7. CONCLUSIONS

Following the measurement protocol with the Artec Eva Lite 3D scanner can make it easier for the researcher to use and interact with the scanner, especially if it is the first time he works with this model. It is intended that the measurement protocol is a reference guide that allows the user to reduce errors in both the execution and operation of hardware and software.

It is necessary to carry out future researches that allow us to know if the measurement protocol proposed in this research work can be applied in job evaluations, anthropometric studies in motorcycle taxis fleets, in redesign of stations, among other activities; specifically using the Artec Eva Lite 3D scanner.

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REDESIGN OF ERGONOMIC SCISSORS FOR SEAMSTRESSES

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Resumen: Las tijeras de costura son una herramienta muy antigua con un diseño que solamente cumple con el fin para el que está destinado, sin tomar en cuenta el cuidado y/o el manejo del usuario debido a que el mango de estas no tiene la inclinación adecuada para el uso constante de las tijeras causando estragos tales como repercusiones en la muñeca y/o extensión de esta misma.

Por lo cual se propone el rediseño del mango de las tijeras convencionales de costura para un mejor aprovechamiento de ellas. Este consiste en la inclinación de los ojales del mango; quedando de manera apropiada y alineada el ojal inferior con las cuchillas de las tijeras.

Palabras clave: Tijeras, costurera, rediseño

Relevancia para la ergonomía: Se presenta una investigación concreta y objetiva sobre la identificación del ángulo correcto en unas tijeras de costurera tradicionales, para así proponer el rediseño de una herramienta de mano que se adapta una necesidad específica del usuario.

Abstract: The sewing scissors are a very old tool with a design that only fulfills the purpose for which it is intended, without taking into account the care and / or handling of the user because the handle of these does not have the proper inclination for the constant use of the scissors causing havoc such as repercussions on the wrist and / or extension of it.

Therefore, it is proposed to redesign the handle of conventional sewing scissors for a better use of them. This consists of the inclination of the eyelets of the handle, leaving the lower buttonhole properly and aligned with the blades of the scissors.

Keywords: scissors, sewing, redesign.

Relevance for ergonomics: We provide concrete and objective research on the identification of the right angle in traditional sewing scissors, thus proposing the redesign of an ergonomic handle that adapts to the specific needs of users.

1. INTRODUCTION

According to the U.S. Department of Labor in a publication on its official OSHA website under the Health and Safety Administration section "sewing and related procedures" states that: "Employees working at manual scissors stations are often exposed to awkward wrist postures, repeated force of grip, and the tension of contact to the hands and fingers. Therefore, based on these observations, the arm, wrists and hands are exposed to serious damage that affects their health both at work and in everyday life. One of the most serious and important problems exposed in a publication article related to the use of scissors by the Pontificia Universidad Javeriana De Colombia, 2014, "the cutting of the rose is done with a tool known as a manual pruning shear, which has given rise to ergonomic problems when making the cut, particularly evident in people with small hands, as the opening of the operation exceeds the maximum length of extension and grip capacity of the hand, which leads to harmful efforts and postures, especially ulnar/radial deviations and pronounced flexion/extension of the wrist, allowing the appearance of lesions due to cumulative trauma in the hand-wrist assembly". Based on this publication relating the sewing scissors with the pruning scissors indicates that the handle is similar so the effort and postures of the fingers and hand make the grip is not correct to perform the activity, so this activity is evaluated with a quasi-experimental research carrying out an ergonomic design of seam scissors achieving a considerable decrease in the effects that these cause in a person with high working days where the use of such scissors is one of the main tools making this way that people who are in constant use with them can work in the best way achieving a better job and more effective without the limitation of any nuisance.

1.1 Justificatión

The ulnar/radiale deviations or best flames ulnar or radial deviation is a deviation of the hand towards the side of the fifth finger and the radial deviation towards the side of the thumb which occurs when the hand loses its alignment with the forearm deviating to the left or right beyond the mid-range of motion. Therefore, due to the studies carried out and the antecedents found, this is one of the most common problems in people with a sewing trade.

The lateral range of motion of the wrist is not very wide and as it deviates a little more than the bill is placed in the extreme range, where movement is more difficult. Therefore the lateral wrist movements are slow and inefficient to make the cuts with scissors, so the seamstress when making a cut and bend his wrist to hold the scissors and do the action this are bent to its greater capacity making it increasingly difficult to repeat.

This is why it creates a proposal for ergonomic redesign of scissors for sewing, since being one of the heaviest jobs and long hours in the manufacturing industry and also made by women this usually leads to consequences beyond the usual so redesigning the scissors is intended to reduce high risks of diseases in hands, fingers and arm achieving that the quality of their work is extended in time and efficiency.

1.2 Delimitation

This study is specifically aimed at women workers in the textile industry in northern Sinaloa, in the cutting area, with an age range ranging from 20 to 60 years, being a mestizo population.

2. OBJECTIVE

To redesign the handle of traditional sewing scissors with the purpose of improving the angle of inclination aligning it with the blades of the same ones, due to the notorious injuries that present the users of the scissors when using them for a prolonged time.

2.1 Specific objective

- Identify the most appropriate tilt angle for people who use scissors.
- Verify and conduct a survey to see the need for redesign and user acceptance.
- Improve operator occupational health by using ergonomic sewing scissors (protection, ease of handling, reduction of wrist discomfort).

3. METHODOLOGY

Due to the characteristics of the study that was developed, the inductive method was used since it proposes the ergonomic redesign of sewing scissors, generating actions focused on the proposal of implementation in workshops and/or sewing maquiladoras.

To create the redesign of these scissors was used field research, conducting a series of questions to facilitate and improve dialogue with participants, these questions were made to seamstresses of different workshops in the region of Los Mochis Sinaloa where their main activity is sewing. This interview was made to 30 seamstresses of daily work with an age range from 20 to 60 years of age, female in its totality. In these interviews at the time of surveying the participants it was possible to see how clearly they were not informed of the serious damages they could suffer or in given cases they had already suffered without realizing what had happened due to their job.

2.1 Process description

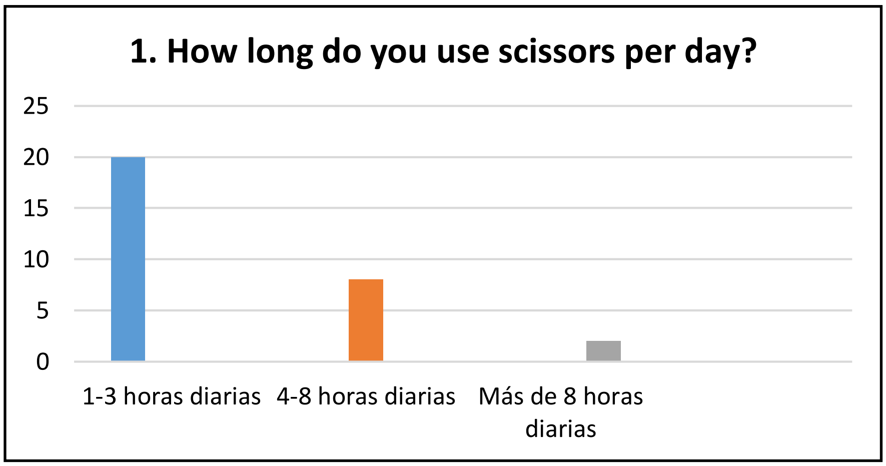
The seamstress is dedicated to cutting different materials with scissors and handling the sewing machine, this consists of repetitive movements, which is carried out to perform its work (cutting of fabrics of different materials), this procedure is done in the following way:

You take the fabric you work with (this material may vary depending on the product you are working with), position it on a table, hold it with one hand while with the other hand you position the scissors to make the proper cuts that the work requires (these are random and depend on the worker and the product you make) and begins to make the proper movements of precision and pressure when using the scissors.

The movements between all the seamstresses are random because they do not all perform the same work or do it in the same way, what is the same is the way in which they use the scissors because they use their hand to make pressure with it achieving that the scissors open and close to be able to cut requiring too good an accuracy being achieved with an angle between the handle of these scissors and the blades which is redesigned in this project.

Below are the graphs of the survey applied to 30 seamstresses in the region for this research, which aimed to obtain information on the discomforts caused by traditional sewing scissors.

Figure 1.- Results obtained question 1



The previous graph shows the hours a day that seamstresses use scissors according to our survey.

Figure 2.- Results obtained question 2

An estimate of the time the seamstresses have been using the scissors is shown.

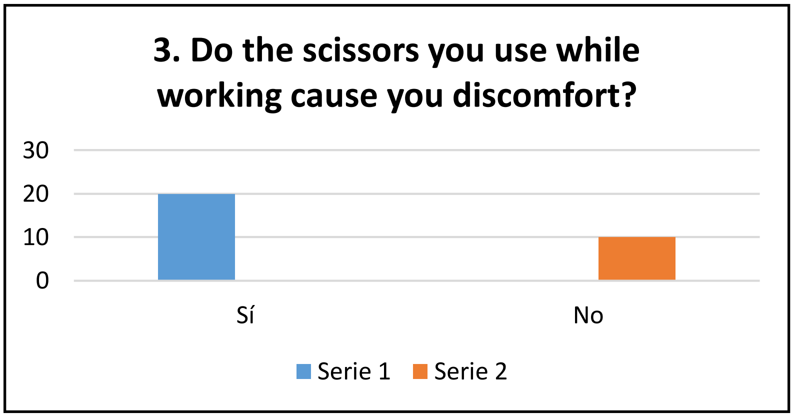


Figure 3.- Results obtained question 3

Information that yields results about whether traditional sewing scissors cause them discomfort

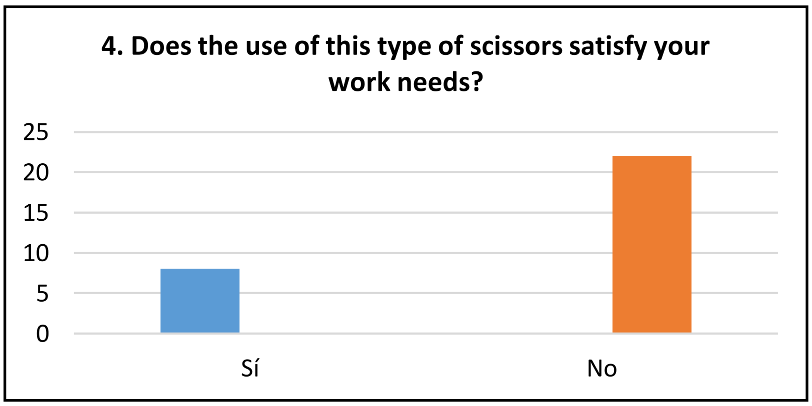


Figure 4.- Results obtained question 4

Information that works on whether traditional sewing scissors meet your needs

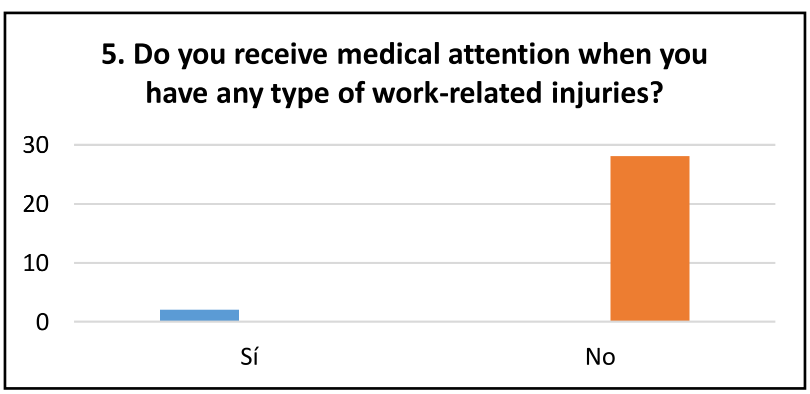


Figure 5.- Results obtained question 5

Information that yields results about whether or not they receive medical care due to injuries

Figure 6.- Results obtained question 6

It shows an estimate between variation or not of the material of the scissors

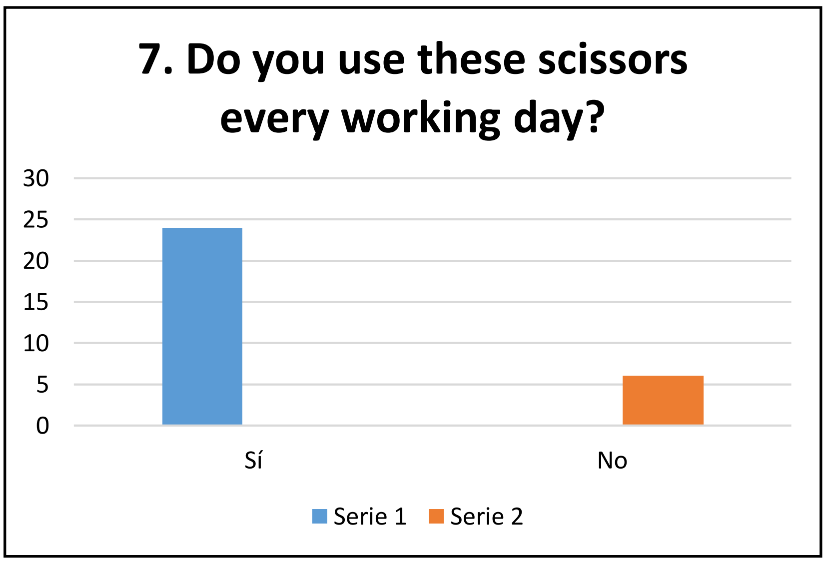


Figure 7.- Results obtained question 7

Information on the days when scissors are used

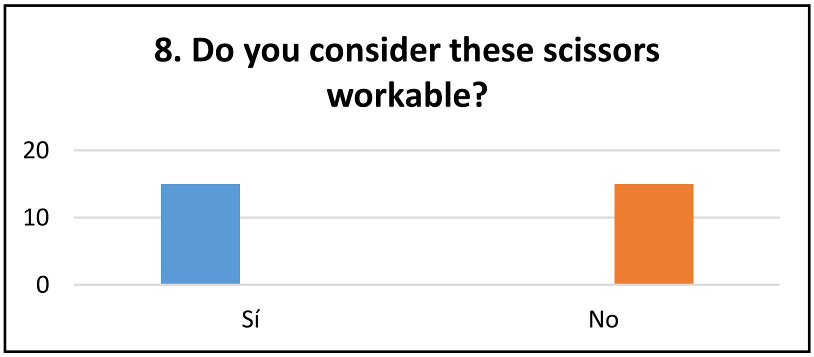


Figure 8.- Results obtained question 8

People who consider traditional scissors to be viable are shown.

Once the movements used to carry out the cutting activity had been analysed and described, a survey was carried out in which the results were shown in the previous space, showing them in a bar table. Once the results of the women interviewed were obtained, a test of anthropometric measurements was carried out in the area of the hands to each one of them, where measurements of thickness and length of the index finger up to the little finger and thickness of the thumb as well as its circumference were recorded, in order to take into account measurements and obtain a percentile so that when having the finished product everyone can use it in the best way without feeling any discomfort and without hindering their work.

Below are the anthropometric measurements of the 30 women dedicated to the area of cutting and dressmaking who were interviewed and also models for the measurements.

The table shows the measurements taken at the 30 seamstresses to obtain the results obtained and thus calculate the appropriate percentiles.

4. RESULTS

Due to the traditional design of the sewing scissors, they do not allow a good position on the wrist and its extension at the time of use, causing discomfort in a lapse of time, which is exhausting for the health of the user, in this case the workers with this tool from the north of the state.

The traditional sewing scissors have been used since historical times, where it was a good trade exclusively for women, however, does not meet the needs that are required causing injuries.

Therefore the redesign of the handle of the traditional scissors is proposed, leaving as normally the blades of these. Using ergonomic measures.

Table 1. Anthropometric measurements.

	Wrist Height (mm)	Internal Grip Diameter (cm)	Palm Length (mm)	Hand Length (mm)	Medium Finger Height (mm)
	85	3.5	10	17	80
	89	3	10	17	80
	84	5	11	17	88
	85	4	10	17	65
	85	3.5	10	17	78
	81	4	9	16	75
	85	4	10	17	79
	87	4	11	17	83
	82	4	10	20	81
	81	4	10	17	75
	87	4	10	17	83
	81	5	10	17	81
	84	4	10	17	78
	84	4.5	5	17	76
	88	4	10	17	80
	83	4	10	17	82
	85	3.5	9	16	82
	88	4	10	17	80
	84	4.5	11	17	80
	85	3.5	9	17	76
	83	4	9	20	88
	83	4	10	16	65
	87	4.5	11	20	78
	88	3.5	10	17	82
	84	5	10	17	80
	84	4	9	17	80
	85	4.5	11	16	80
	85	5	10	20	82
	88	3.5	10	20	88
PORCENTIL %	95	95	95	95	95
OUTCOME	88	5	11	20	88

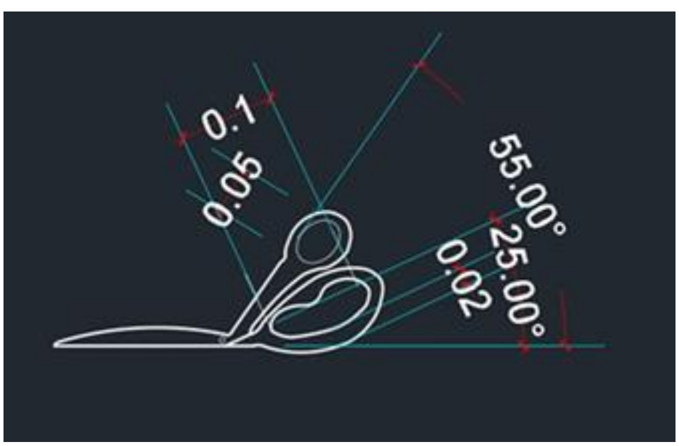


Figure 9.- Dimensioned scissors redesign prototype

5. CONCLUSION

With the obtained results we provide the design of a tool that helps to protect the wrists of the worker avoiding injuries, bad postures and to facilitate his work, since in addition to making it simpler it turns also a work of hours in something more effective so that in his long days of work the health of the operator is always taken care of in the long term that in another form are supported because it is necessary to survive in a hostile environment, therefore it has been innovated in a tool that helps them to make this work in a safe way. It is considered that it will be of much support for all these trades that they carry out daily.

For the design of the ergonomic scissors the standard anthropometric measures already established by a group of workers of the textile industry were used, 30 specifically, women that work in cut and confection of clothes, in the extensive one to take the measures to us making improvements in the handle, avoiding to hurt the hands, dolls and part of the arm to all these workers, all of them inhabitants of Los Mochis, located in the municipality of Ahome, Sinaloa, Mexico. In addition, a survey will be applied to this same population, with the objective of knowing in a reliable way the current position of the worker referring to the condition in which they carry out the different works of sewing that they carry out in the sewing workshops. (Perform operations without ergonomic scissors).

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DESIGN OF BENDING EQUIPMENT TO REDUCE WORKING RISKS WHEN BENDING SHEET MANUALLY

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Resume: La carrera de ingeniería Industrial compro equipo para doblar laminas, en junio de 2018.Ingenieria mecánica no tenia equipo propio, por lo que se inicio el rediseño y diseño de equipo para doblar tubos y laminas como parte de sus competencias profesionales.

Las laminas que se doblan en maquina pueden cortar ya que se manipulan sin sujetadores los cuales adquirieron por separado. Al doblar la lamina se expone el alumno a posible corte con la lamina al jalar las palancas de atrás hacia enfrente. Los alumnos de mecánica decidieron diseñar o rediseñar las dobladoras para que sean más seguras al efectuar el dobles. A los alumnos se les tomaron medidas antropométricas, evaluación de postura. A las estaciones de trabajo se realizaron mediciones de condiciones ambientales de trabajo conforme a normas mexicanas.

Palabras clave: Diseño ergonómico, diseño de fabricación, confort en las posturas.

Contribución a la Ergonomía:

1. El diseño ergonómico debe ser considerado en el diseño de fabricación.
2. Es imprescindible tener en cuenta la antropometría de los alumnos antes de comprar el equipo.

Abstract: The industrial engineering carrier bought equipment to sheet metal bending in June of 2018. Mechanical engineering students did not have them own equipment, so they started a redesign of the current sheet metal bending machine that industrial engineering have as part of them professional competences.

The sheet metals that are bended in the machine may be cut the user because them are manipulated without clamps, at present the current clamps are some that industrial engineering got as separately. When the sheet metal is bended it may be a risk to the user, because the levers are collocated in the way that the user must to pull them to themselves.

The mechanical engineering students decided to redesign the sheet metal bending machine with the objective to got a equipment more secure for them all. They took anthropometric measures and postures evaluations to the remain of students and the work stations were measured according the Mexican ambiental work norms.

Key words: Ergonomic design, manufacturing design, comfort in postures.

Ergonomic providing:

1. The ergonomic design must to be considered in the manufacturing design.
2. It is a must to take in consideration the anthropometric of the students before to buy the equipment.

1. INTRODUCTION

We have a metal sheet bending machine installed on a work table in our manufacturing laboratory since 2018. This equipment was acquired to perform the practices that are required according to the thematic content of some classes. We detected some risks of posture for the operator when the machine is operated, maintained and fed with material. So, we looked into for a solution for these risks of postures.

The first thing we did was present some proposals to build an improved model designed as per the possible solutions we discussed about the issues that we detected previously.

We looked into to improve the operative process, the maintenance and also add the comfort the ergonomics provide.

2. OBJECTIVE

Design a sheet metal bender using the principles of manufacturing design and ergonomics factors to decrease the ergonomic risks when the operator is applying external loads operating manually.

3. METHODOLOGY

Evaluation of ambiental conditions of operation according the norms of the methods of Suzanne Rodgers y RULA were evaluated operative positions of the sheet metal bending machine to design it, anthropometric measures were took to the students and the design of the works stations.

Anthropometric and equipment dimensions

The table 1 shows the anthropometric measures of the operators (Ávila, 2007), for obtain the needed dimensions to our design. (Becker.J), (*Lista de comprobación ergonómica*, 2001).

Methods of ergonomic analysis

Method RULA. Table 2, shows the analysis of the sheet metal bending machine that industrial engineering carrier bought.

Suzanne Rodgers method. Table 3 shows the result of the purchased Bender, with assessments ranging from moderate 7 on shoulders and arms, 4 low back neck and wrists

Table 1 Anthropometric measures of mechanical engineering students

Descripción Antropométrica		Percentiles (mm)		
		P_{05}	P_{50}	P_{95}
2	Estatura	1665	1730	1794
3	Altura de ojo	1540	1619	1699
4	Altura de hombro	1345	1416	1487
5	Altura de codo flexionado	1044	1107	1169
7	Altura a la rodilla	487	515	542
8	Alcance de brazo frontal	698	777	857
10	Profundidad de tórax	188	266	344
15	Anchura codo -codo	333	375	416
16	Anchura de la mano	89	100	112
17	Longitud de la mano	169	181	192
18	Longitud de la palma de la mano	89	97	105
20	Longitud de pie (zapato)	219	269	318
21	Anchura de pie (zapato)	101	108	114
33	Perímetro de la cabeza	531	566	600
34	Anchura de la cabeza	148	155	163
35	Profundidad de la cabeza	181	196	212

Table 2. Method RULA to analyse the bought sheet metal bending machine

MÉTODO RULA Microscopio			
	Puntos		Puntos
GRUPO A. Análisis de brazo, antebrazo y muñeca		GRUPO B. Análisis del cuello, tronco y pierna	
Puntuación de Brazo	4	Puntuación del cuello	2
Puntuación de antebrazo	2	Puntuación del tronco	2
Puntuación de la muñeca	2	Puntuación de las piernas	1
Puntuación giro de muñeca	1	Puntuación del tipo de actividad muscular (Grupo B)	0
Tipo de actividad muscular(Grupo A)	0	Puntuación de carga/Fuerza (Grupo B)	0
Puntuación de carga/Fuerza (Grupo A)	0		
NIVELES DE RIESGO Y ACTUACIÓN			
Puntuación Final RULA	**3**		
Nivel de Riesgo	**2**		
Actuación	**Se requiere una evaluación más detallada y posiblemente, algunos cambios**		

Table 3. SUE Rodgers method for bending machine

MÉTODO SUE RODGERS Dobladora					
	Comprado				
	Intensidad	Duración	Por minuto	Puntaje	Análisis
Cuello	2	1	2	**4**	**Bajo**
Hombro	3	1	2	**7**	**Moderado**
Espalda	2	1	2	**4**	**Bajo**
Brazo y Codo	3	1	2	**7**	**Moderado**
Muñeca, mano, dedo	2	1	2	**4**	**Bajo**

Quoting, prices and budgets: We consult by telephone to several vendors and went for some to receive a quote from them. It is completely profitable, however, and thinking in making not only a unit, but some more of these, it could be a fairly profitable, given cost of operating and functional way it could be profitable selling our machine, based on the prices that are handled currently on the market.

A functional folding machine could haunt the dlls of 1200 - 1800 dlls. So it's an investment more profitable. The following table 4. shows the best prices obtained:

Tabla 4. Lista de precios

Parte	Componente	Material	Costo (C/U $)	DimensionesMínimas
Estructura lateral	Contorno	Tubo 1" C40	400	1" X C40 X 60"
	Placa	Placanegra 1/4"	125	Por kilo
	Bases	Placanegra 1/4"	125	Por kilo
Juego de placas	Placaabatible	Placa 1045 3/8"	1900	Medidaspueden ser definidas
	Placa superior	Placa 1045 3/8"	1900	Medidaspueden ser definidas
	Placa base	Placa 1045 3/8"	1900	Medidaspueden ser definidas
	Mecanismosujeción	Sinfín 3/8" - 16	100	3/8" - 16 X 1'
Palancasextensibles	Palanca	Barra redonda 3/4"	250	3/4" DIA X 5'
	Engomado/perilla	Nylon / Goma	15	Es un accesorio
TOTAL APROXIMADO:			6715 MXN	

* Note: Prices are subject to change by the increase in the I.V.A and price of steel in general.*** Prices were consulted with an expert on the subject.***

4. RESULTS

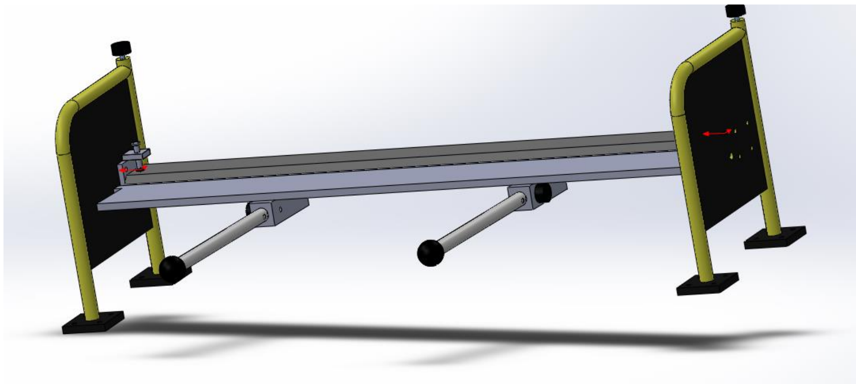

Figure 1 Sheet metal bending machine dimensions

1. The risks of incidents when the lever is pulled were removed.
2. The use of external tools to adjust the levers were removed
3. The length of the levers may be adjusted by the user
4. The position of the external load was adjusted to comfort of the user
5. The heigth of the external load was adjusted to comfort of the user
6. The material clamping was incorporated to the machine
7. The material feed place was adapted to the user
8. The bedplate is now removable for maintenance
9. It is not necessary for the user to inclinate or go around to operate the machine
10. Now is possible give maintanance to the machine without disassembling it.

5. CONCLUSIONS

1. We got to design a ergonomic machine which bend the sheet metals when the user is applying the external loads in a comfortable way compared with the existing equipment in our laboratory at present.
2. It is a must to have anthropometric references of the students of the equipment before to buy it.
3. When the equipment is being installed it is a must to take in consideration the feed material way that is needed.
4. It was more comfortable to the students push the levers than when it was necessary to pull them.
5. The ergonomic postures was improved when the student applies a external load
6. The external loads in the station are now more comfortable

7. Were decreased the time and the postures necessaries to feed with material.
8. The maintenance is now easier

Table 5. Method RULA improvement result analysis

MÉTODO RULA Dobladora			
Dobladora	Comprada	Diseñada	Mejora %
GRUPO A. Análisis de brazo, antebrazo y muñeca			
Puntuación de Brazo	4	2	50
Puntuación de antebrazo	2	1	50
Puntuación de la muñeca	2	2	
Puntuación giro de muñeca	1	1	
Tipo de actividad muscular(Grupo A)	0	0	
Puntuación de carga/Fuerza (Grupo A)	0	0	
GRUPO B. Análisis del cuello, tronco y pierna			
Puntuación del cuello	2	2	
Puntuación del tronco	2	2	
Puntuación de las piernas	1	1	
Puntuación del tipo de actividad muscular (Grupo B)	0	0	
Puntuación de carga/Fuerza (Grupo B)	0	0	
Puntuación Final RULA	**3**	**3**	
Nivel de Riesgo	**2**	**2**	
Actuación	**Evaluación detallada con posibilidad de cambio**		

Table 6. SUE Rodgers for improvement result analysis

MÉTODO SUE RODGERS Dobladora											
	Comprado					Diseñado					
	Intensidad	Duración	Por minuto	Puntaje	Análisis	Intensidad	Duración	Por minuto	Puntaje	Análisis	Mejora %
Cuello	2	1	2	**4**		1	1	2	**1**	**Bajo**	**30**
Hombro	3	1	2	**7**		1	1	2	**1**	**Bajo**	**60**
Espalda	2	1	2	**4**		1	1	2	**1**	**Bajo**	**30**
Brazo y Codo	3	1	2	**7**		2	1	2	**4**	**Bajo**	**30**
Muñeca, mano, dedo	2	1	2	**4**		1	1	2	**1**	**Bajo**	**30**

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Ergonomic Checkpoints, Soluciones prácticas y de sencilla aplicación para mejorar las seguridad, la salud y las condiciones de trabajo, Oficina Internacional del Trabajo – Asociación Internacional de Ergonomía

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REDESIGN OF MANUAL TOOL - ERGONOMIC CROSS WRENCH

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Resumen: En la vida diaria es cada vez más usual que las personas tengan vehiculo propio, dichos vehiculos usan un sistema de neumaticos compuestos por caucho, los cuales en su interior contienen un gas a presión. Con estas características es posible que las llantas puedan sufrir desgaste o algún tipo de deterioro en el uso constante, por lo cual es necesario traer en el auto una llanta extra así como tambien el equipo necesario para hacer el cambio de neumaticos. Debido a que esta situación es impredecible, el conductor siempre debe estar preparado.

Una de las herramientas necesarias para llevar a cabo el cambio de neumático es la llave de cruz (Cruceta), la cual al momento de utilizarla, nuestro equipo de trabajo se percató de las posturas incorrectas que se adoptan, por lo que ideamos un prototipo que mejora la postura al utilizar dicha herramienta y logra que su utilización sea más fácil y requiera menor esfuerzo.

Palabras clave: Diseño, llave de cruz, herramienta

Relevancia para la ergonomía: Se pretende contribuir con un estudio sobre la postura incorrecta que las personas adoptan cuando usan la llave de cruz durante un cambio de llanta en un automóvil de uso personal, así como una propuesta de mejora para el uso óptimo de la herramienta, con el objetivo de disminuir las posibles lesiones causadas por la fuerza excesiva o la postura inadecuada.

Abstract: In daily life it is becoming more and more common for people to have their own vehicle, said vehicles use a system composed of rubber tires, which contain pressured gas. With these characteristics it is possible for the tires to wear down or suffer some deterioration from constant use, so it is necessary to have an extra tire in the car, as well as the necessary equipment to make the change of tires. Given that this situation is unpredictable, the driver should always be prepared.

One of the necessary tools to carry out the change of tire is the cross wrench which, when we used it, our team realized the incorrect postures that are adopted. That is why we devised a prototype that improves the posture of the people when using the tool and makes their use easier and with less effort.

Key words: Design, Cross wrench, Tool.

Relevance for ergonomics: We intend to contribute with a study on the incorrect posture that people adopt when using the cross wrench during a change of tire on a personal use automobile, as well as an improvement proposal for the optimal use of the tool, with the aim of decreasing the injuries caused by the excessive force or inadequate posture.

1. INTRODUCTION

According to Dr. Marta Papponetti, "Body posture is not only an aesthetic issue; a bad body posture can affect the health and functioning of the body", mentions that: "Body posture is not only an aesthetic issue, but a bad body posture can affect the health and functioning of the body."

Based on that information, this work reveals a proposal for a prototype to improve of the cross wrench, given that a postural evaluation was made by the RULA method, revealing that the need to modify the task (its use could cause injuries mainly in the back, shoulders, arms and forearms), to reduce the injuries to which users are exposed.

1.1 Justification

Nowadays the use of a car is fundamental in the life of people, cars use a system composed of rubber tires, which are filled with compressed air. Tires can wear down because of constant use, and also this material may rupture or pinch, this type of accidents can occur virtually anywhere and at any time. These accidents are, by definition, unexpected and generally happen far from a place where we can use professional equipment to change the tire. That is why there are some tools that are essential to bring in the vehicle to change the tire, the main one is the cross wrench which is a type of tool used to tighten or loosen the nuts or bolts that hold the tire.

That is why we have decided to implement different specifications that make the cross wrench an efficient, unique and ergonomic tool, without losing the purpose for which it was made.

1.2 Delimitation

The use of the tool is for people between 22 and 65 years old, specifically those working at the Company DHL's delivery service, as well as other car owners interested in the product, given that they are also exposed to tire damage.

2. OBJECTIVE

Design an ergonomic cross wrench, making it safer to use, starting with the use of strength in the legs and thus improving the user's posture.

2.1 Specific objectives

- To create a prototype that anyone can use in order to change a tire.
- To verify and perform a survey in order to understand the need for this kind of tool and its acceptance.
- To reduce the possible injuries that may occur from using this tool.

3. METHODOLOGY

An explanatory research was carried out to find the causes and consequences of tire damage, as well as the characteristics of the study. We used an inductive method proposing an ergonomic cross wrench design, where people were shown the new prototype.

For the creation of the prototype of the ergonomic cross wrench, a field investigation was carried out, where we applied a survey to drivers working for the delivery company DHL. These workers drive about 8 hours a day, taking deliveries within the city and sometimes even across cities, so they are exposed to tire accidents and malfunctions constantly.

3.1 Process description

We studied 30 drivers at the time of changing a tire, in a controlled environment at the parking lot of the delivery company (simulating that it was on the road). The mean time for the tire change was 9.56 minutes where the operator made 6 different movements (Reach, Grab, Position, Turn, Grab and Release) which are constantly repeated.

There results for the survey are shown below.

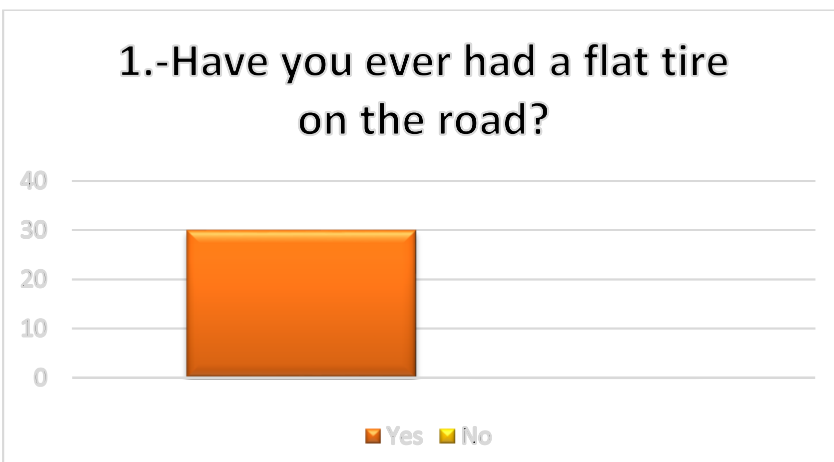

Figure 1: Results obtained in question 1.

Figure 1 shows the results of question 1, where out of 30 people surveyed 100% mentioned that they have suffered a mishap with their tires.

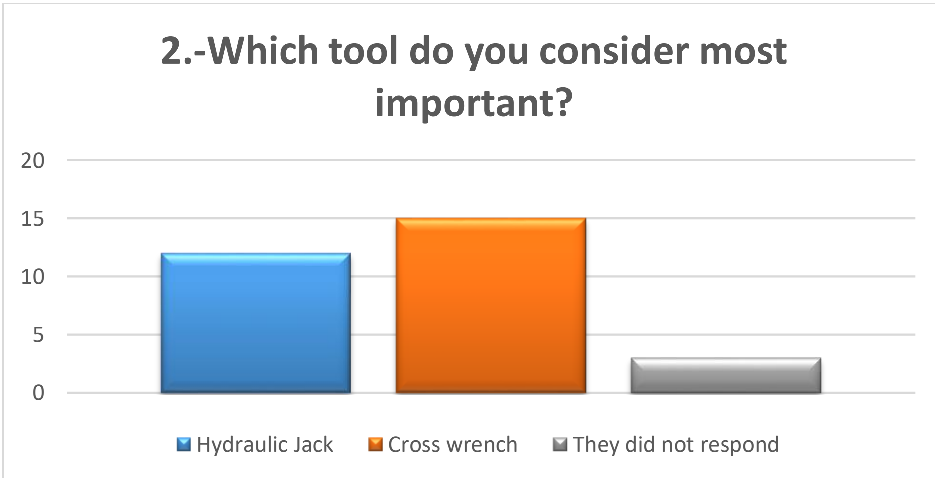

Figure 2: Results obtained in question 2.

Figure 2 shows the answer to question 2, with 40% of people saying that the most important tool was the hydraulic jack, 50% saying it was the cross wrench and 10% not responding.

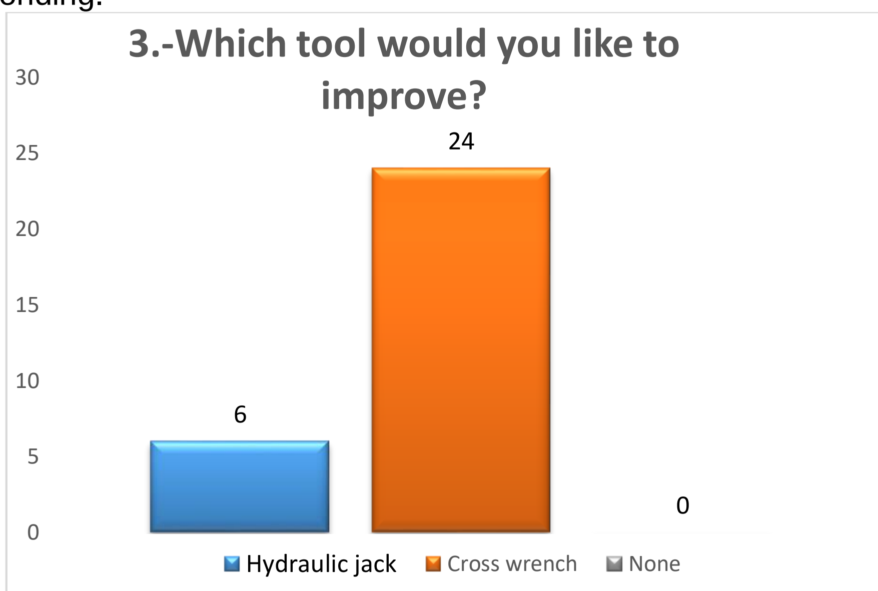

Figure 3: Results obtained in question 3.

Figure 3 shows that 80% of the people surveyed think that the cross wrench should be improved, while 20% mention that the hydraulic jack needs to be improved.

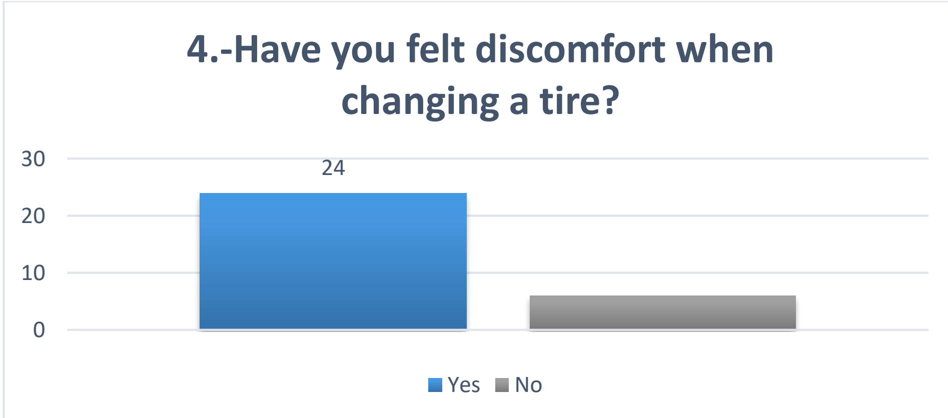

Figure 4: Results obtained in question 4.

Thanks to the information appearing on figure 4, we came to the conclusion that 80% suffer from discomfort in their body after changing a tire, mentioning that it is due to the posture adopted at the time of generating effort when the activity is performed.

Derived from the information gathered through the survey, an ergonomic cross wrench design is proposed to loosen and tighten the nuts of the rims, meeting the characteristics demanded by users: efficient and practical at the same time, with pedals in it that offers greater support and help to apply more force without damaging the operator’s posture and thus generate less risk.

Furthermore, we decided to carry out the evaluation to 10% of the population surveyed using the RULA method, to evaluate the posture with the use of the conventional cross wrench and in the 3 evaluations we had the following result:

Score	Level	Performance
1 or 2	**1**	Acceptable risk
3 or 4	**2**	May require changes in tasks; it is convenient to deepen the study
5 or 6	**3**	Redesign is required in the task
7	**4**	Urgent changes are required in the task

Figure 5: Results table from the RULA method.

The result of the evaluation was 6 and taking as a guide the table above is at level 3, which indicates that the redesign of the task is required, based on this we decided to continue with our project to redesign the cross wrench.

4. RESULTS

We studied the task of "changing a car tire" in addition to the characteristics and main function of the cross wrench, its proper handling and positions suitable for its proper functioning. Also we detected obstructions that cause damage to the human body, and that is where we applied our ideas to redesign this tool in a way that does not cause repercussions to the users.

For the inclusion of the pedals to our modified tool we consulted the article "The size of Mexican's shoes" written by Roy Campos and Carlos Penna, which says that 95% of Mexican men over 18 years of age fit within the interval between 21MX and 29MX. From there we investigated that the 29MX shoes have a width of 109mm ± 5mm depending on the type of footwear, so the width of the pedals is 114mm.

Once the plates have been welded, we continued to cover the middle part of the rods with an anti-slip material to prevent the user's foot from slipping when using it.

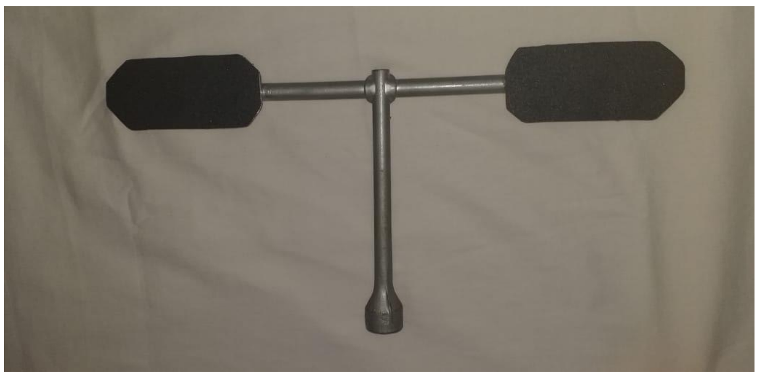

Figure 6: Finished prototype image

In figure 6 is an image of the finished prototype, including the pedals and the anti-slip material.

Figure 7: Posture (Using the conventional cross wrench)

Figure 7 can observe the conventional posture adopted when using the cross wrench, as well as the force used and the difficulty when changing the tire.

Figure 8: Posture (using the modified cross wrench)

Figure 8 shows a picture of the modified cross wrench, using a much more comfortable posture and taking advantage of the body weight, especially compared to the conventional design.

The Official Mexican Norm PROY-NOM-150-SCFI-2002 describes a variety of lug nut sizes, each of them with specific torque requirements. It is important to use the correct cross wrench, adjusting it to the correct torque, to create the correct tension to tighten or loosen the lug nut. 12 mm lug nuts need between 70 and 80 pounds per inch (between 94.91 and 108.47 Nm). Half inch lug nuts (1.27 cm) need a force between 75 and 85 pounds per inch (between 101.69 and 115.24 Nm) to tighten. 9/16 inch lug nuts (1.43 cm) require between 135 and 145 pounds per inch of force (between 183.04 and 196.59 Nm). 5/8 inch lug bolts (1.59 cm) need between 125 and 135 pounds per inch of force (between 169.48 and 183.04 Nm).

Based on that information, we can be confident that when someone uses the conventional cross wrench, they need to apply at east that amount of force with their arms and back, whereas the redesigned cross wrench passes most of that effort to the legs, taking advantage of the fact that there is considerably more strength in the leg's muscles than the arm's muscles; this avoids the incorrect posture adopted when a person uses the conventional cross wrench.
García (2007) says that due to the daily activities we perform with our lower body extremities (such as walking, running or just standing still, bearing our body's weight), they have considerably more strength as compared to the upper body extremities.

5. CONCLUSIONS

There is no doubt that there are many workshops or vulcanizers that make the task of changing a tire easier, employing pneumatic and hydraulic tools, however, sometimes there is the need to change the tire mechanically and therefore it is important to have this ergonomic cross wrench. The presented improvement has the advantage of not wearing so much physically, thanks to the pedals implemented in it, since it can use the weight of the user (if the nuts are very tight) to do the job, while the traditional cross wrench focuses the force on the arms and back to do the job. This tool not only provides a better use of physical force thanks to the pallets, it also offers a better grip when handling it with the integration of anti-slip material, which in turn offers a more comfortable grip.

Score	Level	Performance
1 o 2	**1**	Acceptable risk
3 o 4	**2**	May require changes in tasks; it is convenient to deepen the study
5 o 6	**3**	Redesing is required in the task
7	**4**	Urgent changes are required in the task

Figure 9: Results of the RULA method.

Finally, we re-evaluated the worker's posture using the redesigned cross wrench, and the result was favorable, as it gave us a score of 2, which is at level 1 and tells us that this is an acceptable risk.

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PHYSICAL ERGONOMICS: CONDITIONS THAT AFFECTS THE INFORMAL WORKER FROM THE CURRENTLY COLOMBIAN TRADE.

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Resumen: Objetivo: Analizar las condiciones del dominio de la ergonomía física para establecer la relevancia de sus interacciones, logrando optimizar los elementos de protección y minimizando el riesgo. Método: Estudio descriptivo del análisis de contenido de la categoría, búsqueda de documentos de investigación que introdujeron el trabajo físico ergonómico e informal. Resultados: con esta investigación fue posible determinar que no hay más información sobre la ergonomía física en el sector informal y el sector de comercio en Colombia. Conclusiones: Los trabajadores informales en Colombia no tienen las condiciones ergonómicas óptimas para el desarrollo de su actividad laboral, además, no existe un sistema de seguridad y salud en el trabajo que pueda garantizar el bienestar y las buenas prácticas laborales.

Palabras clave: Ergonomía. Fisiología. Trastornos musculoesqueléticos. Biomecánica. Sector informal

Relevancia para la ergonomía: Esta investigación documental permite caracterizar las variables de análisis, desde la ergonomía física de acuerdo con el desarrollo del trabajo informal, donde hay algunos factores involucrados como el tipo de gesto, la postura mantenida y prolongada, el movimiento repetitivo y otras variables que generalmente están involucradas. En el trabajo diario (empresa y trabajador). Entonces, cuando no hay información, permite
caracterizar esta actividad humana, calificar y cuantificar el riesgo en su desarrollo, logrando una mayor comprensión de la ergonomía en la comprensión de la interacción humano-máquina y el espacio físico.

Abstract: Objective: Analyze the conditions from the domain of physical ergonomics to establish relevance from their interactions, achieving optimize protective elements and minimizing risk. **Method:** Descriptive study of category's content analysis, search of investigative documents that introduced the physical ergonomic and informal work. **Results:** With this investigation it was possible to determine that there is no more information on the regarding to the physical ergonomic in the informal sector and the commerce sector in Colombia. **Conclusions:** Informal workers in Colombia do not have the optimal ergonomic conditions for the development of their work activity, in addition, there is no safety

and health system at work that could guarantees the well-being and good work practice.

Key words: Ergonomics. Physiology. Musculoskeletal disorders. Biomechanics. Informal sector

Relevance for ergonomics: This documentary research let characterize the analysis variables, from the physic ergonomics according to the development of the informal work, where are some involved factors as the gesture type, maintained and prolonged posture, repetitive movement and other variables which are generally involved in the diary work (company and worker). So, when there is no information, it let characterize this human activity, qualify and quantify the risk in its development, getting more to the ergonomics in the understanding of the interaction between human-machine and the physical space.

1. INTRODUCTION

The exercise of labor as proper activity of the human requires through its process of bodily and mental conditions that request to the person an important demand of his time and body waste. It is why during the execution of this person carries out various activities that, if performed in an inappropriate way, generate alteration in the various bodily functions, That is, if the worker during his working day does not carry out his activities seeking bodily comfort this triggers permanent or temporary musculoskeletal injuries that limit the performance of the work practice. One of the topics of injuries is the biomechanic, where we evaluate all the characteristics of human movement that if those are complemented with the physiological and anthropometric factor, it allows the ideal characterization of the work gesture, this ensuring that the worker performs the appropriate activity according to the ergonomic characteristics of the workplace given by the body component of each individual.

This is why in Colombia it is important to understand that the informal workers should be involved in occupational safety and health programs due to that it does not work to have the whole country working if a large part of these workers do not have adequate health guarantees which ensure the citizen welfare of the entire population.

2. OBJECTIVES

2.1 General objective:

Analyze the conditions from the view of the physical ergonomics, in order to establish the relevance since its interactions, achieving optimize protective elements and reducing the risk.

2.2 Specific objectives:

- Collect research studies reggarding to the conditions from the physical ergonomics dominium in the commerce sector.
- Identify biomechanical and anthropometrics physiological factors which affect the population and then let it act.
- Establish interactions of the variable, analyzing its level impact

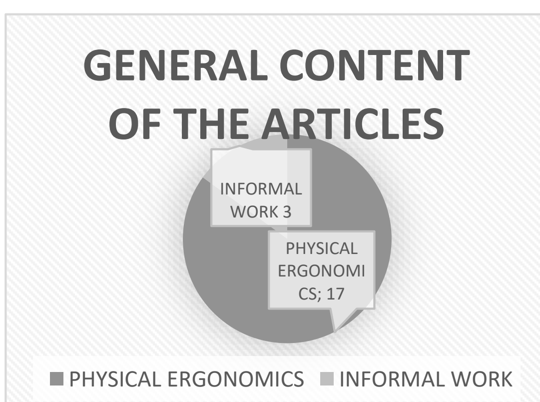
3. METHODOLOGY

- Chronological delineation: A time window was created for the search of articles from 2000 to 2018. This window was established because during this time several investigations were published with key results for research.
- Conceptual delineation: The search was carried out with specific terms such as physical ergonomic, informal worker, trade sector, physiological, biomechanical and anthropometric that allows a greater and bigger approach in research. These terms are the pillars because they clearly support the hypothesis given by the researchers.

4. RESULTS

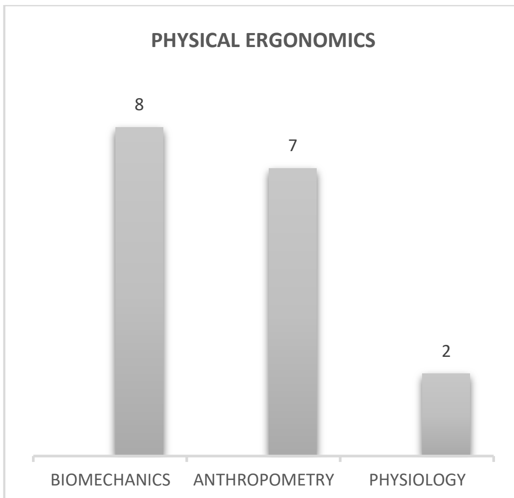
During the development of the research, a search was made of various researches that would allow the development of this document, during this search several publications were obtained whose fundamental basis is informal work and physical ergonomics from categories of analysis (physiology, biomechanics and anthropometry), the articles found were chosen according to inclusion and exclusion criteria established in the research, obtaining 20 documents that contributed to the development of this work.

Graphic 1 shows that within the 20 articles found, 15% refer to informal work where its definition, characterization parameters and statistics are contextualized at the national level in the various sectors and cities, 85% refers to ergonomics physics from its different conditions such as anthropometry, biomechanics and physiology.



Graphic 1. Description of the content of the articles

Graphic 2 the description by subject of the 17 articles related to the physical ergonomics is made, the articles related to the biomechanics present in their content information related to ranges of corporal movements, corporal postures, repetitive movements and physical factors of the development of the work in the human being , the anthropometry described in the articles describes the importance of the jobs from its correct analysis prioritizing all the corporal factors of the human being to grant him a job suitable to his labor need and physical conditions, finally the articles related to the physiology describe the bodily factors characteristic of the work gesture that generate work overload, physical wear and tear that involve the specific mechanisms of cause and effect of any physical activity.

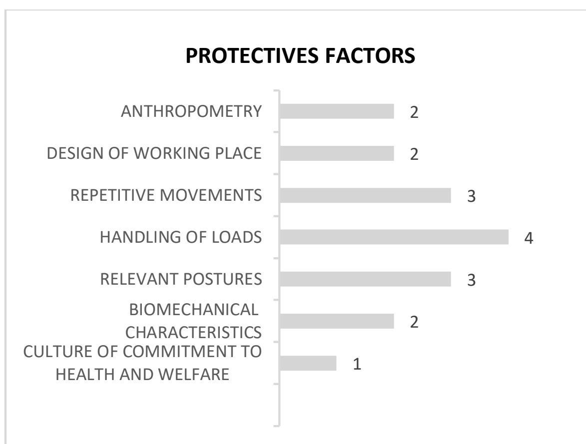


Graphic 2. Contextualization of the content.

The risk factors (graphic 3)are those that during the development of this activity increases the probability of suffering some type of alteration or injury in any situation or body area, as expressed in the graph are 7 the main factors that generate in the informal sector alteration in their well-being and quality of life, thus allowing their work practice to be limited, in the first instance the factors of biomechanical type generate in the worker greater consequences of musculoskeletal type being the postures bodily injuries have the greatest impact on the work.

Graphic 3. Risk factors in informal workers in the commerce sector.

There are several factors that allow the worker to increase their productivity and improve their physical well-being, in the graph they relate some of them found in the analysis of the articles that correlate the correct application of these factors with the quality of life and work of the person (graphic 4).



Graphic 4. Protective factors in informal workers in the commerce sector

The development or inclusion of these factors generate variables of welfare or risk in the worker that is why it is essential that every worker has healthy work practices, thus guaranteeing their physical and productive well-being where their work activity is not affected.

5. DISCUSSION

In Colombia, a number of formal labour activities are carried out where a contract of employment is concluded or is signed between the employer and the employee where certain requirements and obligations for each party during the duration of the contract; on the other hand there is the informal labour activity in which there is no contract signed between the parties concerned or the work is simply performed independently, Luna (2014) refers in his article that in Colombia there is a great tendency to increase precarious employment, informality and underemployment thus leading to a decline in employment and working conditions for most workers, which has an impact on a proportional decrease in the income of the working population, Intensification and densification of the work carried out with negative repercussions on health.

According to Ballesteros (2012) Informal work or informal economy can be taken from different perspectives, the definition of informal economy can be taken from the structuralist school (it groups unpaid family workers, self-employed persons, unprofessional or technical workers, domestic servants, employees and employers of private sector enterprises up to ten workers) such as the institutionalist school, which is based on labour and institutional legality with guarantees of social security in health, pension affiliation and employment contracts, according to it, it is understood that informal workers do not have adequate health and safety conditions so that during the performance of their work there are no situations that alter their personal and family welfare.

Ergonomics is defined by the International Ergonomics Association as described in the Gomes document (2014) as "the body of scientific knowledge applied to adapt work, systems, products and environments to the person's physical abilities and limitations". Among the areas of study we find the domain of physical ergonomics which is established as the one related to physical activity, which includes anatomical aspects, physiological characteristics, anthropometric characteristics and biomechanical factors of the human being in the working practice, where the postures, efforts and movements carried out during the development of the activity.

In the text described by Piedrahita (2014) ergonomics is described as inter and multidisciplinary science with different approaches that depend to a great extent on the approach and what we expect from it, understanding it, ergonomics allows the studies to be developed in an open way thus looking for pertinent results that guarantee the new knowledge and the solution of the problems presented by the workers during their work activities; It is therefore true that if jobs do not have the appropriate structural conditions and analysis to ensure that the activity and the labor gesture developed is the appropriate one can generate that the worker would be exposed to some factors that alter his condition and physical well-being.

During the performance of any work activity, there are various modifications or physiological alterations based on the development of the bodily metabolic needs of the human being in which the good habits are covered foodstuffs, rest and hydration which allows the proper adaptation of the body to the muscular and/or physical effort. Inadequate performance of activity generates body overexertions that increase energy expenditure and increase muscle fatigue thus generating feeling of tiredness that are reflected in musculoskeletal type injuries Zapata (2017) consider that muscle-skeletal injuries have a huge and increasing impact worldwide, from the perspective of productivity and economy of the industry, those are the main cause of pain and disability; Work overload is mainly caused by postural alterations during work activity that trigger various bodily disturbances such as pain, discomfort, movement limitation, among other characteristics representing disability and diminishing working capacity.

The work activity is complemented by activities of biomechanical and physiological type, that means that in the performance of the activity is involved internal and external bodily components as the energetic regulations, physical and mental changes it is why during the performance of any task the person must perform bodily movements within the normal comfort ranges since certain positions and/or movements generate higher body overload (see Figure 1.) this is why performing movements that are not within normal anatomical boundaries, can lead to musculoskeletal injuries, for this reason it is important that the performance of the work gesture would be appropriate and that the place where the activity described as the job is performed is the correct according to each type of productive activity, in this spaces we have to keep in mind the appropriate conditions of the environment, physical structure, among other variables taken in mind according to the anthropometry of the worker, so that this space does not trigger further complications.

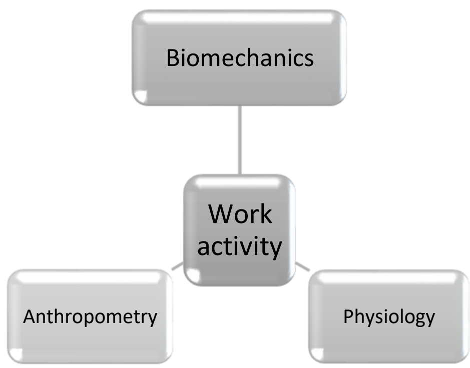


Figure 1. Determinants of work activity
Source: Elaborated by the authors

Informal work has different characteristics during its development, due to that the person who performs this activity generally performs it empirically and by necessity of subsistence, therefore it is observed that during the working day the worker performs his practice in an inergonomic way where the most of his movements are carried out outside the normal work plans which imply that all his movements must be within normal joint ranges, also because they do not have a correct job, their place of work is usually limited to developing on the ground or in elements or places that do not have the anthropometric characteristics necessary for each worker thus generating increased body fatigue, acquisition of forced bodily postures that alter the physical condition of work.

One of the greatest challenges of ergonomics has been the study of man's interaction with physical requirements (posture, strength, movement) as set out in Vernaza's text (2005) "When these requirements exceed the responsiveness of the individual or there is no adequate biological recovery of the tissues, this effort may be associated with the presence of muscle-skeletal lesions related to work."

Its study concludes that the happening of musculoskeletal lesions are associated with biomechanical risk factors (posture, strength, and movement) contributing to the scientific evidence presented by Kumar on the presumption that all occupational musculoskeletal injuries are of biomechanical origin.

The research conducted by Ordoñez (2016) describes that "Muscle-skeletal disorders (MSDs) are caused by laborious work involving prolonged, maintained and forced postures, with little chance of change, outside comfortable angles or in imbalance, with unstable or vibratory support bases, by lifting and manipulating loads and repeated movements" thus relating musculoskeletal disorders with the conditions of the physical type ergonomics where these characteristics are found that effectively generate that type of injury by not performing the work activities correctly. On the other hand, in this same document, modulating factors of an organizational type are listed that can enhance or minimize the risk of musculoskeletal injuries such as "working hours, rest time and its distribution, kinds of control, variety of work and remuneration, as well as individual conditions such the age and gender" it is why it is important to understand that in labour practice there must be rigorous controls to ensure the welfare of all workers in general regardless of the workplace.

Musculoskeletal injuries or disorders can be triggered in any region. Nevertheless, depending on the work activity developed there are some areas of the body where discomfort or injury is most likely from overload employment. Muñoz (2012) refers in their document that the pain of the spine represents a complex problem in its origin and in its consequences, it is as well as individual factors, ergonomic factors of the job and premature retirement from work, thus leading to decreases in productivity and failures in the system of management of safety and health at work since sometimes these alterations are not generated only by the work activity or the working environment but by unhealthy life habits that cause bodily disturbances.

The compilation of skeletal muscle disorders and biomechanical risk factors must be performed (see Figure 2.) as it is found in Montalvo's document (2015) in which questionnaires and risk rating were carried out according to the physical activity of the worker. The results of this study reported that 73.9% of the people were part of the health area, 49.5% of the people manifested muscle aches being the back and the upper limbs the parts of the body the most affected, which concludes that back and hand pain-wrist are significantly associated with the risk of physical load in the health area considering that these professionals must develop different positions or maneuvers to meet the patient's requirement or needs. This is why it is necessary to do a special emphasis on the proper application of ergonomics in all work areas to decrease the incidence of skeletal muscle disorders.

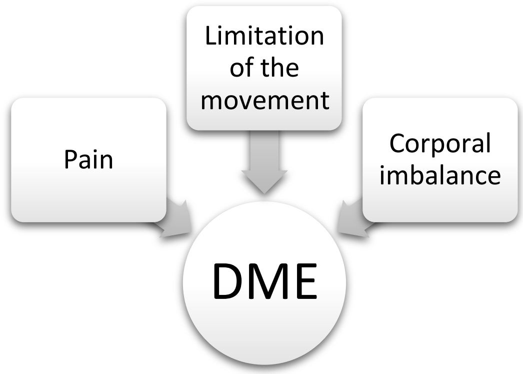


Figure 2. Characteristics of musculoskeletal disorders
Source: Elaborated by the authors

In a general level the whole population at some point in its life presents musculoskeletal problems that are not only derived from work practice but from its daily life, women have higher prevalence in musculoskeletal injuries as Rodriguez concludes (2015). In the study carried out on people from the administrative area of a University in Bogotá, Colombia, where analysis was carried out according to the methods of evaluation of physical ergonomics and showing that women had a higher prevalence of symptomatology in the neck and shoulders in reference to men analyzed, these figures can be related to the general activities carried out by women in their home and that in the Colombian population the average of women is lower than the average of men, finding anthropometric difficulty for job designs.

Musculoskeletal disorders generate various alterations that range from the quality of life of the affected workers and the productivity in their workplace, the best way of eliminating or diminishing it is giving the worker good ergonomic conditions that include their job and work environment, as mentioned during the document and corroborated in the publication by Cotè (2013). When there are no healthy conditions in jobs or places of work there are failures in the processes that harm the productivity and therefore the quality of life of workers. Managing working conditions is a fundamental part of any sector of work because if this process is not carried out, there are consequences such as increases in costs, unnecessary payments, in conclusion, it could be avoided, thus affecting the sustainability of the companies, as it is understood in his research Oviedo (2016). In every company or entity the administrative area enjoy a very important role due to that this area processes and all the possible solutions before the needs of the workers are raised, implemented and supervised, this is reflected in the results of the investigation de Dixon (2009) where they emphasize that the protocols or systems that provide guarantees to workers to avoid musculoskeletal problems or alterations of an ergonomic nature are largely due to the commitment of senior management and the individual efforts of management personnel to intervene in support of prevention programs that include health and safety at work.

It is necessary to understand that every institution, entity or company must provide safe working conditions where the worker has the necessary tools to carry out their work in the healthiest possible way. The environment or work environment is an essential part of the proper development of work activity since if it is within the ergonomic or anthropometric characteristics intended for the worker, he can perform his activity in the best way, which is why Ardila, et to the. (2013) state in their document that the definitions of a healthy work environment have evolved over the last decades, starting from an almost exclusive focus on the physical work environment (traditional occupational health and safety scheme, which considers the physical, chemical risks, biological and biomechanical) to include habits of healthy lifestyles, psychosocial factors and all that determinant that can have a profound effect on employee health and labor productivity levels.

In the work’s sectors, the employee is exposed to a number of risks inherent to the work practice, regardless of whether the work is of a formal or informal type, one must have control over the factors or characteristics that cause the complications. Many of these workers do not have knowledge about the performance of their work practice adequately because some of them acquire knowledge empirically or because their place of work is not appropriate, it is not normal for academic institutions to be taught to student and professional future as biomechanically positioned to develop their activity and this lack of teaching is reflected in the work practice where the worker generates several injuries and / or illnesses due to the improper performance of his work practice added to the lack of work stations duly analyzed according to the company's requirement and the anthropometric conditions of the worker as established in the Isper document (2018).

In several industrial sectors such as agriculture there are higher prevalence rates per year as corroborated in the document described by Barrero (2014) which states that these workers have a high occurrence of musculoskeletal diseases. In this article they emphasize the way in which the magnitude of the problem, its causes and possible solutions are understood. They propose to improve the ergonomic conditions of the working population of this sector of the industry, decreasing the presence of bodily alterations that affect the work practice, the study was carried out in 2007 in which the Ergonomics Study Center of the Department of Industrial engineer. Whose overall objective of the work is the prevention of diseases based on past projects which focused on the evaluation of the ergonomic conditions of the work, the characterization of the working population and the development, implementation and testing of solutions. Developing an effective way of prevention with the proper application of ergonomics in the industrial sector and reducing the incidence of skeletal muscle diseases in its workers.

Another important area of formal work is the cinematographic area from where the biomechanical risk assessment is carried out behind the cinema screens. As expressed in Vitela's paper (2015) show how in recent years Ergonomics has aroused more interest in the study of musculoskeletal disorders and manual handling of material, the main objective of the project was to redesign the work area , from the ergonomic point of view where it was recorded in the results that these workers have a high risk of presenting work accidents or occupational diseases due to bad practices and for not taking into account ergonomics or risk control measures in each task perform.

Another significant area of work is the area of aesthetics where some workers acquire their remuneration for the work generated in the day to day, some of these workers do not have the social benefits given by the employer and their work may not be constant but requires body wear to remain in a sitting position prolonged maneuver as done by the manicurists who must adapt to the patient's body conditions adapting their workplace to the needy to perform their work according to the need of the client, in their activity these workers they must constantly lean, rotate the body, reach the objects many times out of the normal working plane, thus generating various bodily alterations in both upper and lower trains that, due to the complexity of their workplace, cause disorders at the musculoskeletal level, this was determined through the valuation by the Rula method described in the article by Garcia (2017).

The role of ergonomics in the change of working conditions has certain perspectives in Latin America as it is mentioned in its document Gomes (2014). The evolution of the industrial society in the last centuries has been demanding of the ergonomics and the engineering of production a joint and continuous effort towards the supply of solutions through concepts, methods, techniques and tools, in order to satisfy the needs of modern societies. Among the needs of the human being is health is for this reason that from the work practice should be guaranteed to the worker the enjoyment of this, due to that in Colombia not all workers can ahieve this benefit because the informal sector is not a fundamental part of the social security system. It is observed that in various commercial activities, workers do not have the right conditions in their workplace, nor perform the biomechanically correct activity can be deduced that many of these people have musculoskeletal disorders that affect their well-being and productivity thus generating limitation and diminution of the labor development.

It is important to generate a culture of prevention in the population. Health and well-being is generated in order to reduce the incidence of musculoskeletal injuries and improve the quality of life of human beings, generating improvements in the conditions of decent and decent work regardless of the informal and formal work sector. Providing timely preventive actions for the performance of safe and timely work. Strategies and / or methods must be generated in a mandatory way that includes the informal working population and ensures that the development of their activity is appropriate, generating a reduction in injuries and repercussions on workers' health, in addition to providing the state with figures real where all the Colombian working population is included in the social security system that allows greater coverage and support.

The analysis of physical ergonomics in informal work, shows the precariousness of information due to the exhaustive search that was carried out, the vacuum of knowledge is disclosed in the informal sector of the population in general, it is for this reason that during the During the course of the research special emphasis was placed on the conditions from the domain of physical ergonomics and its different variables within which is physiology, biomechanics and anthropometry, in order to establish interactions that lead us to improve and strengthen the protective elements in the informal population in Colombia, where it is possible to optimize job designs, raise awareness about the manual handling of loads, repetitive movements, pertinent positions, thus avoiding the presence of forced or anti-gravitational positions during working hours. Which generate the greatest impact at the musculoskeletal level and they are reflected in the increase in injuries.

In Colombia, labor informality is part of the economy of the country where a large part of its population is immersed in it, these workers perform the work practice without any specific control where they are analyzed and indicate if the development of this is done optimally and does not generate repercussions on their health, nor are there policies that include informal workers in their guidelines, thus leaving this working class unprotected and thus generating shortcomings in the national health and safety at work system, taking into account that this system should include to the entire working population, thus guaranteeing the reduction of figures related to accidents and occupational diseases

6. CONCLUSIONS

• Emphasis must be placed on the creation of methods of incorporation into the system and analysis of the worker from his position of work that guarantees the development of his work activity, thus allowing inclusion in the system where the coverage of his entire population is given and allow the mitigation of injuries.
• In Colombia there are no clear guidelines or methods for the development of job analysis, for workers in the informal area.
• Workers try the work practice without any specific control where they have analyzed and indicated if the development of this is done optimally and does not generate repercussions on their health.

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EVALUATION OF ERGONOMIC RISKS IN A FLOUR TORTILLA STORE IN LOS MOCHIS, SINALOA, MEXICO

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Resumen: Las cargas posturales son un problema muy frecuente en los puestos de trabajo, pues por la cultura que se tiene en nuestro país no se les presta la suficiente atención para realizar estudios o aplicar métodos en el puesto de trabajo para poder encontrar el motivo principal de las cargas posturales para posteriormente llegar a una solución. En esta investigación se evaluará el puesto de trabajo de una tortillería de tortillas de harina en la ciudad de Los Mochis, Sinaloa, México.

La tarea del puesto de trabajo que se estudiará será la estación donde se extiende y se le da forma a la tortilla con la ayuda de un bolillo de madera, esto con el fin de estudiar los posibles DTA´s (Desorden de Trauma Acumulado) o las posibles enfermedades que pueden ser causadas en las zonas de la espalda, cuello, muñecas y hombros por lo cual para esta investigación se utilizó el método RULA (Rapid Upper Limb Assessment) el cual se encarga de evaluar las extremidades superiores del cuerpo, por medio del ángulo de la postura, para posteriormente obtener un puntaje, donde una vez obtenido el puntaje, este se utilizará para tomar una decisión para implementar cambios de forma no tan urgente si el puntaje no es alto, o en caso de obtener un puntaje alto se tendrán que implementar cambios de forma inmediata, como lo puede ser una herramienta, rotar los puestos de trabajo, cambiar las posturas, etc.

Palabras clave: RULA, repetitividad, carga postural.

Relevancia para la ergonomía: Aportamos a la ergonomía una investigación objetiva de un puesto de trabajo que es muy común en la ciudad de los Mochis, Sinaloa, con el fin de dar a conocer los riesgos ergonómicos a los que están sujetas las trabajadoras y para poder realizar mejoras en este puesto de trabajo para evitar o disminuir estos riesgos en la mayor medida posible.

Abstract: Postural loads are a very frequent problem in the workplace, because of the culture that we have in our country it is not given enough attention to conduct studies or apply methods in the workplace to find out the main reason of the postural loads, and later reach a solution. In this investigation we will evaluate the work position of a flour tortilla store in the city of Los Mochis, Sinaloa, Mexico.

The task of the job position to be studied will be the station where it is extend and gives shape to the tortilla with the help of a wooden roll. This in order to study the possible DTA's (Cumulative Trauma Disorder) or possible diseases that can be caused in the areas of the back, neck, wrists and shoulders, so because of this we used the RULA method (Rapid Upper Limb Assessment) which is responsible for evaluating the upper extremities of the body, by means of the angle of the posture, to then obtain a score, once the score is obtained it will be used to make a decision to implement changes in a not so urgent way if the score is not high, or in case of obtaining a high score, changes will have to be implemented immediately, as it can be a tool, rotate jobs, change positions, etc.

Keywords: RULA, repeatability, postural load.

Relevance for Ergonomics: We contribute to ergonomics an objective investigation of a job that is very common in the city of Los Mochis, Sinaloa, in order to give knowledge about the ergonomic risks to which the workers are subjected to and being able to perform improvements in this job to avoid or reduce these risks to the greatest extent possible.

1. INTRODUCTION

According to the research carried out by the students Romero, D. and Pacheco, R. from the Intercultural Autonomous University of Sinaloa (UAIS) El Fuerte, Sinaloa in January 2019, an evaluation of workplace in the flour tortilla store “x” was carried out by the methods of Yoshitake, Corlett and Bishop and Four Points of Luke. As a result of the different methods, it was concluded that the position of the workers requires a redesign as there is effectively fatigue, pain and tiredness throughout the workday.

Based on the foregoing, this document presents the evaluation of the position taken in a work station of a flour tortilla store, performed with the RULA method which is intended to show if there is indeed an alarmed postural load, derived from the high repeatability that exists in the process of extending the tortilla where a hand tool (wooden roll) is used. Taking the results of the evaluation, it will be decided if it is necessary or not to redesign the workstation, in order to improve the working conditions of all workers who develop the same activity and avoid health problems.

1.1 Justification

Excessive postural load in a workplace is so common that not even most of the time is taken into account, making believe that feeling tiredness, fatigue or stress at the end of the workday is something normal causing you not to take the importance necessary, that is why the present investigation pretends to make conscience through an ergonomic risk assessment, the big problem that involves having this kind of situations in the workplace where the use of any ergonomic tool or the knowledge of which are the correct positions that should be taken throughout the activity.

An article was published by the National Institute for Safety and Hygiene at Work (INSHT) of Spain in 2014, which it concludes with the existence of some diseases in the neck, back, and shoulders caused by the repeatability of job position where these areas of the body are used. The pathophysiology is a disease of the neck caused by work overload, repetitive use of muscles or forced neck postures maintained for long periods of time are factors that can trigger the contracture.

The Polytechnic University of Catalonia in Spain in 2015 made a publication related to the back problems that can be generated by the repeatability in the workplace, where you can notice the wear that the worker has in the back, for example, low back pain is a painful and persistent contracture of muscles that are in the lower back, specifically in the lumbar area.

2. OBJECTIVE

Evaluate postures acquired in a workplace, specifically in a flour tortilla store, to determine if there is excessive postural load on the worker.

2.1 Specific Objectives

- Propose the redesign of the workstation if necessary.
- Analyze the positions using the RULA method.
- Know the possible diseases derived from the repeatability of the task of tortilla spread.

2.2 Delimitation

This study is specifically aimed to people who are in the workplace of a flour tortilla store of Los Mochis, Sinaloa, expanding and shaping the tortilla with the wooden roll, where the workers are between 25 and 60 years old, being a mestizo population from the north of Sinaloa.

3. METHODOLOGY

To carry out the study, an investigation field was developed to collect data by taking pictures and video, in order to publicize the inconvenience or difficulties that a worker may have in the flour tortilla workplace, since this activity may involve DTA'S (Cumulative Trauma Disorder), because of time and the repeatability of the activity. The objective of this investigation is to take the study of the RULA method (by its acronym of Rapid Upper Limb Assessment) to be able to evaluate the positions by giving a score between 1 and 7, depending on the angles of the posture and the repeatability of itself, and determine if it is necessary to make a redesign of the workplace immediately or in long term.

In order to obtain data, the workers from the flour tortilla store “x” were interviewed. In the workplace there are 2 workers per shift, there are 2 shifts per day therefore we have a total of 4 workers per day, the range in which they find the workers is between 25 and 60 years old.

In this job position, the shift is 8 hours long and the only task of the workers is to shape and expand the dough for flour tortillas during the shift.

To carry out this research, we visited the workplace and took in consideration the following steps:

1. Workers were observed at their jobs positions while performing their activities.
2. We proceeded to take some photos and used a digital tool for the measurement of the angles in their postures.
3. Applied the RULA method to evaluate the risk that exists with the positions that are adopted in the workplace.

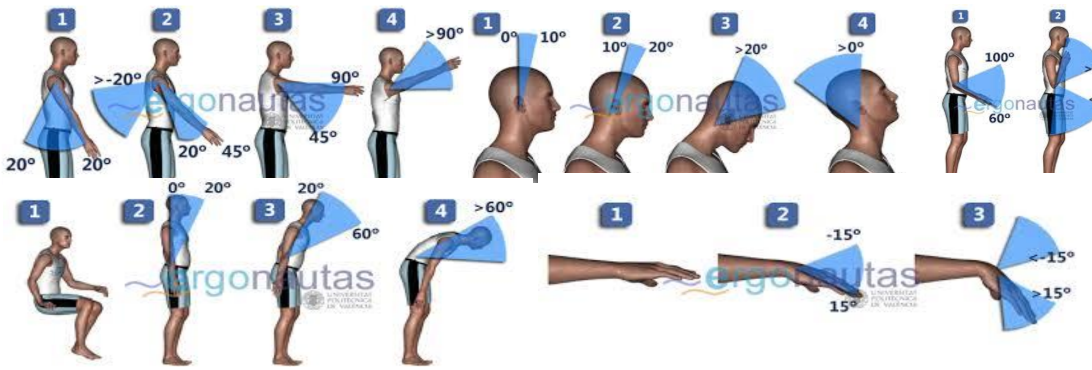

Figure 1. Score and angles of the postures in the RULA method

In figure 1 we can observe the score that will be considered depending on the posture´s angle, then locate it in the corresponding table to the extremity (neck, wrist, back, arm, and forearm) which is studied.

Figure 2. Angles of posture with extended arms (Group A)

In figure 2 we can observe the angles obtained in the parts of the body of the worker that make up group A which are arm, forearm and wrist. With these angles we can give a score to each one, the arm has a score of 3 points, the forearm has 2 points, the wrist has 4 points and 2 points in the rotation of the wrist.

Figure 3. Angles of posture with extended arms (Group B)

Figure 3 shows the angles that the worker have in the members of group B. Due to these angles the score of each one is; trunk 2 points, neck 3 points and the legs when standing normally have 2 points.

Figure 4. Angles of posture with retracted arms (Group A)

In figure 4 we observe the measure of the angles in group A of posture´s members with retracted arms, with these measures we can give them their respective score; arm 2 points, forearm 2 points, the wrist has 4 points and 2 points for the wrist rotation.

Figure 5. Angles of posture with retracted arms (Group B)

Figure 5 shows the angles of group B which are neck, trunk and legs, with this we assign their respective scores: neck 3 points, trunk 2 points and legs 2 points

Table 1. Result of group A in extended arms posture

GROUP "A" (extended arms)									
Arm	Forearm	WRIST							
		1		2		3		4	
		Wrist twist		Wrist twist		Wrist twist		Wrist twist	
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table 2. Result of group B in extended arms posture

GROUP B (extended arms)												
Neck	TRUNK											
	1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Tables 1 and 2 show the final scores of groups A and B correspondingly.

Table 3. Final score of the extended arms posture

	FINAL SCORE (extended arms)							
	Score D (neck, trunk , legs)							
Score C (upper members)		1	2	3	4	5	6	7+
	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8+	5	5	6	7	7	7	7

Table 3 shows the final score, which is the risk level of the worker's position with extended arms. It should be mentioned that because of the high repeatability in this activity we will add 1 extra point to the final score of each group.

Table 4. Result of group A in retracted arm posture

GROUP A (retracted arms)									
ARM	**FOREARM**	WRIST							
		1		2		3		4	
		Wrist twist		**Wrist twist**		**Wrist twist**		**Wrist twist**	
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table 5. Result of group B in retracted arm posture

GROUP B (retracted arms)												
NECK	TRUNK											
	1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Tables 4 and 5 show the final scores in groups A and B in arms retracted posture.

Table 6. Final score of the retracted arms posture

	FINAL SCORE (retracted arms)							
	Score D (neck, trunk, legs)							
Score C (upper members)		1	2	3	4	5	6	7+
	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8+	5	5	6	7	7	7	7

Table 6 shows the level of risk to which the worker is subjected when she has the arms retracted posture. Because of the high repeatability of this activity we will add 1 extra point to the final score of each group.

4. RESULTS

Table 7. Action levels in the RULA method

Risk Level	RULA score	Action Level
1	1-2	Posture is acceptable, and changes are not required.
2	3-4	In-depth research is required, it is possible to make changes.

3	5-6	It is required to redesign the task; it is necessary to carry out research activities.
4	7	Immediate changes are required

The score obtained according to the information in table 7 tells us that we need to make a change in the frequency of the worker's activities, or rotate the workers during the workday, since the result of the application of the RULA method indicates a risk level 3 which is suggested to make changes in the operations of the workplace as soon as possible to avoid injuries due to repeatability of their work. With the results obtained we could realize there is an excessive postural load in the job position.

5. CONCLUSIONS

The RULA method is a great tool to evaluate the upper parts of the body as it was in this investigation, thanks to this we can conclude that changes are needed in the short term to avoid problems such as those that are occurring in this job position, because this can not only be found in this flour tortilla store, this problem is generated on a large scale because it is a very common activity in microenterprises of flour tortillas by not having specialized machinery for the extension and shape of the flour tortilla.

After carrying out this investigation and analyzing the results, we can conclude that the activity that is develop in this job position leaves a serious danger in workers' health, due it presents a big risk because of the postures they have at the time of doing their activities, and if we add the high repeatability that the workers have, it locate them into a serious problem because they can get some diseases like: Epicondylitis, Quervain's disease, Torticollis, etc.

Taking into account all the above, it is recommended to make a significant change that improve their workplace which could be by raising the table or being able to use an ergonomic chair in the workplace, complementing this wearing shoes with anti-fatigue sole, and if it is possible to set tasks rotations to avoid the high repeatability that exists.

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PREVENTION OF ERGONOMIC RISKS THROUGH INTELLIGENT DEVICE

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Abstract: The objective of this project is to design a prototype that allows to prevent the occurrence of risk situations of environmental conditions for a user, identifying those situations where there is a deficient or excessive environmental condition, to let the user know when it is necessary the use of personal protective equipment, with the purpose to avoid accidents, injuries and illnesses. This, through the use of electronic sensors and a microcontroller, the ones will allow to monitor and capture the environmental conditions in the ones that the user finds himself in his workplace and in his activities in the present time, showing the intensity of the illumination, humidity relative, ambient temperature and the comparison of the environmental sound level with one previously calibrated. Being the design of this device able to alert the user when he is exposed to risk conditions in the work environment.

Key words: Environmental Ergonomics, Risk Factors, Noise, Lighting, Temperature, Humidity.

1. INTRODUCCION

A key piece to increase the efficiency is to have an ergonomic environment suitable for the worker (Velázquez, 2015). The work environment must be projected in such way that it does not have harmful effects on people, whether it be of physical, chemical or biological order, and procuring that it works to maintain health and well-being, as well as the capacity and good disposition for work. The environmental risk factors or environmental conditions are noise, lighting, ventilation, temperature, colors, vibrations and radiations. Of which, the noise, lighting, temperature and humidity, will be the conditions to be considered and evaluated in this project.

The study and evaluation of these conditions are of vital importance, since the occupational diseases and disabilities increase every year and one of the great causes of this, is the work environment to which the operator is exposed.

According to the ILO (2012), about every 15 seconds a worker dies due to work-related accidents or illnesses, equivalent to 6300 people per day; and every 15 seconds 160 workers have a work accident. Annually, an estimate of 160 million people suffers from work-related illnesses and more than 337 million accidents occur at work; many of these accidents result in work absenteeism. The ILO has estimated that 4% of the global annual gross domestic product is lost as a consequence of occupational diseases and accidents at work.

The WHO (2004), shows in its table of Ergonomic Stressors by Region, the number of people exposed to ergonomic stressors and the number of people dying of it, having globally 898 thousand people exposed to occupational ergonomic stressors attributed daily and 890 people that die because of it.

In México the situation is complicated, statistics at the national level shows the important elements to consider, in where the data presents increase in the diseases produced in the works. Of the diseases evaluated by the IMSS 2012-2014, the highest grade is hearing loss; produced by the excessive noise, with a total of 1,361 cases.

Similarly, permanent disabilities that have been diagnosed, being the hearing loss the most severe; with a total of 1,605 cases, with increases since the year of 2012 to 2014.

IMSS 2012-2014, also shows the statistics of permanent disabilities in Sonora region, where there are two disabilities with more occurrence in relation to environmental ergonomics, such disabilities are: Hearing loss and pneumoconiosis, being the hearing loss the one presented only in men. The danger in these statistics is the increase that has been having; presenting 12 cases in the year of 2014.

For all the above, the following project searches to design a device that helps to evaluate these ergonomic environmental risks by collecting information, making use of a microprocessor and electronic sensors.

Although nowadays there are high precision measuring instruments that measure several variables, it has the great disadvantage that their price is very high and they are unconventional, because most of them are for sample measurements; therefore they must be controlled by the evaluator directly; this leads to evaluate an operator, invading their work space, either because they may feel observed and as a consequence affect the accuracy of the evaluation of the same.

Having a controlled work environment is not only a matter of business ethics or a legal issue, but also a matter of productivity, efficiency and failure prevention in an organization.

1.1 Objectives

The objective is to design a prototype that allows to prevent situations of risk due to environmental conditions for a user, using electronic sensors and a microcontroller that allows to monitor the noise, temperature and humidity conditions, to which ones the operator is exposed in his workplace and associated tasks, as well to identify those where is a deficient or excessive condition.

1.2 Delimitation

The device to design will be limited to collect the levels of illumination, temperature, humidity and the exceeding of a noise threshold, as well to transmit that information through Bluetooth.

2. MATERIALS AND METHODS

For the detection of environmental conditions; that could be causes of working diseases and accidents, a set of electronic sensors will be used, the ones that will be installed on the worker's protective equipment, in order to measure the environmental conditions that the worker is exposed. This way it will be possible to monitor the environmental where the operator is during all his workday, and thus determine the exposure time to each of the situations. The activities carried out by the operator during his workday will be minimally affected because of the reduced size of the sensors.

2.1 *Procedure*

2.1.1 Define prototype elements

To perform the measurement and monitoring, 3 elements are required:

1. Measurement Sensors: The sensors are responsible for converting the information of the variables of the environment into electrical pulses.
2. Microprocessor: The microprocessor is responsible for interpreting the electrical pulses and convert it into understandable information.
3. Information transmission module: The function of this element is to transmit the information from the microcontroller to the device where we will visualize the information.

2.1.2 Select materials to be used

In order to select the materials, it was determined that the main characteristic of these was that they did not obstruct in any way with the operator acting. For it was relevant that the material to be used must be as small as possible.

The selected materials are shown below:

- Arduino Uno
- Bluetooth Module HC-05
- Temperature and Humidity sensor DTH11
- HY-037 Sound Module
- LDR 2MOhms photoresistor
- Resistances
- Motor with vibration disc
- Arduino programming and software

2.1.3 Sensor programming and Bluetooth Module

For the microcontroller to be able to interpret the electronic signals emitted by the sensors and sent it through a Bluetooth signal, it is necessary that a code be created in which the procedure that will be executed is based on the obtained information that is describe. For this, the Arduino software will be used; which works with Arduino Programming Language which is a variant of C++ language.

2.1.4 Installation of Sensors

Once the code is created, we continue with the installation of the sensors, for which the use of a helmet was chosen; due to its common use in the industry. Analyzing that the location of the sensors were the correct ones for each one of them according to the factor that they will measure, at the same time that they do not interfere with the activities of the operator.

2.1.5 Data collection

Once the previous steps have been completed, the data collection is realized. Because the device uses a Bluetooth signal to transfer the information, the "Puty" software was used to visualize the information of the environmental conditions measured with the device.

2.2 Materials

For the elaboration of this prototype it is required:

- Arduino Uno: Arduino is an open-source electronic prototype platform based on a flexible hardware and software, as well as being easy to use. The microcontroller on the board is programmed using the Arduino Programming Language.
- Bluetooth Module HC-05: This Bluetooth Module allows you to transmit information wirelessly with the Arduino board.
- DHT11 sensor: The DHT11 is a low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and displays the data via digital signal on the data pin.
- Sound Module KY-037: For sound detection the module has two outputs: AO, which is the analog output of the real-time output voltage signal of the microphone, and DO, which is when the sound intensity reaches a certain threshold, with the signal output being high and low. The sensitivity threshold can be adjusted using the potentiometer on the sensor.
- LDR, 2 MOhms: A photoresistor is a device used to measure the amount of light received at any time. One of its characteristics is that it is not linear like a photodiode, being very slow to the rapid response of variations of light intensity.
- Resistors: Electronic component designed to introduce a determined electrical resistance between two points of circuit.
- Vibration motor: This device rotates the vibration disc when it is supplied with electrical power.

3. RESULTS AND DISCUSSION

A prototype was obtained that works so that every five seconds the microprocessor reads the status of the sensors and interprets the information to show us the intensity of the illumination, relative humidity, environmental temperature and the comparison of the ambient sound level with one previously calibrated; to notify to the operator by vibrations that the calibrated sound level is being exceeded, see figures 1 and 2.

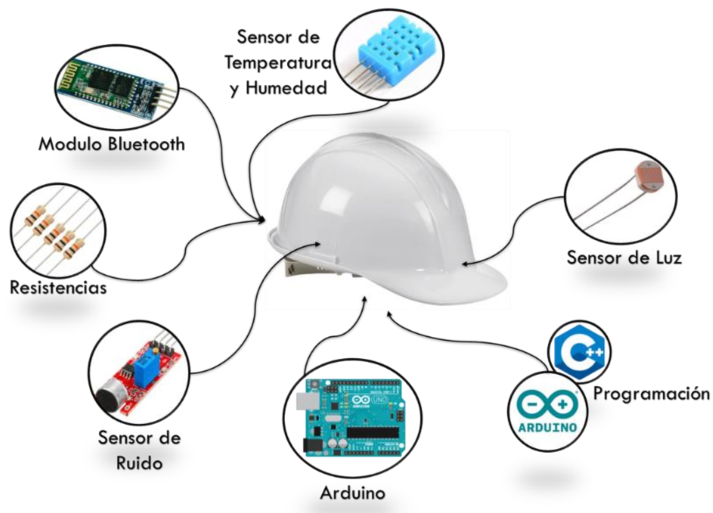
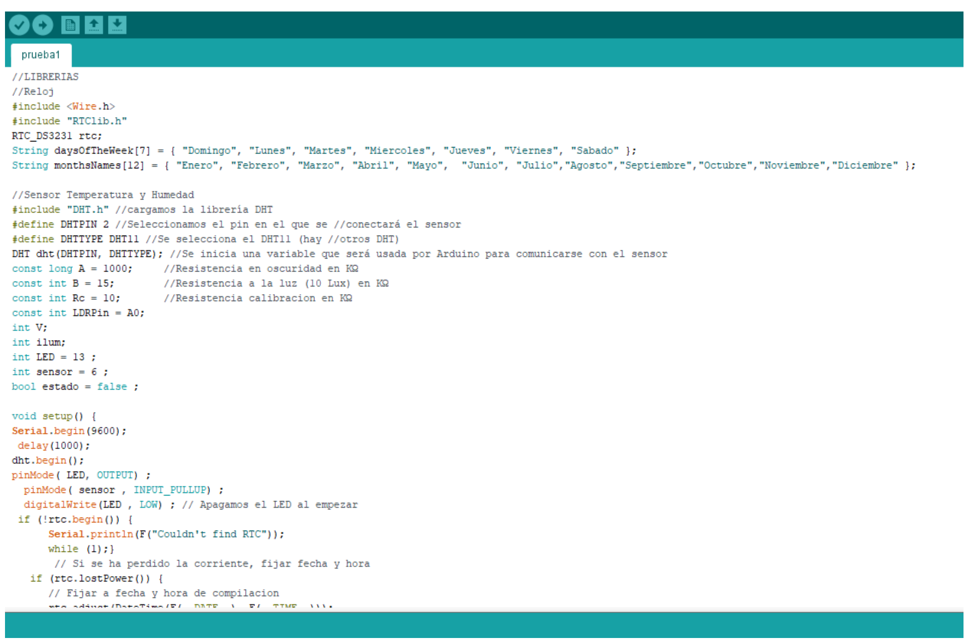


Figure 1. Components Device




```
//LIBRERIAS
//Reloj
#include <Wire.h>
#include "RTClib.h"
RTC_DS3231 rtc;
String daysOfTheWeek[7] = { "Domingo", "Lunes", "Martes", "Miercoles", "Jueves", "Viernes", "Sabado" };
String monthsNames[12] = { "Enero", "Febrero", "Marzo", "Abril", "Mayo",  "Junio", "Julio","Agosto","Septiembre","Octubre","Noviembre","Diciembre" };

//Sensor Temperatura y Humedad
#include "DHT.h" //cargamos la librería DHT
#define DHTPIN 2 //Seleccionamos el pin en el que se //conectará el sensor
#define DHTTYPE DHT11 //Se selecciona el DHT11 (hay //otros DHT)
DHT dht(DHTPIN, DHTTYPE); //Se inicia una variable que será usada por Arduino para comunicarse con el sensor
const long A = 1000;     //Resistencia en oscuridad en KΩ
const int B = 15;        //Resistencia a la luz (10 Lux) en KΩ
const int Rc = 10;       //Resistencia calibracion en KΩ
const int LDRPin = A0;
int V;
int ilum;
int LED = 13 ;
int sensor = 6 ;
bool estado = false ;

void setup() {
Serial.begin(9600);
 delay(1000);
dht.begin();
pinMode( LED, OUTPUT) ;
  pinMode( sensor , INPUT_PULLUP) ;
  digitalWrite(LED , LOW) ; // Apagamos el LED al empezar
 if (!rtc.begin()) {
      Serial.println(F("Couldn't find RTC"));
      while (1);}
       // Si se ha perdido la corriente, fijar fecha y hora
   if (rtc.lostPower()) {
      // Fijar a fecha y hora de compilacion
```

Figure 2. Code

Table 1. Data readings

Lectura	Iluminación	Ruido	Temperatura	Humedad
1	200	92.1	30°	20%
2	210	91.2	30°	20%
n	220	92.4	30°	20%

4. CONCLUSIONS

The device that is designed is able to alert the user when it he is exposed to risk conditions in the work environment and at the same time capture the data collection of the actual environmental condition, facilitating the conventional way of collecting data; which consists of an evaluator that makes use of several measurement instruments, such as the luxometer and thermometer. Obtaining as advantages that the method is not invasive in any way towards the operator, resulting to be a more comfortable and easy way, which is of great help for data collection, adding that it tells the operator when to use safety equipment; with respect to the noise.

5. RECOMMENDATIONS

It is recommended to consider the environmental ergonomics, since an unsafe work environmental supposes expenses for the company due to the accidents and illnesses that the operator could suffer, besides being one of the factors that affects productivity.

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RISKS ANALYSIS IN THE AREA OF MILLING AND PLATING IN AN AGGLOMERATED BOARD COMPANY

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Resumen: La implementación de prácticas ergonómicas en la industria de la manufactura ha tenido una tendencia creciente. Sin embargo, aún se presentan factores de riesgo en empresas dentro de este sector. Esta investigación tiene como objetivo realizar un análisis de los factores de riesgo en una empresa de manufactura dedicada la fabricación de tablero aglomerado. El análisis se enfocó en las condiciones en las cuales los trabajadores realizan sus diferentes tareas. Como método, se utilizó la herramienta de Modo de Falla y Análisis de Efectos (Failure Mode and Effect Analysis, PFMEA). Los resultados indicaron que existen 14 factores de riesgo, entre ellos fuego, falta de equipo de protección personal, y cortos eléctricos, por mencionar algunos. De estos 14 factores de riesgo, el fuego tuvo el mayor nivel de severidad y el mayor número de prioridad de riesgo (Risk priority number, RPN) con 10 y 420, respectivamente.

Palabras clave: Análisis de riesgos, factores de riesgo, PFMEA

Relevancia para la ergonomía: Esta investigación ha demostrado que el PFMEA es una herramienta que puede servir como base para proyectos ergonómicos posteriores, ya que su utilidad demostrada para detectar factores de riesgo, determinar su nivel de gravedad y generar propuestas de mejora.

Abstract: Implementation of ergonomic practices in manufacturing industry has had an increasing trend. However, risk factors are still presented in companies within this sector. This research aims to perform an analysis of risk factors in a manufacturing company dedicated to the manufacture of agglomerated board. The analysis focused on the conditions in which workers perform their different tasks. As a method, the Failure Mode and Effects Analysis tool (PFMEA) was used. Results indicated that there are 14 risk factors, including fire, lack of personal protective equipment, and electric shorts, to name a few. Of these 14 risk factors, the fire had the highest severity level and the highest risk priority number (RPN) with 10 and 420, respectively.

Keywords: Risks, analysis, risk factors, PFMEA

Relevance to Ergonomics: This research has shown that the PFMEA is a tool that can serve as a basis for subsequent ergonomics projects, since it demonstrated its usefulness for detecting risk factors, determining its level of severity and generate proposals for improvement.

1. INTRODUCTION

Although ergonomic implementation in manufacturing companies has been in an increasing trend, risk factors are still present in companies belonging to this sector. Such risk factors may include uncomfortable body postures, manual material handling, repetitive movements, mental workload, among others (Realyvásquez, Delfín-Nieblas, Hernández-Escobedo, González, & Maldonado-Macías, 2019). This research project was developed in a company located in the city of Tijuana. This company is dedicated to the manufacture of agglomerated boards. Within the facilities of the company, specifically in the area of milling and plating, there are unsafe conditions for workers, as indicated by the at least 35 occupational hazards presented during the year 2018. Figure 1 shows the working conditions in the manufacturing company, whereas Table 1 shows the different occupational risks occurred in 2018, their frequency, the area where they occurred and the damages they caused. Due to this, the company has the need to improve working conditions. Based on these backgrounds, this research analyses work conditions by means of a Failure Mode and Effect Analysis (PFMEA) tool in the area of milling and plating. The research was focused on the work conditions on which employees perform the different tasks. This risks analysis represents a first step to decrease or remove occupational risk factors in this company.

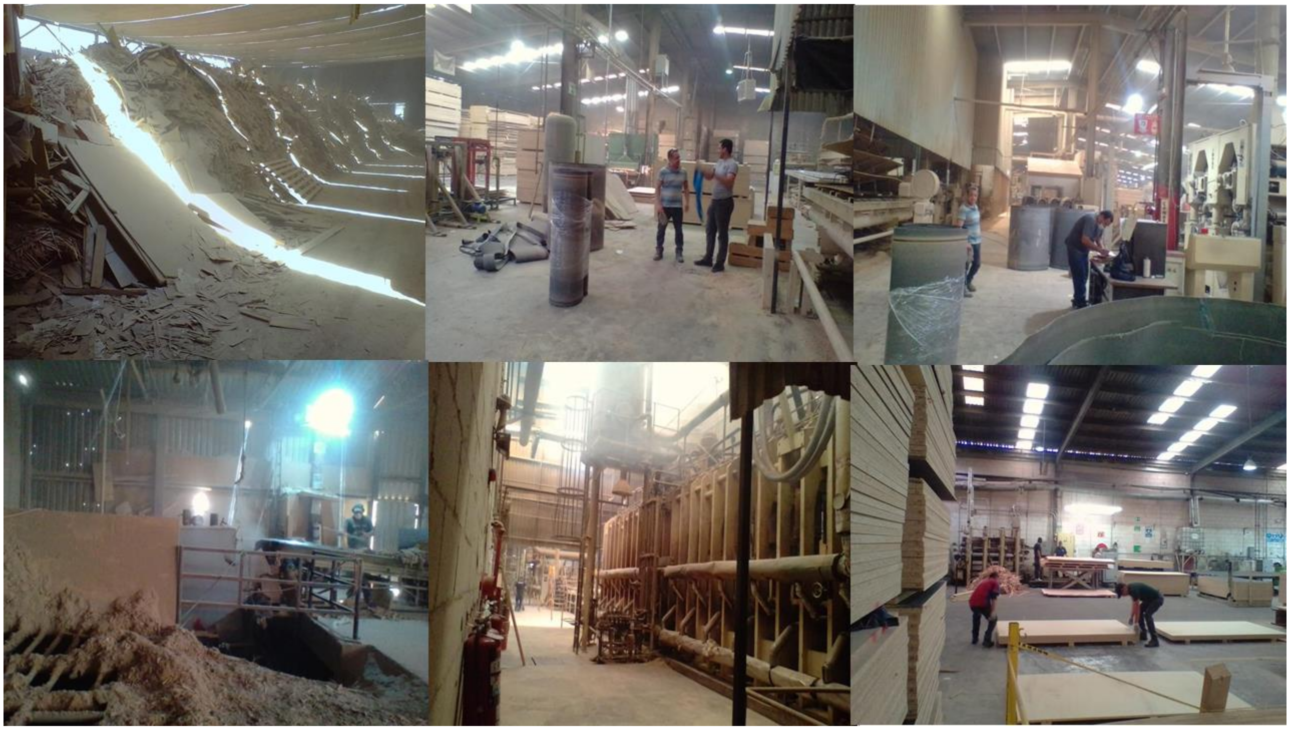

Figure 2. Working conditions in the manufacturing company.

Table 1. Occupational risks presented in 2018

Occupational risk	Frequency	Area	Damages
Fires	20	Production	Loss of equipment
Electric short	4	Milling	Loss of equipment
Finger pressing	2	Plating	Loss of extremes
Sharp and cutting wounds	3	Production/saws	Cuts in hands
Dehydration	2	Production	Fainting
Burn injuries	1	Milling	First degree burn
Tears and bruises	2	Milling and production	Tears

2. OBJECTIVES

Carry out a risk analysis of the milling and plating area, as well as proposing ergonomic improvements that help increase industrial safety and decrease work accidents.

3. DELIMITATION

The present investigation is carried out only in the area of milling and plating, and only an analysis of the risks is performed. The solutions and the problems are beyond the scope of this project.

4. METHODOLOGY

The methodology consisted of applying the steps of the PFMEA tool (Blank, 2014), which evaluates the potential failure of a product or process and its effects, identifies what actions could be taken to eliminate or minimize the failure from occurring and documents the whole procedure (Johnson & Khan, 2003). Figure 2 shows the sequence of these steps, and they are explained below.

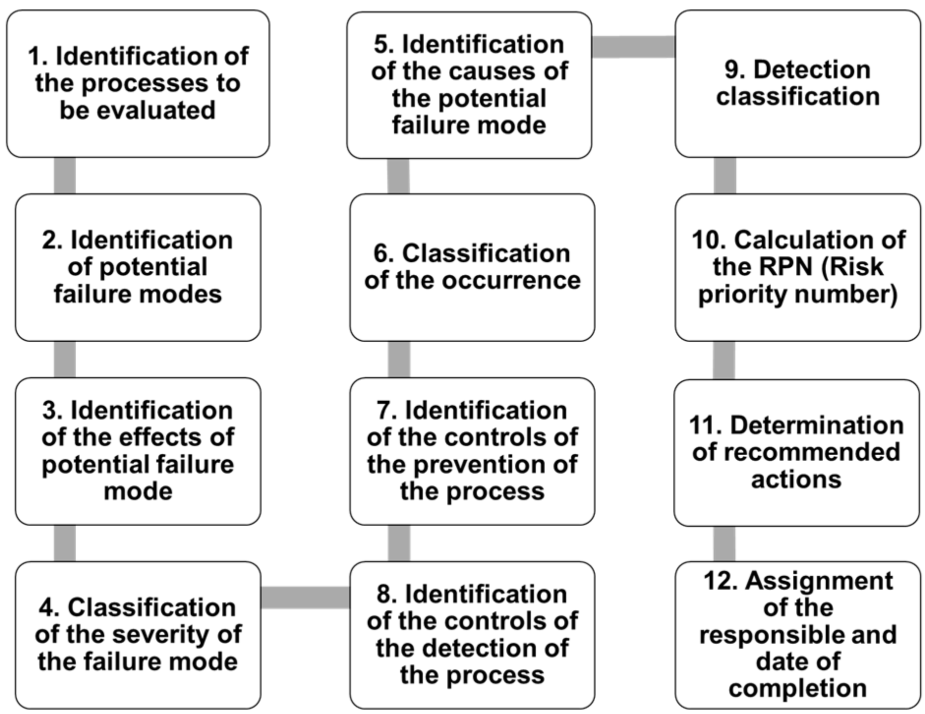

Figure 2. Steps of the PFMEA applied to the risk analysis.

Step 1: This step consists in identifying the areas where the PFMEA will be applied. To select the most critical area, data shown in Table 1 were used.
Step 2: Here, different risk factors are identified in the areas to be evaluated. These risk factors are the failure modes in the PFMEA.
Step 3: In this step, the effects of the potential failure mode are identified with respect to the consequences originated from the risk factors identified in the failure modes in the previous step.

Step 4: The weighting of severity of the risk factors was based on Table 2 (Díaz-Cajas & Quimbiurco-Villa, 2008), and by the engineers involved in the process, such as maintenance engineers, quality and production engineers for fixing each level.

Table 2. Weighting criteria for the severity of risk factors

Weighting	Description
1	None There is no reason to expect the failure to have any effect on safety, health, the environment or the mission.
2	Very low Less interruption to the capacity of the function. The repair of the fault can be completed during the report of the problem.
3	Low Less interruption to the capacity of the function. The repair of the fault may be longer than the report of the problem, but it does not retract the mission.
4	Low or moderate Moderate interruption to the capacity of the function. Some part of the mission may need to adapt or the process to be delayed.
5	Moderate Moderate interruption to the capacity of the function. 100% of the mission may need to adapt or the process to be delayed.
6	Moderate or High Moderate interruption to the capacity of the function. Some part of the mission is lost. Moderate delay in restoring the function.
7	High High interruption to the capacity of the function. Some part of the mission is lost. Significant delay in restoring function.
8	Very high High interruption to the capacity of the function. The entire mission is lost. Significant delay in restoring function.
9	Danger Potential danger of health, safety or environmental issue. Failure could occur with warning
10	Danger Potential danger of health, safety or environmental issue. Failure could occur without warning

Step 5: In this step, all the possible causes of the originating sources of each risk factor are identified.

Step 6: The weighting of the occurrence of the risk factors was based on the frequency of events presented in the year 2018 (see Table 1).

Step 7: This step identifies if there are current controls to prevent the effects of the risk factors of the areas evaluated.

Step 8: Here, we identified if there are current controls to detect the effects of risk factors.

Step 9: The weighting of the detectability of the effects of the risk factors is based on Table 3, based on the existing detection controls described in step 8.

Table 3. Weighting criteria for the detectability of risk factors

Weighting	Description
1	Almost sure Almost sure the current control detects the failure mode.
2	Very high Very high probability that the current controls will detect the failure mode.
3	High High probability that the current controls detect the failure mode.
4	Moderately high Moderately high probability that current controls will detect the failure mode.
5	Moderate Moderate probability that the current controls detect the failure mode.
6	Low Low probability that current controls will detect the failure mode.
7	Very Low Low probability that current controls will detect the failure mode.
8	Remote Remote probability that the current controls will detect the failure mode.
9	Very Remote Very remote probability that current controls will detect the failure mode.
10	Almost impossible None of the available controls can detect the failure mode.

Step 10: The next step is to calculate the Risk Priority Number (RPN) by applying Equation (1) (Pantazopoulos & Tsinopoulos, 2005).

$$RPN = Severity \times Occurrence \times Detectability \quad (1)$$

Step 11: This step lists all the recommended actions to contain the problem of risk factors.

Step 12: The responsible persons are assigned, who will be in charge of the execution of the activities recommended in step 11.

5. RESULTS

Fourteen risk factors were detected in the milling and plating area. Some of them were: noise, fire, temperature, electrical shorts, and chemical pollutants, to name a few. The level of severity of the 14 risk factors was greater than or equal to 4, in an escalation from 1 to 10. Two risk factors (fire in both areas) resulted with the level of severity of 10 and another two with a level of 9. Figure 3 shows the results for the severity, occurrence and detectability on all the 14 risk factors in the milling and plating areas.

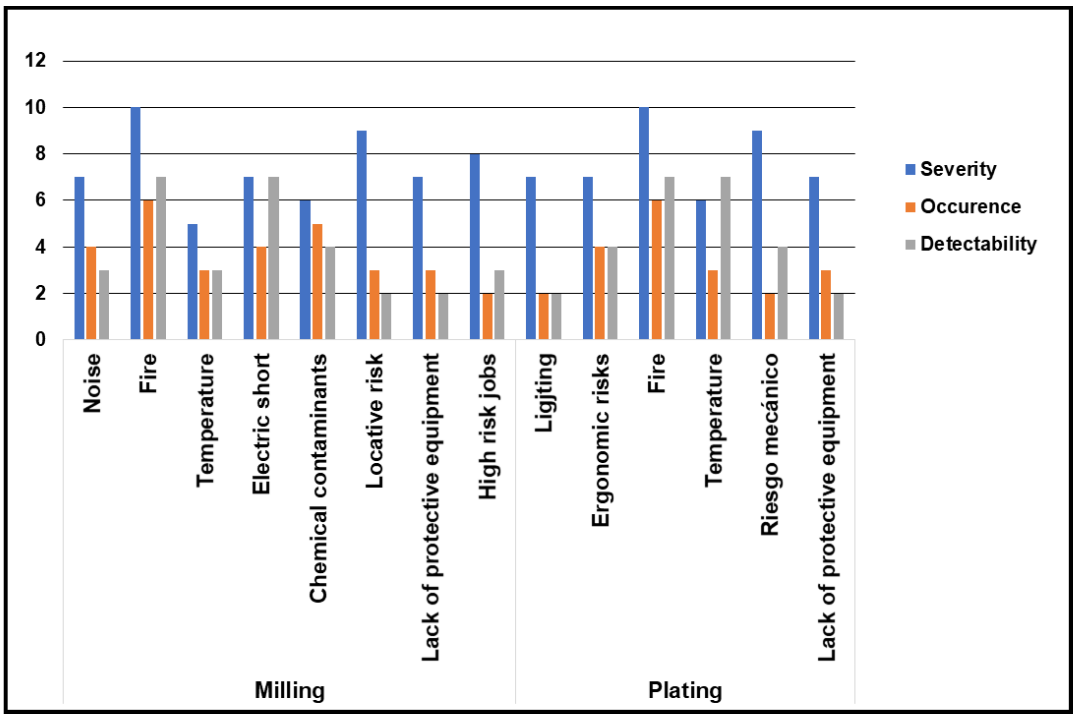

Figure 3. Severity, occurrence and detectability of the risk factors.

On the other hand, Figure 4 shows the RPN values for all the risk factors. Note that in both areas, milling and plating, fire has the highest RPN value with 420, followed by electrical short with 196 in the milling area. So, the company would have to focus on these risk factors and implement improvements, such as those mentioned in the followed section.

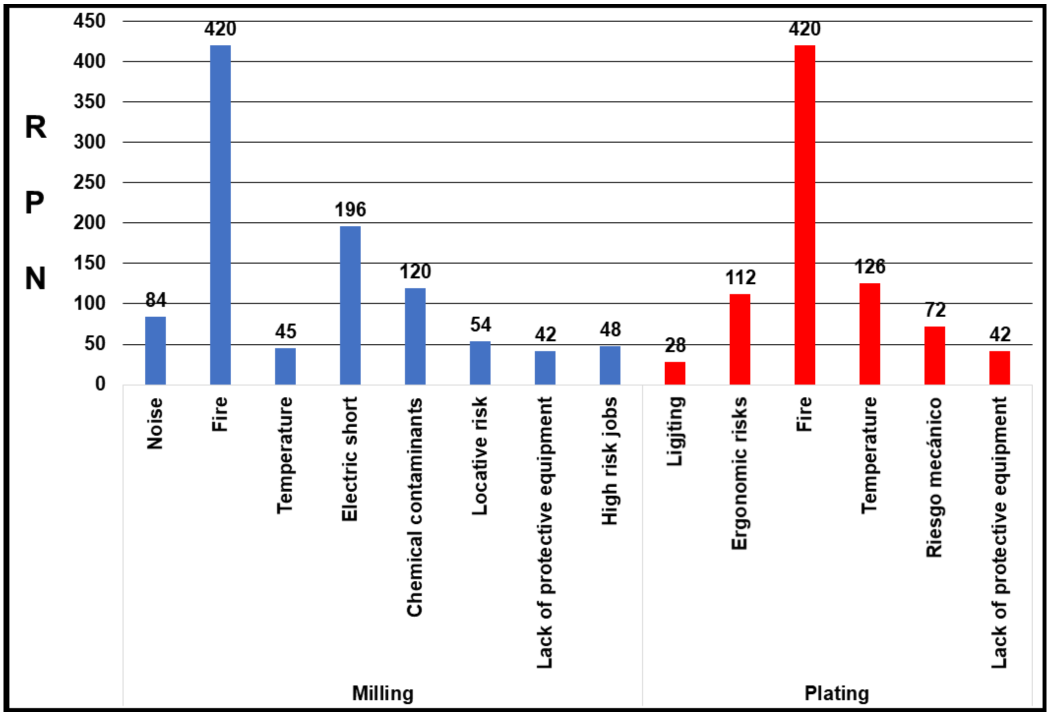

Figure 4. RPN of the risk factors.

6. CONCLUSIONS

As conclusions, the company must implement changes immediately, these changes can be taken from the recommendations arising from the application of the PFMEA. Regarding this tool, it is concluded that it is a tool that can be used as a basis for subsequent ergonomics projects, since it proved useful for detecting risk factors, determining their level of severity and generating proposals for improvement.

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PROPOSAL OF ERGONOMIC DISPLAYS FOR THE PREVENTION OF THE PIRIFORM SYNDROME IN MEN

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Resumen. El accesorio principal de un hombre hoy en día es la billetera, donde suelen almacenar efectivo, tarjetas bancarias, tarjetas de negocios, recibos, entre otras cosas. Un accesorio tan común, ¿puede causar algún tipo de daño al usuario? El hombre generalmente guarda su billetera en el bolsillo trasero de su pantalón durante todo el día, incluso cuando permanece sentado. En el momento en que se sienta, la cartera causa un declive, lo que trae consigo una inclinación de la pelvis, creando una demanda en vértebras y columna vertebral durante un cierto período de tiempo. Con el tiempo, el uso de la billetera causa el "síndrome piriforme" o "síndrome de la billetera" que, junto con el daño a la pelvis y la columna vertebral, es el daño al nervio ciático. Para la demostración de este problema, se realizaron muestras aleatorias en hombres mayores de 18 años y luego se analizaron mediante diferentes métodos estadísticos.

Palabras clave: Display, síndrome periforme, nervio ciático.

Relevancia para la ergonomía: Información y propuesta de dispositivo para el uso correcto del accesorio para guardar, que generalmente lleva al hombre a diario.

Abstract: The main accessory of a man today is the wallet, is where they usually store cash, bank cards, business cards, receipts among other things. A gadget so common, can it cause some kind of damage to the user?
The man usually keeps his wallet in the back pocket of his trousers throughout his day, including staying in a seated position. The moment he sits, the wallet causes a drop, which brings with it a pelvis inclination, creating a demand in vertebrae and spine for a certain period of time. Over time, the use of the wallet causes the "Piriformis syndrome" or "wallet syndrome" that together with damage to the pelvis and spine, are the damage to the sciatic nerve.
For the demonstration of this problem random samples were performed in men over 18 years of age, and then analyzed by different statistical methods.

Key Words: Display, Piriformis Syndrome, Sciatic Nerve.

Relevance for Ergonomics: Information and device proposal for the correct use of the gadget to keep, which usually carries the man daily.

1. INTRODUCTION

Leaving the wallet in the back pocket of the trousers is a very common habit among men. But, although it seems harmless, it can cause impingement or compression of the sciatic nerve by increased pressure in the area.

In the car, in the office, in the collective, in the bar, during lunch or during a meeting. The man usually repeats the same procedure: keep the wallet in the back pocket of his trousers and sit. This common practice, apparently simple and harmless, can bring about severe health consequences. It Was named "wallet syndrome", although it also received the denomination of "Piriformis syndrome" or "sciatic nerve entrapment syndrome", which is produced by compression of the sciatic nerve at the height of the pyramidal muscle (the gluteus).

1.1 Delimitation

Men 18 years of age or older who use wallets frequently.

2. OBJECTIVE

Create an alternative to avoid piriformis syndrome, caused by the use of the wallet in men.

2.1 Specific objectives:

1. Reduce Low back pain.
2. Improve the quality of life of man.
3. Increase man's performance during his daily activities.

3. METHODOLOGY

It Was observed how a man complained of muscular pain in the pelvic area; His explanation was that I forgot to take the wallet out of his back bag of his trousers and remained seated for a long time; Then from there came the unknown what is the matter with the wallet? An investigation was conducted to see history of this problem and indeed it was; During the investigation it was found that this problem already had a name "Piriformis syndrome" or "wallet syndrome".

This is understood by knowing the path of the sciatic nerve and its relationship with the piriformis muscle. The sciatic nerve is the largest nerve in the body. It Is A mixed nerve formed by two nerves (tibial and peroneal Common) that passes through the back of the leg, from the last section of the spine to the tibia. Born in the L4 lumbar vertebrae and reaches the S3, then leave the pelvis through the major sciatic hole and extending to the hollow popliteal (hollow that forms behind the knee) and become

In the internal and external popliteal sciatic nerves (prolongations of the same nerve). The pelvis is located under the Piriformis muscle and then covered by the muscles in the anterior compartment of the leg.

Figure 1. Mechanical Demand in vertebrates.

The sciatic nerve can be oppressed by the inflammation of the piriformis muscle, a deep muscle found in the gluteal region (trochanter). It Is an elongated muscle that covers the sciatic nerve in the pelvis area, and is the closest to the surface of all deep muscles. It originates in the sacrum and then crosses the major sciatic hole to Be inserted into the head of the femur (Trochanter major).

When the man sits on a wide purse in his pocket, a part of the hip is raised on one side, creating a levelling of the back and neck (Figure 1).

Later in a field study where a random sample of 25 was taken with an unknown population. Where the necessary variables were taken for the statistical calculations for the determination of the ergonomic problem investigated.

Hypothesis test Was used with T Student. With A confidence rating of 95%. With the formula.

$$t = \frac{\bar{x}-\mu}{s_x/\sqrt{n}},$$

(1)

Where:

X = Sample Media

μ = so-called

Sx = Standard deviation

n = Sample Size.

4. RESULTS

Table 1. Frequency of responses.

Question	Always	Sometimes	Never
How often do you suffer from muscle aches in the buttocks, leg and back?	4	13	8

In table 1. Results obtained from a random sample of 25 men over 18 years of age are shown

To whom a test of hypothesis was applied. Where the null hypothesis is; Men who use wallet in their back pocket suffer some kind of muscle discomfort in the buttocks, leg and back.

H0 = 2
H1 = 2
n = 25
X = 1.84
S = 0.4733
∝ = 0.05
by Replacing the formula (1) you get: t =-1.6902

$$t_{(0.05,24)} = -1.17$$

The calculated statistical value is greater than that of table t then; It is accepted H0 can be affirmed with a 95% confidence that all men who use wallet in their back pocket suffer some form of muscular discomfort in the buttocks, leg and back.

Table 2. Average Percentages.

Question	Yes	No
Do you use a wallet?	100 %	0%
You keep it in your back pocket?	80%	20%
Do you Usually sit with your wallet in your back pocket?	68%	32%

During The field study it was observed that the percentage indices are considerable (see table 2.), since the problem persists in more than half of the male population over 18 years; So it was given to the task of elaborating 2 possible solutions listed below. 1. Informative Display. 2. Display Vibrator for wallet.

4.1 Informative Display

Figure 2. Informative Display.

One of the possible factors of the problem raised is to ignore the subject, for this reason the informative display is proposed (Figure 2). In order to raise awareness of the male population that uses the wallet on all the ergonomic problems that the device Has forgotten in the back pocket of the trousers to remain in a seated position for a certain period.

4.2 Vibrator Display

80% of the sample of men over 18 years of age interviewed use the wallet in their back trouser pouch and 68% leave their wallet in the back pocket of their trousers to be in a seated position.

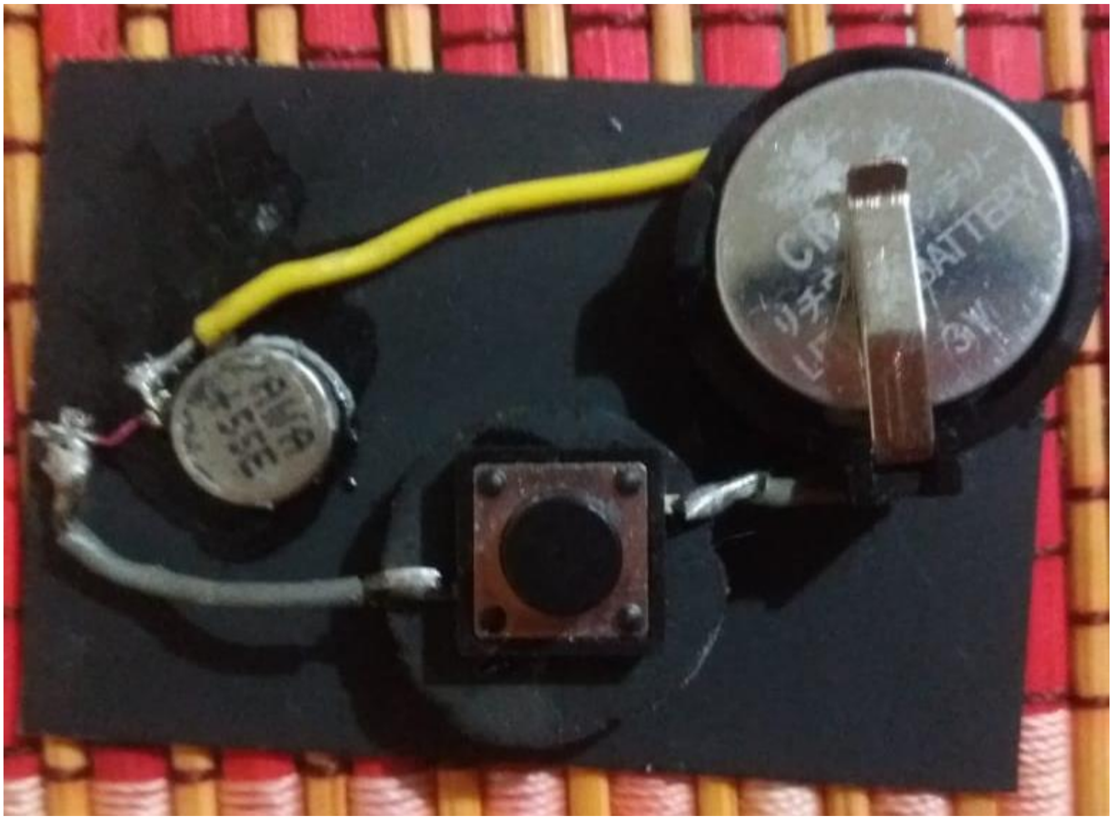

Figure 3. Vibrator Display1. .

Figure 4. Vibrator Display2

.

To decrease the percentages, a vibrator display is proposed (Figure 3) that is placed inside the wallet, the function of this is: at the time the user sits down, presses the wallet this causes the display to vibrate and reminds the user to remove his wallet from the back pocket of his trousers and consequently will not suffer any kind of sequel for misuse of the gadget. The display counts for operation with:

• Pizoelectrico
• Trainer
• Vibrator
• Metal Base
• Fabric Lining
• switch

The connection of these elements makes possible the main objective of the investigation; Avoid Piriformis syndrome in men.

4. DISCUSSION/CONCLUSIONS

The percentage indices studied are high enough to create a need for study and solutions accessible to the entire male population.

The user has the need to save his money, cards and other items, for that reason he uses the wallet. But such a gadget when overloaded or misused causes various breakdowns in the muscular system and nervous system (sciatic nerve). But ergonomics were created to adapt any device to the user; The most optimal adaptation in this research is the two display´s. The first will allow you to know the Piriformis syndrome.

The Vibrator Display prevents the use of the wallet in the back pocket by staying in a seated position.

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APPLICATION OF THE 4-POINT LUKE SCALE IN STUDENTS WHO WORK AND STUDENTS WHO DO NOT WORK FROM THE INDUSTRIAL ENGINEERING DEPARTMENT (ITLM)

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Resumen: INTRODUCCIÓN. Luke y Col. (citados por Dagnino *et al.,* 2011), utilizaron una escala para determinar el nivel de fatiga en mujeres embarazadas. En esta escala, llamada los 4 puntos de Luke, se catalogan los niveles de fatiga después de un día normal de trabajo, en donde la escala de medición es la siguiente: "nada cansado" 1 punto, "cansado" 2 puntos, "muy cansado" 3 puntos y "extremadamente cansado" 4 puntos. Las respuestas a "muy cansado" y "extremadamente cansado" fueron agrupadas en fatiga. OBJETIVO. Detectar los niveles de cansancio de alumnos con actividades laborales extraescolares y sin éstas de la carrera de Ingeniería Industrial (ITLM), por medio de la aplicación de la escala de 4 puntos de Luke. DELIMITACIÓN. El estudio se concentra en un grupo de alumnos de la carrera de Ingeniería Industrial correspondiente al quinto semestre, al momento de cursar la asignatura de Ergonomía (INF-1010, SATCA: 2-3-5). METODOLOGÍA. Se eligió a un grupo de quinto semestre de la carrera de Ingeniería Industrial, el cual se encontraba cursando la asignatura de Ergonomía (Plan de Estudios IIND-2010-227), donde 14 estudiantes trabajan y 14 sólo se dedican a sus estudios. Se utilizó la escala de 4 puntos de Luke para determinar el cansancio que experimentaban al momento de iniciar y terminar su jornada de trabajo escolar. Los datos recopilados abarcan un periodo de tiempo correspondiente a cuatro semanas. RESULTADOS. Los resultados obtenidos se tabularon según las categorías de Nada Cansado, Cansado, Muy Cansado y Extremadamente Cansado. También se analizaron las diferencias entre ambos grupos de estudiantes (aquellos con actividades laborales extraescolares y aquellos únicamente dedicados a sus estudios). CONCLUSIONES. Los estudiantes experimentan distintos niveles de cansancio al momento de iniciar y/o terminar su jornada de trabajo escolar. Cabe mencionar que los factores externos atribuidos como causantes del cansancio presentan alta diversidad; desde la carga horaria, asignaturas que cursan, la unidad o temario en estudio hasta situaciones laborales y/o familiares.

Palabras clave: Cansancio, 4 puntos de Luke, estudiantes.

Relevancia para la ergonomía: Acerca del trabajo y su relación con el bienestar de los trabajadores, Aguilar, Luna, Ramírez & Ruiz (2011) reiteran la importancia de que las personas desarrollen sus actividades laborales en un ambiente donde se aprovechen al máximo las capacidades físicas y mentales, resultando en mayor productividad, menor número de accidentes y mayor satisfacción. Sin embargo, señalan la existencia de efectos adversos, como el estrés y la fatiga, los cuales pueden ser originados por el trabajo.

Abstract: INTRODUCTION. Luke and Col. (quoted by Dagnino *et al.*, 2011), used a scale to determine the level of fatigue in pregnant women. In this scale, called Luke's 4 points, the fatigue levels are cataloged after a normal working day, where the scale of measurement is the following: "not tired" 1 point, "tired" 2 points, "very tired "3 points and" extremely tired "4 points. The responses to "very tired" and "extremely tired" were grouped in fatigue. OBJECTIVE. To detect the fatigue levels of students with extracurricular work activities and without these of the Industrial Engineering department (ITLM), through the application of Luke's 4-point scale. DELIMITATION. The study focuses on a group of students in the Industrial Engineering department corresponding to the fifth semester, at the time of taking the Ergonomics course (INF-1010, SATCA: 2-3-5). METHODOLOGY. A group of the fifth semester of the Industrial Engineering department was chosen, which was studying the subject of Ergonomics (IIND-2010-227 Study Plan), where 14 students work and 14 are only dedicated to their studies. Luke's 4-point scale was used to determine the fatigue experienced when starting and finishing a school/work day. The data collected covers a period of time corresponding to four weeks. RESULTS. The results obtained were tabulated according to the categories of Not Tired, Tired, Very Tired and Extremely Tired. The differences between both groups of students (those with extracurricular work activities and those solely dedicated to their studies) were also analyzed. CONCLUSIONS. Students experience different levels of fatigue when starting and/or finishing their school/work day. It is worth mentioning that the external factors attributed as causes of fatigue present high diversity; from the workload, subjects that take place within the semester, the unit or subject under study.

Key words: Tiredness, Luke’s 4-point scale, students.

Contribution to ergonomics: About work and its relationship with workers' well-being, Aguilar, Luna, Ramirez & Ruiz (2011) reiterate the importance of people developing their work activities in an environment where physical capacities are maximized and mental, resulting in greater productivity, fewer accidents and greater satisfaction. However, they emphasize the existence of adverse effects, such as stress and fatigue, which can be caused by work.

1. INTRODUCTION

Luke and Col. (quoted by Dagnino *et al.*, 2011), used a scale to determine the level of fatigue in pregnant women. In this scale, called Luke's 4 points, the levels of fatigue are cataloged after a normal working day, where the scale of measurement is the following: "not tired" 1 point, "tired" 2 points, "very tired "3 points and" extremely tired "4 points.

The responses to "very tired" and "extremely tired" were grouped in fatigue. In this study, the interest is to compare the students who work and students who only dedicate themselves to studies, all of them students of the Technological Institute of Los Mochis. Today, thousands of students work in order to provide for the sustenance of their family, resulting in physical and mental problems, as well as various discomforts that affect their performance in school activities.

Work is one of the most valuable sources of psychological and social well-being for human beings, and provides most of the meaning and structure of their lives. However, when combined with the academic load that a bachelor's degree requires, it can also cause negative effects, one of them being fatigue, an effect common to all activities that require effort and tension. Both men and women who work in addition to studying may suffer fatigue due to overwork or the lack of rest that can bring these two routine tasks.

However, work fatigue can also occur in students who only study, due to the load of tasks that not only affect their physical performance, but also their mental performance. Occupational fatigue can cause various physical ailments and even affect mental health, causing depression, loss of appetite, headaches, decreased attention span, among others.

2. OBJECTIVE

To detect the fatigue levels of students with extracurricular work activities and without these of the Industrial Engineering department (ITLM), through the application of Luke's 4-point scale. The study focuses on a group of students in the Industrial Engineering department corresponding to the fifth semester, at the time of taking the Ergonomics course (INF-1010, SATCA: 2-3-5).

3. DELIMITATION

The study focuses on a group of students in the Industrial Engineering department corresponding to the fifth semester, at the time of taking the Ergonomics course (INF-1010, SATCA: 2-3-5).

More precise results could be obtained by applying the surveys to the students of the different semesters of the Industrial Engineering department, including applying the study to different degrees of the Technological Institute of Los Mochis, in a way that it can be compared and interpreted if there is any difference due to the different academic charges of each grade. However, there is not enough time to calculate and interpret the results of more than 400 students.

4. METHODOLOGY

A group of the fifth semester of the Industrial Engineering department was chosen, which was studying the subject of Ergonomics (IIND-2010-227 Study Plan), where 14 students work and 14 are dedicated to their studies. Luke's 4-point scale was used to determine the fatigue experienced when starting and finishing their school/work day. The data collected covers a period of time corresponding to four weeks.

• Method for determination of fatigue

To select students to be surveyed; previously to communicate what the study is about and ask for their collaboration, in order to obtain more reliable answers.To perform a daily evaluation to each of them for four weeks, fill out the forms for determination of fatigue of the Luke’s 4-point scale.

To concentrate the answers obtained from the evaluation of the 14 students who study and work and the 14 students who only study during the four weeks. Finally, to interpret the answers and suggest recommendations.

5. RESULTS

The results obtained were tabulated according to the categories of Not Tired, Tired, Very Tired and Extremely Tired. The differences between both groups of students (those with extracurricular work activities and those solely dedicated to their studies) were also analyzed.

Students who don’t work

Table 1. WEEK 1

	ENTRY	EXIT
Not Tired	68	25
Tired	67	75
Very Tired	20	46
Extremely Tired	10	19
TOTAL	**165**	**165**

Table 2. WEEK 2

	ENTRY	EXIT
Not Tired	62	22
Tired	71	79
Very Tired	19	43
Extremely Tired	12	21

TOTAL	**165**	**165**

Table 3. WEEK 3

	ENTRY	EXIT
Not Tired	57	18
Tired	63	67
Very Tired	28	54
Extremely Tired	17	26
TOTAL	**165**	**165**

Table 4. WEEK 4

	ENTRY	EXIT
Not Tired	43	10
Tired	69	52
Very Tired	14	71
Extremely Tired	19	32
TOTAL	**165**	**165**

Students who work

Table 5. WEEK 1

	ENTRY	EXIT
Not Tired	41	25
Tired	67	47
Very Tired	20	59
Extremely Tired	28	34
TOTAL	**165**	**165**

Table 6. WEEK 2

	ENTRY	EXIT
Not Tired	37	19
Tired	57	46
Very Tired	40	63
Extremely Tired	31	37
TOTAL	**165**	**165**

Table 7. WEEK 3

	ENTRY	EXIT
Not Tired	35	16
Tired	49	43
Very Tired	44	67
Extremely Tired	37	39
TOTAL	**165**	**165**

Table 8. WEEK 4

	ENTRY	EXIT
Not Tired	28	12
Tired	47	31
Very Tired	43	63
Extremely Tired	47	59
TOTAL	**165**	**165**

6. CONCLUSION

Students experience different levels of fatigue when starting and/or finishing their school/work day. It is worth mentioning that the external factors attribute as causes of fatigue.

It can be noticed that over time young people get more tired, even those who only study, but we can appreciate that students who work and study are those who are observed with extreme fatigue.

With this information, it can be concluded that the academic load of the students is exhausting, affecting their performance. It is recommended to implement strategies that allow students to have a better school development, such as improving furniture or facilities in general, so that the student is more comfortable and can perform better in their daily activities.

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ANALYSIS OF FATIGUE IN THE DEBONING PROCESS OF CRAB

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Resumen: Análisis de los trabajadores del área de producción, en el departamento de deshuesado de la empresa. Se realizo la metodología de cuestionario de Yoshitake para hacer una evaluación de fatiga de los trabajadores, estudiar motivos de fatiga física y mental al inicio de cada jornada y en la finalización.

Palabra clave: Fatiga física, Salud Ocupacional, Yoshitake

Relevancia para la ergonomía: Hasta hace unos años, trabajar en ergonomía era una tarea reservada casi exclusivamente a algunas empresas, mientras que el resto se preguntaba si podían permitirse asumir los costos de aplicar la ergonomía en su trabajo y en su organización. Hoy en día el paisaje ha cambiado, y las empresas están comenzando a considerar si pueden soportar los costos de no tener este tipo de estudios (según los datos de la OIT, los trastornos musculoesqueléticos representan la primera o segunda causa de enfermedad ocupacional en todos los países, siendo los costos sociales y económicos que causan, particularmente alta). (Melo 2009)

Abstract: Analysis of the workers in the production area, in the boning department of the company. The methodology of Yoshitake questionnaire Was conducted to make an evaluation of fatigue of the workers, Study Motives for Physical and mental fatigue at the beginning of each day and at the end.

Keywords: Physical Fatigue, Occupational Health, Yoshitake

Relevance to Ergonomics: Until a few years ago, working in ergonomics was a task reserved almost exclusively to some companies while the rest wondered if they could afford to assume the costs of applying ergonomics in their jobs and in their organization. Today the landscape has changed, and companies are beginning to consider whether they can bear the costs of not having this type of studies (according to ILO data, Musculoskeletal disorders represent the first or second cause of occupational disease in all the countries, being the social and economic costs that cause, particularly high). (Melo 2009)

1.INTRODUCTION

Given the importance of adapting the environment to the people through the scientific determination of the conformation of the work posts, an improvement project was carried out in the company Integral Development of Jaiba de México S.A. of C.V. Located in the city of Los Mochis, analyzing from the ergonomic point of view, the deboning process in the packing plant, in order to find optimal solutions for workers to perform better when carrying out their activities; increasing its efficiency, safety and well-being; and remedy the problems that exist in the production area. The analysis was made based on the use of the Yoshitake questionnaire with fatigue measurement

We can say that Ergonomics is responsible for adapting the environment to people through the scientific determination of the creation of jobs. It is a systematic study of people in their work environment in order to improve their work situation, their working conditions and the tasks they perform; this is how it is defined by the International Labor Organization (ILO 1998)

Skeletal muscle injury (SCI) has been a concern for professionals dedicated to health, safety and hygiene at work. Cumulative trauma disorders (DTA) are a type of SCI caused by the repeated use of a joint. In several studies related to this topic it has been found that approximately 30% of workers have upper limb injuries and it is also mentioned that, with specific prevention programs, the incidence of this type of injuries can decrease. In Mexico, according to statistics from the Mexican Institute of Social Security (IMSS), during 2010 506,528 work risks were reported, of which 11.34% correspond to alterations of the superior member. 24,459 permanent disabilities were recorded; of these, those that have to do with superior member represent a 28.26%. Of the 403,336 work accidents, 34.37% are from the upper limb and of the 3,466 occupational diseases, 11.77% are diagnosed as synovitis and Teno synovitis. Another important fact reported by the IMSS is that "Synovial capsule, synovium and tendon disorders" increased between 2006 and 2010 by up to 300%

2. OBJECTIVES

2.1 General objective.

Analyze from the ergonomic point of view the deboning process in the packing plant of the company Desarrollo Integral de Jaiba de México S.A. of C.V. in order to increase the efficiency, safety and welfare of workers.

2.2 Specific objectives.

- Detect risks of physical and / or mental fatigue in workers.
- Identify the positions that can cause possible DTAs.

• Perform ergonomic evaluations with subjective methods.
• Propose improvement actions in the packing plant process

3. DELIMITATIONS

Ergonomics uses anthropometric data to design workspaces, tools, safety equipment and personal protection, considering the differences between the characteristics, capabilities and physical limits of the human body.

4. METHODOLOGY

It was done using the Yoshitake questionnaire methodology to make a fatigue assessment of the workers. Different subjective questionnaires were applied, which factors were physical and mental fatigue at the beginning of each day and at the end of the day to later analyze the results obtained. Results and discussions evaluation of fatigue and dta's Yoshitake Surveys

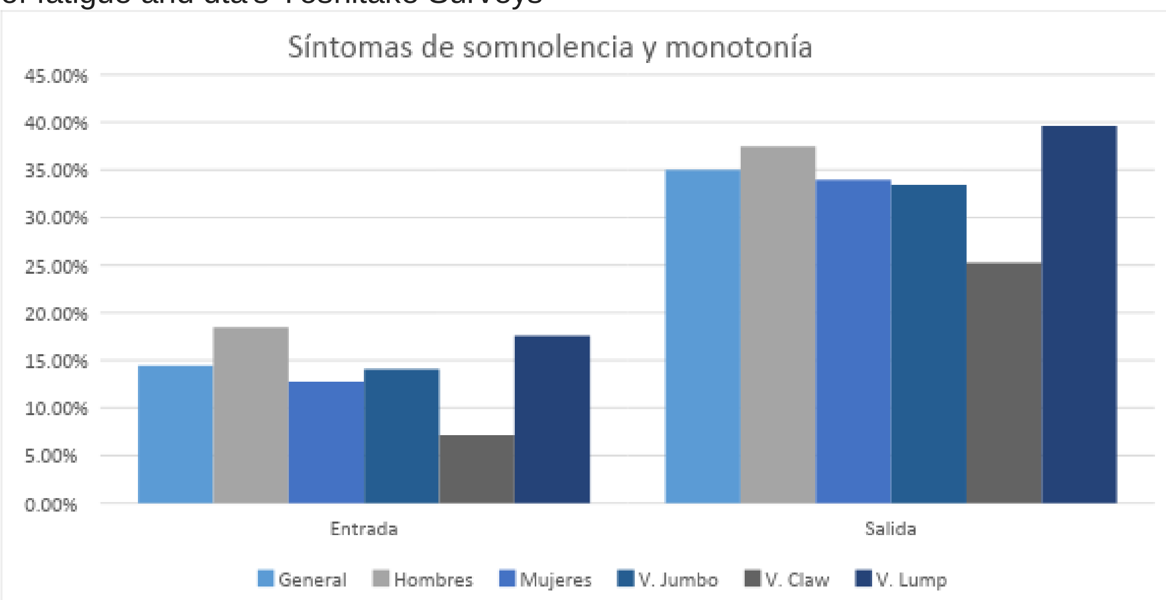

Figure 1 Symptoms of drowsiness and monotony at the time of entering and leaving work.

Yoshitake's graphs in the first part of the monotony symptoms questionnaire (See Figure 1) show in a general way the existence of fatigue that occurs during the days of the week in the period of the three weeks in which the research was carried out. It is observed that, it is maintained below 40% that they have monotony in their workday.

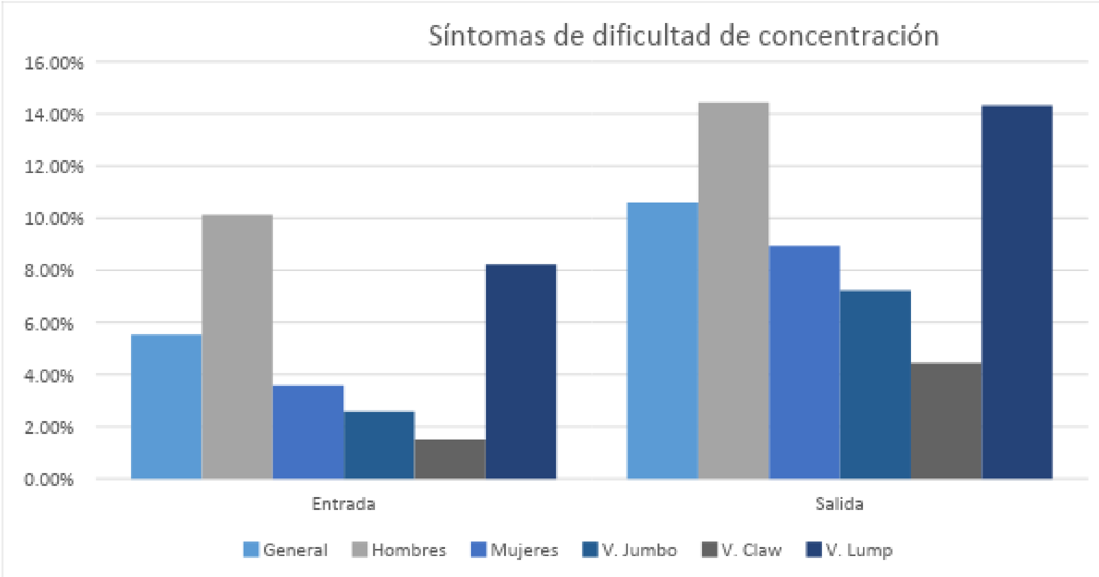

Figure 2 Symptoms of difficulty of concentration when entering and leaving work

The graphs of Yoshitake in the second part of the questionnaire on symptoms of difficulty of concentration (See Figure 2) shows in a general way the existence of fatigue that occurs during the days of the week in the period of the three weeks in which the investigation. It is observed that, they do not present too much trouble when concentrating on their activities since they are maintained at the beginning and end of their working day with less than 15% concentration difficulty.

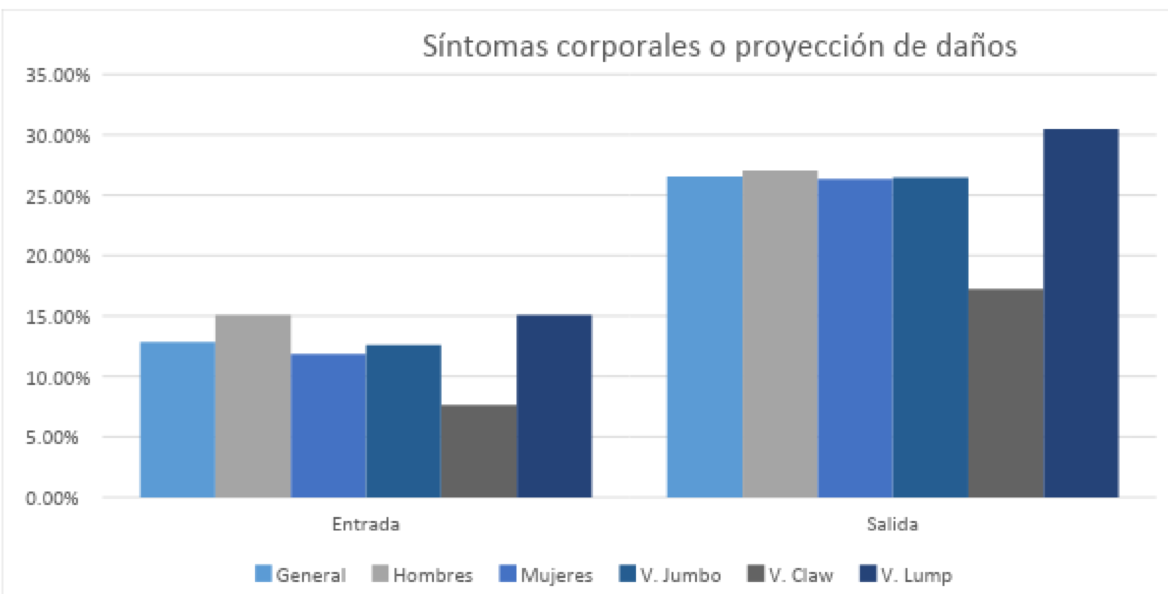

Figure 3. Body symptoms or projection of damage when entering and leaving work.

The graphs of Yoshitake in the third and last part of the questionnaire about corporal symptoms or damage projection (See Figure) shows in a general way the existence of fatigue that occurs during the days of the week in the period of the three weeks in which the investigation was carried out. It is observed that, they present little problem regarding these symptoms carrying out the activities of their day with a percentage lower than 35%.

5. RESULTS

To carry out this research, it was chosen to study the ergonomic risks, especially those in which repetitive movements of the upper extremity of the workers are carried out, since, in the characterization of the risk for this company, they occupy the first place. Repetitive movements

• Repetitive movements are made with the upper limb.

• They use mostly the wrist and the elbow and less often the shoulder. • Does not have recovery periods, only 30 minutes of food. It was noted that they spend most of the day foot.

• It has bad postures, especially in the back. It has postural overload, since they spend the two periods with a raised and flexed forearm.

6. CONCLUSIONS

According to the results obtained in this investigation, it can be concluded that:

1) The ergonomic characteristics of the evaluated workplace represent a risk to the health of workers. This is demonstrated by the results obtained when applying the ergonomic evaluation methods, likewise it was observed that the workers do not have enough breaks, nor with a safety and hygiene program that helps to prevent injuries.

2) The repetitive movements performed by the workers that generate Cumulative Trauma Disorders are: alternate movements of the hands in front and behind; bending of the wrist; extension of the wrist; and arm in abduction with forearm in flexion.

3) Both methods of evaluation showed that there is a high risk to present cumulative trauma disorders in the wrist and average risk for elbow and shoulder

7. RECOMMENDATIONS

Taking into account the suggestions of different authors (Gutiérrez, 2006, López, 2008, Rodríguez, s / f, and Zaragoza, 2009) and the results obtained in this research, the following proposal of preventive and control measures is prepared: At the beginning of the day, in each work break and at the end of the day, perform relaxation exercises and strengthening the anatomical structures of the upper limb

1.-The exercise routine suggested to be performed during the workday does not exceed 15 minutes and should be done daily at the beginning, during work breaks and at the end of the day. They can be done sitting or standing.

2.-Since postures and natural movements are essential for effective work, it is important that the workplace is adapted to the operator's body dimensions.
In the work stations of the boning process currently work of 6 people deboning and 1 reviewing the process with a total of 7 people, up to 8 people deboning and 1 reviewing the process with a total of 9 people working depending on the number of people who have attended that day to work (See Figure 4).

Figure 4 Current measurements of stainless steel tables.

A work table was designed to have a better layout of the space that is needed for the realization of the tasks that are developed in the jobs

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ANALYSIS OF FATIGUE BY THE 4 POINTS OF LUKE AND YOSHITAKE IN WATER TREATMENT PLANT POTABLE WATER BOARD IN THE MUNICIPALITY OF AHOME.

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RESUMEN. En términos generales se define la fatiga como "el fenómeno que aparece en los seres vivos, directamente relacionado con la actividad de uno o varios órganos, que consiste en una disminución del rendimiento, acompañada o no de sensación de cansancio". Desde el punto de vista fisiológico, podemos considerar la fatiga como: "sensación penosa que se experimenta después de un trabajo físico o intelectual, prologando o intenso".

La fatiga laboral es una consecuencia de la actividad excesiva y del trabajo monótono, pudiendo ser aliviada con horarios razonables, periodos de descanso adecuados y tiempo suficiente para el sueño, el recreo y la alimentación. La fatiga por tanto, se presenta como una aptitud decreciente para efectuar un trabajo. Los periodos de trabajo largos van asociados inevitablemente al cansancio, en estos casos, la sensación de fatiga actúa como un dispositivo de protección del organismo, que sirve para impedir el agotamiento total.

En el presente trabajo se evaluaron a los empleados de diferentes áreas de la potabilizadora mediante la implementación de la Prueba de síntomas subjetivos de fatiga o Cuestionario de Yoshitake y los 4 puntos de fatiga de Luke, Para determinar si se presentaban los siguientes síntomas: de somnolencia y monotonía, de dificultad de concentración o síntomas corporales o proyección de daños físicos. Con esta metodología se lograron obtener los grados de cansancio que presentaban los trabajadores al concluir sus jornadas laborales.

Una vez realizado el análisis aplicando las metodologías antes mencionadas se visualizó que existen ciertos grados de fatiga originadas por deficiencias en cuanto a diseño y condiciones de las instalaciones. Tomando en cuenta los resultados obtenidos mediante las metodologías de Yoshitake y 4 puntos de Luke, se logró tener un panorama real de la situación que presentó la planta potabilizadora en relación a la fatiga de sus trabajadores y la relación directa en la disminución del rendimiento laboral, lo que ayudó a detectar los principales problemas que originaban estas causas e implementar las posibles soluciones para estos.

Palabras clave: Salud ocupacional, Yoshitake, 4 puntos de Luke y Fatiga

Relevancia para la ergonomía: Disminuir la fatiga laboral, lesiones y tiempos de paro.

ABSTRACT. In general terms fatigue is defined as "the phenomenon that appears in living beings, directly related to the activity of one or several organs, which consists of a decrease in performance, accompanied or not by a feeling of fatigue". From the physiological point of view, we can consider fatigue as: "painful feeling that is experienced after physical or intellectual work, prolonged or intense".

Work fatigue is a consequence of excessive activity and monotonous work, which can be alleviated with reasonable hours, adequate rest periods and sufficient time for sleep, recreation and feeding. Fatigue, therefore, appears as a decreasing ability to perform a job. Long periods of work are inevitably associated with fatigue, in these cases, the feeling of fatigue acts as a protective device of the body, which serves to prevent total exhaustion.

In the present work, employees from different areas of the water treatment plant were evaluated through the implementation of the Fatigue Symptoms Test or the Yoshitake Questionnaire and the 4 fatigue points of Luke, to determine if the following symptoms were present: drowsiness and monotony, of difficulty of concentration or bodily symptoms or projection of physical damage. With this methodology it was possible to obtain the degrees of fatigue that the workers presented at the end of their working days.

Once the analysis was carried out applying the aforementioned methodologies, it was seen that there are certain degrees of fatigue caused by deficiencies in design and conditions of the facilities. Taking into account the results obtained through the methodologies of Yoshitake and Luke's 4 points, it was possible to have a real picture of the situation presented by the water treatment plant in relation to the fatigue of its workers and the direct relationship in the reduction of work performance, which helped detect the main problems that caused these causes and implement the possible solutions for these.

KEY WORDS: Occupational health, Method 4 points Luke and Yoshitake, Fatigue

RELEVANCE TO ERGONOMICS: Decreased work fatigue, injury, downtime

1. INTRODUCTION

The water treatment plant has a network of 42 facilities distributed by the municipality, this being the main plant. It is necessary to establish bases for future adjustments, thus allowing the human capital to carry out its tasks without risking their physical integrity, complying with the provisions of the Federal Regulations on Safety and Health at Work. The analysis of the plant is required to know that both workers and facilities are in optimal conditions, based on different tools.

2. GENERAL OBJECTIVE:

Detect those facilities and operations within the water treatment plant of JAPAMA that require redesign, based on an analysis of ergonomic factors that may put the health or well-being of the worker at risk.

2.1 Specific objectives

Evaluate the design of facilities and operations of the water treatment plant.
Perform fatigue analysis among operators.
Make proposals for improvement for its future implementation

3. DELIMITATION

Water treatment plant of JAPAMA

4. METHODOLOGY

The methodology of the Yoshitake questionnaire and 4 Luke points were used. To determine if the following symptoms were present: drowsiness and monotony, difficulty concentrating or bodily symptoms or projection of physical damage.

These were carried out in each of the areas in which the plant was segmented, applying the corresponding formats of the aforementioned methodologies. Subsequently, the formats that were used in each of the areas were selected, making modifications to obtain customized formats of the activities carried out in the plant.

The first evaluation instruments selected, aimed at analyzing broadly the ergonomic situation of the facilities, so that the criteria to be considered in that evaluation were selected.

Once all the evaluation formats were applied, we proceeded to collect all the information obtained, digitize the formats and create a database for further treatment in order to locate those red lights that indicate which areas or operations of the plant should be modified

5. RESULTS

5.1 Fatigue Analysis Results

A fatigue analysis seeks to determine if the worker observed is experiencing fatigue or possible deterioration of accumulated trauma thanks to the work activities performed. Based on the results of the fatigue analysis, it is possible to carry out corrective actions for the welfare of the personnel.

For three weeks, symptoms were analyzed in the workers to determine if there were levels of fatigue that could put the worker's physical integrity at risk. To arrive at a conclusion, two methods were applied, throwing information that ranged from general, with Luke's Four Points, to the Yoshitake Questionnaire. In general, the results obtained in aspects of fatigue are not very useful, which are broken down in the following points.

5.2 Four Points of Luke

As mentioned above, among the methods applied, it is this one that yields the most general results, due to the simplicity of its questions and answers. For three weeks, each of the four workers was questioned about the level of fatigue experienced at the beginning and end of their workday

Table 1. Luke's Four Point Results Table

HOW DO YOU FEEL GENERAL?

TRABAJADOR	MOMENTO	L	M	M	J	V	S	D	L	M	M	J	V	S	D	L	M	M	J	V	S	D
IGNACIO SUÁREZ OCHOA	START OF DAY		1	1	1	1	1			1	1	1	1	1			1	1	1	1	1	
	END OF DAY		1	1	2	1	1			1	1	1	1	1			1	1	1	1	1	
LEÓN RUIZ CAMACHO	START OF DAY	1			1	1	1	1	1			1	1	1	1	1			1	1	1	1
	END OF DAY	1			1	1	2	1	1			1	1	1	1	2			1	2	1	1
JAVIER VERDUZCO VALE	START OF DAY	1	1	1			1	1	1	1	1			1	1	1	1	1			1	1
	END OF DAY	1	1	1			1	1	1	1	1			1	1	1	1	1			1	1
LUIS ESPINOZA LUGO	START OF DAY	1	1	1	1			1	1	1	1	1			1	1	1	1	1			1
	END OF DAY	1	1	1	1			1	1	1	1	1			1	1	1	1	1			1

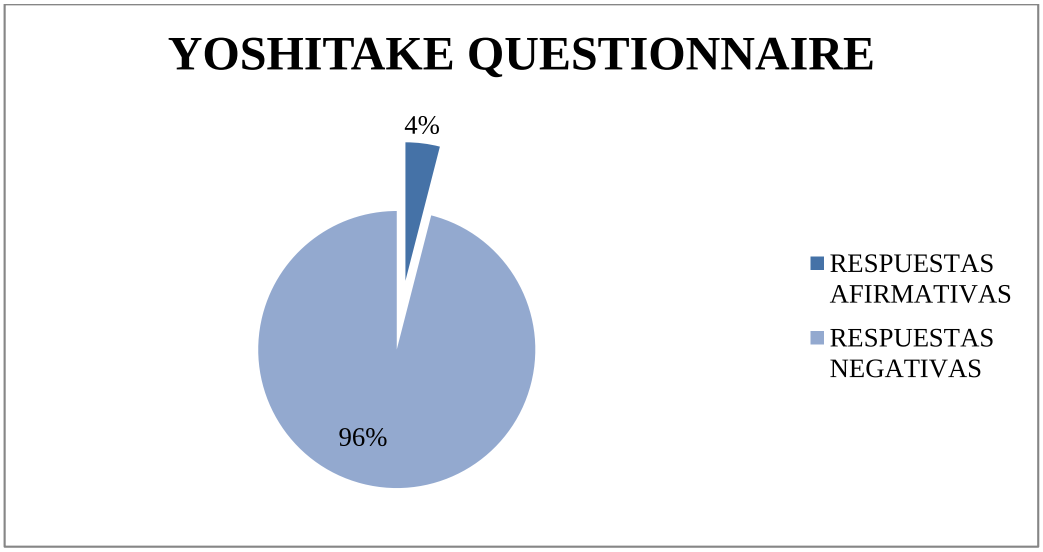
1. NOTHING TIRED 2. TIRED 3. VERY TIRED 4. EXTREMELY TIRED

Own source

As it is possible to appreciate in Table 1, there is minimal variation of the results, ranging between "not tired", with a 96.66% frequency and "tired" with 3.33%.

5.3 Yoshitake questionnaire.

Continuing with the fatigue analysis, the Yoshitake Questionnaire was applied, which consisted in the application of 30 questions over three weeks at the beginning and end of the workday. Like the previous method, its results do not allow to demonstrate the existence of fatigue among workers.



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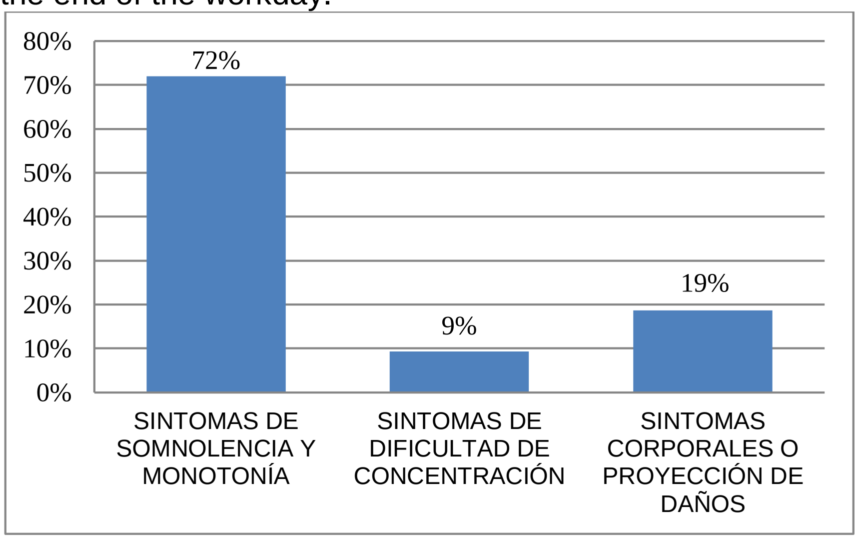
Graph 1. Preliminary results of the Yoshitake Questionnaire

As shown in graph 1, only 75 questions were answered in the affirmative, equivalent to 4% of the total number of questions asked over three weeks, of which 67 were at the end of the workday.



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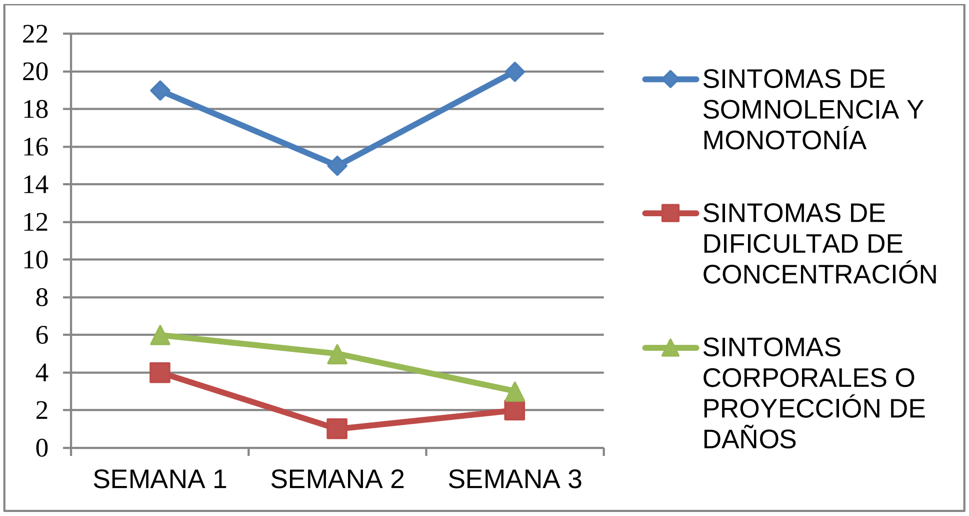
Graph 2. Distribution of affirmative answers from the Yoshitake Questionnaire

Graph 2 shows that the aspect with the most affirmative answers was the symptoms of drowsiness and monotony with 72%, due to the routine results of the activities performed, on the other hand, the one that had the lowest incidence was the Symptoms of Difficulty of Concentration with 9%.



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Graph 3. Behavior of the results of the Yoshitake Questionnaire

In order to determine if the levels of fatigue increased as the weeks of study passed, graph 3 was constructed, where it is possible to appreciate that the response behavior does not follow a defined pattern, because some factors decreased along the study.

6. CONCLUSION

Once the analysis was carried out using the aforementioned methodologies, it was concluded that there are certain degrees of fatigue caused by deficiencies in the design and conditions of the facilities. Taking into account the results obtained through the methodologies of Yoshitake and Luke's 4 points, it can be affirmed that, the current situation of the water treatment plant, once detected the main problems that were located in the different areas of the plant, call lack of equipment, poor installation conditions, unsafe situations and other safety problems. These factors contribute to the generation of certain problems related to the work performance of employees.

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COMPARISON OF DISCONFORT AND BODY PAIN IN STUDENTS WHO WORK AND STUDENTS WHO DO NOT WORK

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Resumen: INTRODUCCIÓN. La incomodidad corporal es considerada como un estado desagradable que puede seguir a un esfuerzo inconveniente en el trabajo, a la mala salud o al conflicto psicológico o sociológico. La Organización Mundial de la Salud la define como "*Un estado de mala salud*". Es considerada como una señal de advertencia al organismo de que algo puede ser perjudicial o peligroso; su manifestación es el dolor el cual se puede experimentar de muchas formas, desde una sensación vaga hasta el dolor agudo que impida toda actividad o una sensación de hormigueo y/o entumecimiento. Muchos estudiantes logran desarrollar las competencias necesarias en su proceso formativo que favorecen la consecución de sus objetivos académicos, mientras que otros jóvenes presentan dificultades que sólo se registran en indicadores de elevado abandono académico. Existen personas que además de dedicarse a sus estudios, se toman un tiempo para trabajar, lo cual puede hacer que el estrés aumente en gran porcentaje, así como también los malestares corporales. OBJETIVO. Comparar la molestia/dolor corporal, detectado por medio del mapa de Corlett & Bishop, entre alumnos con actividades laborales extraescolares y sin éstas. DELIMITACIÓN. El estudio se concentra en un grupo de alumnos de la carrera de Ingeniería Industrial correspondiente al quinto semestre, al momento de cursar la asignatura de Ergonomía (**INF-1010, SATCA: 2-3-5**). METODOLOGÍA. Se eligió a un grupo de 5to. semestre donde 14 estudiantes trabajan y 14 sólo se dedican a sus estudios, respondieron un cuestionario por semana durante un mes, donde se analizaban la cantidad de malestares corporales que sentían al iniciar y terminar su jornada escolar y se compararon los resultados del grupo de estudiantes que trabajan y los que no, con la finalidad de detectar en cuál grupo de alumnos se concentran más molestias. RESULTADOS. Se tabularon los resultados en dos categorías: estudiantes que trabajan y estudiantes que no trabajan, midiendo su desempeño tanto al iniciar la jornada como al terminar. CONCLUSIÓN. Es notorio como el índice de molestias corporales en personas que además de estudiar se dedican a trabajar, es mayor que el de los estudiantes regulares y las cifras son lo suficiente altas como para atender ese foco rojo dentro de ese grupo, así como de cualquier escuela.

Palabras clave: Molestia, dolor, Corlett & Bishop, estudiantes.

Relevancia para la ergonomía: Es poca la importancia que se le da a la comodidad o condiciones en las que los estudiantes se desenvuelven, sin embargo, pasan por bastantes factores que deterioran su bienestar tanto corporal como psicológico. Mucho menos se toma en cuenta a personas que no sólo estudian, sino que también se desenvuelven en el medio laboral, los cuales pasan por más estrés que el estudiante regular, conociendo estos datos se pueden mejorar las instalaciones y ambiente de los estudiantes, lo cual es muy importante.

Abstract: INTRODUCTION. Body discomfort is considered an unpleasant state that can follow an inconvenient effort at work, poor health and psychological or sociological conflict. The World Health Organization defines it as "a state of ill health". It is considered as a warning signal to the body that something may be harmful or dangerous; its manifestation is pain which can be experienced in many ways, from a vague sensation to acute pain that prevents any activity or a sensation of tingling and/or numbness. Many students manage to develop the necessary competences in their educational process that favor the achievement of their academic objectives, while other young people present difficulties that are only registered in indicators of high academic dropout. There are people who, besides dedicating themselves to their studies, take time to work, which can cause stress to increase in a large percentage, as well as body discomforts. OBJECTIVE. To compare body discomfort/pain, detected by means of the Corlett & Bishop map, among students with out-of-school work activities and without them. DELIMITATION. The study focuses on a group of students in the Industrial Engineering department corresponding to the fifth semester, at the time of taking the Ergonomics course (INF-1010, SATCA: 2-3-5). METHODOLOGY. A group where 14 students work and 14 only dedicate themselves to their studies was selected, they answered a questionnaire per week during a month, where they analyzed the amount of corporal discomfort they felt at the beginning and end of their school day and compared the results of the group of students that work and those who do not, with the purpose of detecting in which group of students has more damage. RESULTS. The results were tabulated in two categories: students who work and students who do not work, measuring their performance both at the beginning of the day and at the end. CONCLUSION. It is notorious that the index of body discomfort in people who works and studies, it is higher than the index of regular students and the figures are high enough to address the red focus within that group.

Key words: Disconfor, pain, Corlett & Bishop, students.

Contribution in Ergonomics: There is little importance given to the comfort or conditions in which students develop, however, they go through many factors that impair their well-being both physical and psychological. There are even more factors that should be thought of when talking about students that don’t only attend to school but also have either a part-time or full time job.

1. INTRODUCTION

Body discomfort is considered an unpleasant state that can follow an inconvenient effort at work, poor health or psychological or sociological conflict. The World Health Organization defines it as "a state of ill health". It is considered as a warning signal to the body that something may be harmful or dangerous; its manifestation is pain which can be experienced in many ways, from a vague sensation to acute pain that prevents any activity or a sensation of tingling and / or numbness.

Many students manage to develop the necessary competences in their educational process that favor the achievement of their academic objectives, while other young people present difficulties that are only registered in indicators of high academic dropout. In this last situation, students generally experience a high stress load during their formative process (Mendez, 2015).

Some students manage to develop adequate strategies to face the academic demands, while others do not achieve it, and they come to feel impeded to modify the problematic situation, which results in the use of escape or avoidance behaviors as forms of coping that are not necessarily appropriate in this situation. As is known, problems that are not resolved grow and are accompanied by a cumulative process of prolonged discomfort.

This can contribute to generate feelings of not being able to give more of himself, both physically and psychically, a negative attitude of criticism, devaluation, loss of interest in transcendence, value in the face of study and growing doubts about one's ability to perform it.

There are people who, besides dedicating themselves to their studies, take time to work, which can cause stress to increase in a large percentage, as well as body discomforts. This statistical analysis of fatigue, injuries and pain is presented comparing people who study and people who study and work, with the main idea that students who study and also work, face greater physical and psychological strain than those who do not work.

A study was carried out using the Corlett and Bishop questionnaire, considering students in the 5th semester of the Industrial Engineering field of the Technological Institute of Los Mochis, who had classes lasting 2 hours. These students were questioned for 4 weeks.

2. OBJECTIVE

To compare body discomfort/pain, detected by means of the Corlett & Bishop map, among students with extracurricular work activities and without them, also considering the duration of each one of their classes.

To subsequently seek the optimal solution and offer facilities, within our reach to colleagues whose work, employment or occupation interfere in some way with their objective of reaching the maximum school development and project the highest scope of their abilities.

3. DELIMITATION

The study focuses only in a group of students of the Industrial Engineering department corresponding to the fifth semester, at the time of taking the subject of Ergonomics (INF1010, SATCA: 2-3-5). More concise results could be achieved if we had a larger sample, encompassing more groups and degrees within the campus.

4. METHODOLOGY

Among all the groups of the Technological Institute of Los Mochis and their diverse degrees, a group of fifth semester of Industrial Engineering was chosen where, according to the registry, 14 students work and 14 only dedicate themselves to their studies, they answered a questionnaire per week for a month.

This study analyzed the amount of body discomfort felt at the beginning and end of their school day and compared the results of the group of students who work and those who do not, in order to detect which group of students are more damaged. The average age of the students is 20.5 years old and the duration of their classes is 2 hours.

5. RESULTS

The results obtained were tabulated in two categories, students who do not work and students who work, analyzing their pain and disconfort:

Table 1. First week

	STUDENTS WHO DON'T WORK		STUDENTS WHO WORK	
	DISCONFORT	**PAIN**	**DISCONFORT**	**PAIN**
ENTRY	**186**	**16**	**218**	**69**
EXIT	**186**	**50**	**256**	**136**

Table 2. Second week

	STUDENTS WHO DON'T WORK		STUDENTS WHO WORK	
	DISCONFORT	**PAIN**	**DISCONFORT**	**PAIN**
ENTRY	**191**	**22**	**223**	**74**
EXIT	**197**	**57**	**262**	**142**

Table 3. Third week

	STUDENTS WHO DON'T WORK		STUDENTS WHO WORK	
	DISCONFORT	**PAIN**	**DISCONFORT**	**PAIN**
ENTRY	**196**	**25**	**228**	**85**
EXIT	**201**	**63**	**271**	**151**

Table 4. Fourth week

	STUDENTS WHO DON'T WORK		STUDENTS WHO WORK	
	DISCONFORT	**PAIN**	**DISCONFORT**	**PAIN**
ENTRY	**202**	**29**	**236**	**93**
EXIT	**207**	**68**	**279**	**159**

6. CONCLUSION

Because of what is stated in this article, it can be highlighted that the index of body discomfort in people who, in addition to studying, dedicate themselves to work, is greater than the index of regular students. Within the analysis exposed, it is possible to envision that the figures are high enough to give priority over to these issues, to put special attention to the mentioned group, and in the same way, in other groups, schools or educational systems.

Regarding with the information that has been addressed before, it is important to recognize situations in other degrees and prioritize colleagues whose jobs involve considerable physical effort as well as assess the general conditions of the study area and take immediate action.

However, the fact that this schedule model is more or less damaging to the students cannot be concluded within an accurate way since there are not research documents available of these same students who work and do not work in a cycle in which the duration of their classes is only 1 hour long, since this is an important factor to consider when making conclusions and analyze the disconfort presented as result.

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APPLICATION OF THE YOSHITAKE FATIGUE QUESTIONNAIRE IN STUDENTS OF THE ITLM INDUSTRIAL ENGINEERING DEPARTMENT

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Resumen: INTRODUCCIÓN. La idea de esta investigación nace a raíz del nuevo sistema de horarios en el Instituto Tecnológico de Los Mochis. Los estudios y el análisis de la fatiga y el desgaste físico son muy comunes en el área laboral; sin embargo, pocas veces estudiantes realizan estudios de este tipo en el medio en el que se desenvuelven. Una de las intenciones de este trabajo corresponde al registro de los resultados para la comparación a futuro con condiciones diferentes. OBJETIVO. Determinar la Frecuencia de Quejas de Fatiga (FQF) que presentan los alumnos de la carrera de Ingeniería Industrial (quinto semestre), a través de la aplicación del cuestionario Yoshitake. DELIMITACIÓN. El estudio se concentra en un grupo de alumnos de la carrera de Ingeniería Industrial correspondiente al Quinto semestre, al momento de cursar la asignatura de Ergonomía (**INF-1010, SATCA: 2-3-5**). Se podrían obtener resultados más precisos si se aplicara a más grupos de diferentes carreras, incluso a toda la escuela, así como también si se hicieran pruebas por un periodo más largo de tiempo y así poder comparar como empeoran los síntomas al paso de un mes o cómo se encuentra el estudiante al empezar el semestre y en cuáles condiciones lo termina; sin embargo, no se tiene el tiempo para poder calcular los resultados de más de 500 estudiantes. METODOLOGÍA. La prueba que se utilizó para medir los síntomas subjetivos de fatiga fue Yoshitake, el cual es un cuestionario que mide los tipos y las magnitudes de la fatiga que presentan los trabajadores. El estudio fue aplicado a 35 alumnos de quinto semestre de la carrera de Ingeniería Industrial del Instituto Tecnológico de los Mochis, cada uno contestó un cuestionario por semana durante un mes, es decir, se recopiló la información de 140 cuestionarios contestados. RESULTADOS. La investigación analizó los resultados de 35 estudiantes, los cuales toman clases de Lunes a Viernes desde las 7 de la mañana hasta la 1 de la tarde. CONCLUSIONES. Los resultados mostraron que se presenta un índice de fatiga considerable en el salón de clases de este grupo y es notoria la manera en la que los síntomas de fatiga aumentan, primero de entrada a salida y después de la primera semana a la cuarta.

Palabras clave: Fatiga, cuestionario Yoshitake, estudiantes.

Relevancia para la ergonomía: Se hace hincapié en el cuidado del trabajador dentro de su zona de trabajo, pero también se debe de tomar en cuenta cada uno de estos cuidados en el estudiante dentro del salón de clases; dado que, aunque no esté expuesto a realizar actividades físicas en una fábrica o a operar maquinaria pesada, es necesario recordar que la fatiga es algo que se intenta disminuir en la medida que sea posible.

Abstract: INTRODUCTION. The idea of this research was born as a result of the new system of schedule at the Technological Institute of Los Mochis; studies and analysis of fatigue and physical exhaustion are very common within the work area; however, students rarely study this within the environment in which they develop. This is the main objective of the study, the recording of the results for future comparison with different conditions. OBJECTIVE. To determine the frequency of complaints of fatigue (FQF) presented by the students of the Industrial Engineering department (fifth semester), through the application of the Yoshitake questionnaire. DELIMITATION. The study focuses on a group of students in the Industrial Engineering department corresponding to the fifth semester, at the time of taking the Ergonomics course (INF-1010, SATCA: 2-3-5). More precise results could be obtained if it were applied to more groups of different degrees, including the whole school, as well as if tests were done for a longer period of time, so it could be compared how the symptoms worsen at the passage of a month or how the student is at the beginning of the semester and under what conditions it ends; however, you do not have the time to calculate the results of more than 500 students. METHODOLOGY. The test that was used to measure the subjective symptoms of fatigue was Yoshitake, which is a questionnaire that measures the types and magnitudes of fatigue that workers present. The study was applied to 35 students of the fifth semester of the Industrial Engineering department of the Technological Institute of Los Mochis, each one answered a questionnaire per week during a month, that is, the information of 140 answered questionnaires compiled. RESULTS. The research analyzed the results of 35 students, who take classes from Monday to Friday from 7 in the morning until 1 in the afternoon. CONCLUSIONS. The results showed that there is a considerable fatigue index in the classroom of this group and it is notorious the way in which the fatigue symptoms increase, first of entry to exit and from the first week to the fourth.

Key words: Fatigue, Yoshitake questionnaire, students.

Contribution to Ergonomics: Emphasis is placed on the care of the employees within their work area, but each of these activities must also be taken into account in the student's classroom; Given that, although not exposed to physical activities in a factory or operating heavy machinery, it is necessary to remember that fatigue is something that Ergonomics tries to reduce as much as possible.

1. INTRODUCTION

Decision-making activities related to school achievement are usually carried out by people who, although they have experience in the subject, do not currently develop as students. The new model in the Technological Institute of Los Mochis establishes that classes are now organized in two-hour modules; thus, it modified the school dynamics for both teachers and students and motivated the need of research for those who experience this change.

All people experience, at times, fatigue. It is part of the condition of the human being. Fatigue is perceived, usually after overexertion or sustained tension. Under this term are labeled states of different intensity (from very light to total exhaustion) and it is not easy to give a single definition and acceptable to all. It can be said that it manifests as a sensation of weakness and exhaustion accompanied by discomfort, even pain and inability to relax.

In students, the movement of the hand muscles during writing and the eyes muscles when reading causes muscle fatigue. Other common causes of school fatigue are: incorrect lighting of the classroom, inadequate ventilation in the school space, poorly balanced diet and non-compliance with the sleep schedule. At lunch time, it is recurrent for students to experience headache, nausea, sleepiness and irritation; they begin to express some symptoms that characterize fatigue; be it physical, visual, mental or nutritional deficit (Nilton, 2017).

The assessment of fatigue has been central to work health, forcing the constant development of instruments that, through physiological indicators or subjective tests, allow estimating their intensity and characteristics. One of them is the Subjective Fatigue Symptoms Test (PSSF), which was developed by the Industrial Fatigue Research Committee of the Industrial Health Association of Japan in 1954.

This instrument consists of 30 items that explore the presence of symptoms that were originally classified into three groups: physical, mental and sensorineural. Saito, Kogi and Kashigawi, in 1970 subjected to factorial validity the instrument obtaining three factors: drowsiness and heaviness, projection of physical discomfort and difficulty to concentrate. Yoshitake in 1978 related the first factor with undifferentiated work, the second with physical work and the third with mental work; additionally, he proposed the qualification of the test through the percentage of affirmative answers, which is the fatigue test selected to apply.

The idea of this research was born as a result of the new system of schedule at the Technological Institute of Los Mochis, studies and analysis of fatigue and physical exhaustion are very common in the work area, however, students rarely study this type in the environment in which they develop. One of the objectives of this study is the recording of the results for future comparison with different conditions.

2. OBJECTIVE

To determine the frequency of complaints of fatigue (FQF) presented by the students of the Industrial Engineering department (fifth semester), through the application of the Yoshitake questionnaire.

3. DELIMITATION

The study focuses on a group of students in the Industrial Engineering department corresponding to the fifth semester, at the time of taking the subject of Ergonomics (INF-1010, SATCA: 2-3-5), which was chosen this way because when studying these issues, doubts began to arise about the conditions of the classrooms and furniture within the campus.

More precise results could be obtained if it were applied to more groups of different degrees, including the whole school, as well as if tests were done for a longer period of time and so we could compare how the symptoms worsen at the passage of a month or how the student is at the beginning of the semester and under what conditions it ends; however, there is not enough time available to calculate the results of more than 500 students.

4. METHODOLOGY

The test that was used to measure the subjective symptoms of fatigue was Yoshitake, which is a questionnaire that measures the types and magnitudes of fatigue that workers present.

It addresses three dimensions of the subjective perception of work fatigue by asking 10 questions for the mental requirement at work, 10 for the physical manifestations of fatigue and finally 10 items inquiring about the mixed symptoms. The questions are designed in a way that they require a dichotomous answer (YES / NO).

The study was applied to 35 students of the fifth semester of the Industrial Engineering department of the Technological Institute of Los Mochis, the average age of the participants is 20.5 years old, each one answered a questionnaire per week during a month, which is, the information of 140 questionnaires answered.

5. RESULTS

The research analyzed the responses of 35 students, who take classes from Monday to Friday from 7 o’clock in the morning until 1 o’clock in the afternoon. The results are presented within the three categories of Drowsiness and Monotony, Concentration Difficulty and Corporal Symptoms.

Table 1. First week results

	ENTRY	EXIT
SYMPTOM A (Drowsiness and monotony)	623	707
SYMPTOM B (Difficulty of concentration)	505	569
SYMPTOM C (Corporal symptoms or damage projection)	409	555
TOTAL AFFIRMATIVE ANSWERS	**1537**	**1831**

Table 2. Second week results

	ENTRY	EXIT
SYMPTOM A (Drowsiness and monotony)	627	712
SYMPTOM B (Difficulty of concentration)	510	573
SYMPTOM C (Corporal symptoms or damage projection)	413	560
TOTAL AFFIRMATIVE ANSWERS	**1550**	**1845**

Table 3. Third week results

	ENTRY	EXIT
SYMPTOM A (Drowsiness and monotony)	632	719
SYMPTOM B (Difficulty of concentration)	517	579
SYMPTOM C (Corporal symptoms or damage projection)	419	567

TOTAL AFFIRMATIVE ANSWERS	**1568**	**1865**

Table 4. Fourth week results

	ENTRY	EXIT
SYMPTOM A (Drowsiness and monotony)	641	729
SYMPTOM B (Difficulty of concentration)	527	588
SYMPTOM C (Corporal symptoms or damage projection)	428	577
TOTAL AFFIRMATIVE ANSWERS	**1596**	**1894**

6. CONCLUSION

The results showed that there is a considerable fatigue index in this group and it is notorious the way in which the fatigue symptoms increase, first from entry to exit and from the first week to the fourth week.

There are several factors that can affect the students' performance during the school day and some of these are those contemplated in the questionnaire answered by the 35 students. When interpreting the results, it is not difficult to decipher that fatigue rates are high, however, it cannot be concluded that the 2-hour schedule worsens this situation as there are not previous studies carried out available.

The following proposals are presented as future research projects:

Promoting "pilot semesters" with the school directors, ideally, where the schedule of the current educational system is put to the test, rotating the schedules of the system with classes of 45, 60, 90 and 120 minutes and performing the questionnaires among the classmates during the semester.

To rotate groups between rooms with different types of furniture; desks, tables and individual tables and perform the same questionnaires among classmates.

To manage tests with the use of air conditioning, changing classroom temperatures and carry out questionnaires.

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COMPARATIVE FATIGUE STUDY BETWEEN PAINTERS, SCULPTORS AND ENGRAVERS IN FOUR LEVELS OF CONTINUOUS JOB HOURS

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Resumen: Las semanas de trabajo de cuarenta horas constituyen uno de los esquemas de trabajo más comunes en México, esta estrategia es muy utilizada en los sectores de servicios públicos y en algunos sectores industriales, sin embargo, existen algunas actividades donde las horas de trabajo tienen patrones irregulares, debido principalmente al tipo de tareas que se desarrollan, uno de actividades son los trabajos relacionados con la actividad del arte plástico, en particular con el que desarrollan los escultores, pintores y grabadores. De acuerdo a Paley, Price and Tepas (1998), existe una tendencia hacia los trabajos con esquemas de horarios con mayor número de horas por día. Otros autores como Rosa et al. (1988) señalan que en este tipo de trabajos de tiempo extendido, hay una reducción del nivel de atención, así como una sensación de fatiga y de deseo de mas descanso durante la jornada. Duchon and Smith(1993) indican que los trabajos con jornadas de más de ocho horas son premisas para los problemas de salud y los riesgos de accidentes. En esta investigación se realiza un estudio de fatiga durante 9 semanas, en trabajadores de arte que laboran en jornadas de 8, 10, 12 y 14 horas . Se realiza un análisis de varianza para determinar el comportamiento de la media del índice de fatiga entre los diferentes esquemas de trabajo. La fatiga se mide a través del índice de fatiga propuesto por Yoshitake (1978) utilizando el cuestionario, el cual se aplica por nueve semanas consecutivas a 59 artistas plásticos masculinos de la ciudad de Hermosillo, Sonora, México. Los artistas plásticos laboran en diferentes ámbitos de la plástica: escultura, pintura y grabado. La hipótesis de investigación, es que la fatiga es acumulativa y va en aumento entre las semanas, y es mayor entre los escultores. Los datos obtenidos son tratados estadísticamente con el fin de probar la hipótesis planteada.

Palabras clave: Fatiga, arte, pintura, escultura, grabado

Relevancia para la Ergonomía: De acuerdo con la revisión realizada al estado de la técnica, con respecto a la fatiga en las tareas de arte, hay muchos estudios relacionados con la fatiga, sin embargo, no se encontraron estudios relevantes en los entornos laborales de arte. Este estudio abre un nuevo campo de investigación en ergonomía, teniendo en cuenta una población que no es habitual en este campo de investigación.

Abstract: Forty hour labor of the week, is one of the most common working schemes in México, this strategy is used in service and certain industrial sectors, however, there are some other labor activities, such as those related to art activity where the working hours have an irregular pattern, due to the circumstances linked to the tasks required to complete the work demanded; one of the art sectors that demand such labor schemes, is the art, in a specific way, the labor related to painters, sculptors and engravers. According to Paley, Price and Tepas (1998), today, there is a strong tendency for alternative labor programs, that demands an increase of labor hours by day (more than eight hours by day). There are other research papers (Rosa et al, 1988) that suggest that the security level alert goes down when the labor hours are longer than eight hours, there is also, evidence that workers experience fatigue and with this, more demand for rest periods. Duchon and Smith(1993) said that labor hours more than eight are premises for health problems and the risk of accidents. This investigation leads us to understand the fatigue experienced by the art worker, that have a labor day of 8, 10, 12 and 14 hours from three different areas: painting, sculpting and engraving. An ANOVA Test is established in order to determine the behavior of fatigue between the four working schemes. Fatigue is determined from a fatigue index calculated from Yoshitake fatigue symptom survey that applies to a total of 59 art male workers from Hermosillo, Sonora, México, for a total of nine continuous weeks. The research hypothesis is that the experienced fatigue goes to higher levels, according to working hours and it is greater in the sculpting activity. The results of the survey are statistically treated with variance analysis and the Duncan Test in order to prove the proposed hypothesis.

Keywords: Fatigue, art, painting, sculpting, engraving

Relevance to Ergonomics: According to the revision made to the state of the art, in regard to fatigue in art tasks, there are many studies related to fatigue, however, there were not found relevant studies furthermore in art labor environments. This study opens a new investigative field in ergonomics, taking into account a population that is not usual in this research field.

1. INTRODUCTION

According to Ashberg(1988), fatigue is a physical symptom that impacts work performance and efficiency, and the effects of which can be perceived are as follows: making incorrect judgements of particular situations, having inadequate performance, omit details in a procedure, so that there is an impact in the quality of life, and in more serious cases, in aspects relating to working conditions.

For Ashberg, fatigue includes certain body changes, that includes changes in performance, perception that conduct to reduce the capacity of the physiological potential of tissues or a reduction in the force capacity in a muscle. In general, when someone has fatigue, we notice a loss of energy, a generalized disinterest towards work and in terms of changes in perception, is a feeling of tiredness, weakness and the feeling of being exhausted, sleepy.

The manifestations of fatigue can be described in three terms. Physiological, objective and subjective. Physiological manifestations are associate to decreased capacity to generate strength, often related to a decrease in blood sugar and accumulation of lactic acid and this is considered a sign of fatigue. Objective manifestations, can be seen in physical expressions such as yawn. The subjective manifestations, according to Gamberale et al. (1990), are related to aspects such as low concentration, difficulty in making decisions, thinking slowly, being very sleepy and being called that, because they depend on personal perception.

In this research, the fatigue is measured using the Yoshitake (1978) Fatigue Symptom survey, which has been applied during nine weeks to a total of 59 art workers, where 15 are sculptors, 35 painters and 9 are engravers. The three categories of art workers labour in four different work schemes: eight, ten, twelve and fourteen hours. An ANOVA test is carried out for every category of art worker, in order to understand the fatigue mean behavior.

2. OBJETIVES

In this research, we have the following objective:

To determine the level of fatigue mean experienced by painters, sculptors and engravers who work in a continue 8,10, 12, 14 labor hours, and compare results between the weeks and the labor schemes for each art activity.

3. METHODOLOGY

3.1 Equipment and materials

It was used the fatigue symptom survey developed by Yoshitake (1978) during nine weeks, the survey was self answered by the 59 art workers, who develop his artistic activity in the city of Hermosillo, Sonora, México. After data collection and summarization, a data matrix in excel software was developed, and then the data were processed in SPSS software using an ANOVA test.

3.2 Procedure

They were generated three ANOVA Test for every category of art worker and also, there were prepared the post hoc Duncan test over each of the dependent variables: weeks and working hours schemes: eight, ten, twelve and fourteen hours.

4.RESULTS

4.1 ANOVA and Post Hoc Duncan tests.

They were generated three ANOVA Test for every category of art activity: Sculptors, painters and engravers, when required, it was developed the post hoc Duncan Test in order to understand the differences between fatigue index means.

4.1.1 ANOVA and Post Hoc Duncan Tests for Sculptors

Table 1 shows us the results of the ANOVA Test in the category of sculptors, where the independent variable is the fatigue Index and the dependent variables are: the week and the work hours.

Table 1. ANOVA Test Sculptors
Variable: Fatigue Index Efects: Week and Work Hours

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3076.208	35	87.892	1.346	.129
Intercept	53941.387	1	53941.387	825.882	.000
WEEK	563.554	8	70.444	1.079	.385
WORK HOURS	945.069	3	315.023	4.823	.004
WEEK * WORK HOURS	1495.100	24	62.296	.954	.532
Error	6400.741	98	65.314		
Total	64688.889	134			
Corrected Total	9476.949	133			

Figure 1 shows us the Fatigue Index mean graph in the category of sculptors, we can see the behavior of fatigue index mean, thru the weeks and thru the work hour schemes.

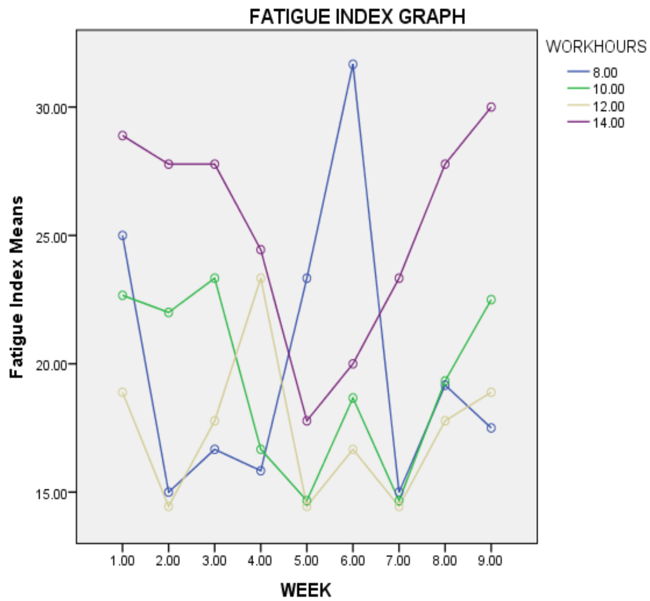

Figure 1 Fatigue Index Sculptors thru the weeks and for the work hour schemes

The post Hoc Duncan Test is shown in figure 2 and figure 3, as follows:

Table 2 Fatigue Index Post Hoc
Duncan Test: Weeks

WEEK	N	Subset	
		1	2
7	15	16.4444	
5	15	17.5556	17.5556
4	15	19.3333	19.3333
2	15	19.7778	19.7778
8	15	20.6667	20.6667
3	15	21.3333	21.3333
9	14	21.9048	21.9048
6	15	22.0000	22.0000
1	15		23.7778
Sig.		.114	.075

Table 3 Fatigue Index Post Hoc
Duncan Test: Work Hours

WORK HOURS	N	Subset	
		1	2
12.00	27	17.4074	
10.00	44	19.3182	
8.00	36	19.9074	
14.00	27		25.3086
Sig.		.247	1.000

4.1.2 ANOVA and Post Hoc Duncan Tests for Painters

Table 4 shows us the results of the ANOVA Test in the category of painters, where the independent variable is the fatigue Index mean and the factors: week and work hours as a dependent variable.

Table 4. ANOVA Test Painters
Variable: Fatigue Index Effects: Week and Work Hours

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2488.566[a]	35	71.102	1.245	.171
Intercept	84939.376	1	84939.376	1487.092	.000
WEEK	358.183	8	44.773	.784	.617
WORKHOURS	1138.129	3	379.376	6.642	.000
WEEK * WORKHOURS	1099.397	24	45.808	.802	.734
Error	15821.623	277	57.118		
Total	132433.333	313			
Corrected Total	18310.188	312			

The figure 2 shows the fatigue index thru the weeks and for the four categories of work hours schemes:

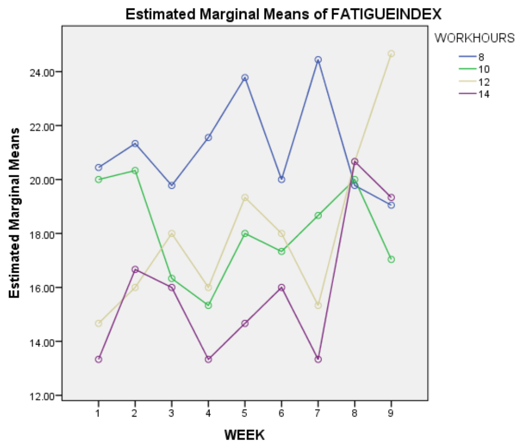

Figure 2 Fatigue Index Painters thru the weeks and for the work hour schemes

The post Hoc Duncan Test are shown in Table 5 and table 6, as follows:

Table 5 Fatigue Index Mean Post Hoc Duncan Test, Effect: Week

WEEK	N	Subset 1
4	35	17.8095
3	35	18.0000
6	35	18.3810
1	35	18.4762
9	33	19.3939
2	35	19.6190
7	35	19.9048
8	35	20.0952
5	35	20.1905
Sig.		.279

Table 6 Fatigue Index Post Hoc Duncan Test: Weeks

WORK HOURS	N	Subset	
		1	2
14	45	15.9259	
12	45	18.0741	
10	89	18.1273	
8	134		21.1443
Sig.		.123	1.000

4.1.3 ANOVA and Post Hoc Duncan Tests for Engravers

Table 7 show us the results of the ANOVA Test in the category of engravers, where the independent variable is the fatigue Index mean and the factors: week and work hours as a dependent variable.

Table 7. ANOVA Test Painters
Variable: Fatigue Index Effects: Week and Work Hours

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1508.889[a]	34	44.379	1.608	.068
Intercept	18202.697	1	18202.697	659.695	.000
WEEK	533.623	8	66.703	2.417	.029
WORKHOURS	8.814	3	2.938	.106	.956
WEEK * WORKHOURS	757.613	23	32.940	1.194	.299
Error	1241.667	45	27.593		
Total	30377.778	80			
Corrected Total	2750.556	79			

In the figure 3 we can observe the fatigue index thru the weeks and for the four categories of hours schemes:

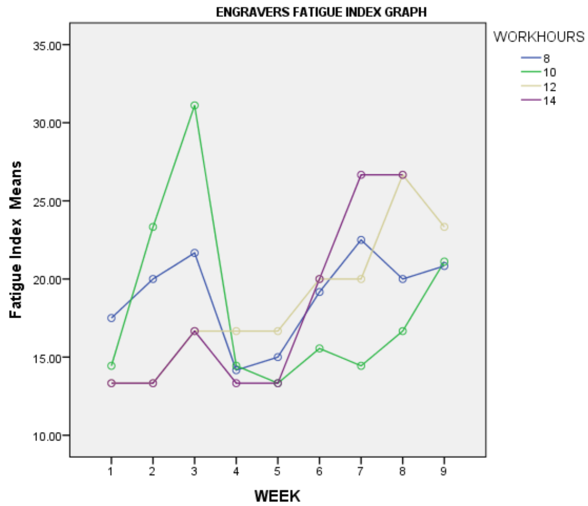

Figure 3 Fatigue Index Engravers thru the weeks and for the work hour schemes

The tables 8 and 9 shown the post Hoc Duncan Test for Engravers:

Table 8 Fatigue Index Engravers
Post Hoc Duncan Test: Weeks

WEEK	N	Subset		
		1	2	3
4	9	14.4444		
5	9	14.4444		
1	9	15.5556	15.5556	
6	9	18.1481	18.1481	18.1481
2	9	19.6296	19.6296	19.6296
7	9	20.0000	20.0000	20.0000
8	9		20.3704	20.3704
9	8			21.2500
3	9			23.7037
Sig.		.055	.091	.055

Table 9 Fatigue Index Mean Engravers
Post Hoc Duncan Test, Effect: Work hours

WORK HOURS	N	Subset 1
14	8	17.9167
10	27	18.2716
12	9	18.5185
8	36	18.9815
Sig.		.640

5. CONCLUSIONS

According to ANOVA Test results, we can notice that there is not statistic evidence to say that the fatigue index mean thru the weeks is equal, due that p-value= 0.385>0.05. For the other dependent variable: work hour scheme, we can infer that there is statistic evidence to say that the fatigue index is different thru the work hours, and according to Duncan Test is higher for the 14 hours work scheme, this result was expected, due that the sculptor task demand high levels of energy. The fatigue index mean is equal for the interaction of effects.

The results found for painters, reveals that the fatigue index mean is equal thru the weeks, due that p-value=0.617>0.05; and for the work hour scheme the p-value=0<0.05 which leads us to say that the fatigue index mean is different between work hours and is greater for the eight hour scheme. This result is due that the painters do not have rest periods in this scheme and for the others work hour schemes have many rests during the labor activity. The fatigue index mean was equal for the interaction of effects.

In the other hand, for engravers, it was found that fatigue index means is equal thru the weeks, however, for the work hour scheme is different and the higher level was found in the eight hour scheme. The fatigue index mean is equal for the interaction between effects. The results found for this category are related to the fact that engravers have not rest for short work periods.

The study of the art activities is quite complex, due that the works performed are not repetitive thru the days and the weeks, so, the energy level demands are different for the three categories of art work, and rest periods are variable in time and periodicity.

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PHYSICAL FATIGUE IN CFE WORKERS

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Resumen: El trabajo que desarrolla personal del área comercial CFE, se ve influenciado por efectos negativos como la fatiga, debido a la necesidad de mantener posturas que le permitan realizar ciertos movimientos o esfuerzos por largos periodos de tiempo, lo que conlleva a disminuir su capacidad de concentración y aumento de posibles errores en el desempeño de sus funciones.

Mediante la aplicación de método Yoshitake se midió los tipos de fatiga que presentan los trabajadores, siendo estos somnolencia, monotonía y dificultad en la concentración mental.

Por medio de método Corlett and Bishop, se recopilaron los síntomas que presentan mayor incidencia entre los auxiliares de área comercial CFE, entre los que destacan molestias en cabeza, en cuello y en pies.

Con los resultados obtenidos se sugiere plan para prevenir el desarrollo de fatiga laboral.

Palabras clave: Fatiga, Yoshitake, Corlett and Bishop

Relevancia para la ergonomía: Detección de fatiga física en trabajadores, para posibles estudios posteriores.

Abstract: The work developed by the CFE commercial staff is influenced by negative effects such as fatigue, due to the need to maintain positions that allow you to perform certain movements or efforts for long periods of time, which leads to decrease its ability of concentration and increase of possible errors in the performance of their duties.

Applying method Yoshitake, measured rates of fatigue that workers have these drowsiness, monotony, and difficulty in mental concentration.

Corlett and Bishop Method including discomfort in the head, neck and feet collected symptoms presenting greater incidence among CFE commercial assistants.

With the results suggested plan for preventing the development of labour fatigue.

Keywords: Fatigue, Yoshitake, Corlett and Bishop

Relevance to ergonomics: Detection of physical fatigue in workers, for possible future studies.

1. INTRODUCTION

The purpose of this work is to determine if there is physical fatigue in the assistants of the commercial department that work in CFE Northwest area in the city of Los Mochis and based on the results present solutions or corrective actions in the activities they carry out.

In order to determine the type of fatigue that occurs in workers, the subjective methods Yoshitake and Corlett & Bishop that were implemented.
Hypothesized was that fatigue predominates in the commercial assistants of the designated department, since their work requires physical, mental and exposure to various environmental factors.

2. OBJECTIVES

Determine if there is physical fatigue in the assistants of the commercial department through subjective methods based on the results propose solutions or corrective actions.

3. DELIMITATION

The criteria that were taken to be considered in the study were, worked at least 1 year in the company, age of 19 to 50 years, given consent to participate in the study.

4. METHODOLOGY

Twenty business assistants were selected to work in the company, the subjective methods of Yoshitake and Corlett & Bishop were applied, the implementation was carried out through sampling for a period of 8 weeks, for further analysis.
The information collection was implemented during 5 working days, in 8-hour shifts, in a period of 8 weeks. Subsequently, the results analysis was performed.

5. RESULTS

Yoshitake's questionnaire presents three categories which are monotony, concentration and physical damage. The percentages obtained during the analysis period reflect the category with the greatest influence on the causes of fatigue is physical damage with approximately 51% of the references, while monotony and concentration have frequencies of 38% and 11% respectively. According to the analysis it is detected that there is a slight increase in the references of the category of physical damage in relation to the application schedule of the questionnaire to the assistants, the collaborators have physical damage at the end of their work in comparison with the beginning, as illustrated in figure 1 and figure 2.

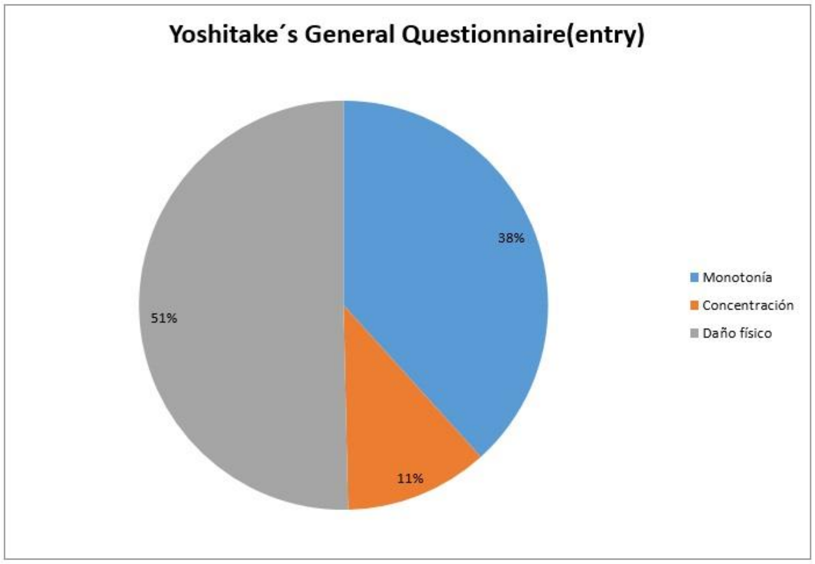

Figure 1: Yoshitake ´s General Questionnaire (Entry)

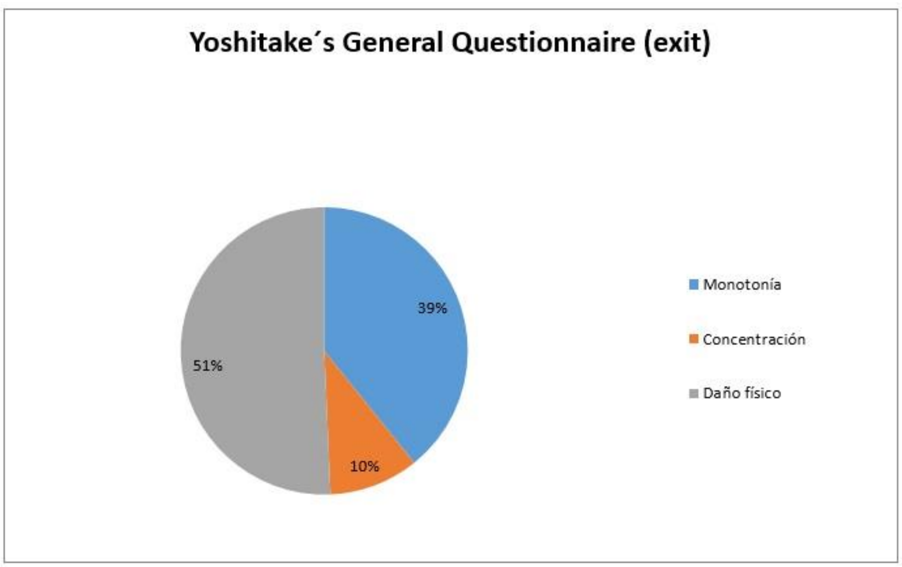

Figure 2: Yoshitake´s General Questionnaire (Exit)

To present explicitly how often the factors corresponding to each of the three categories of the Yoshitake questionnaire occurred, the three weeks are plotted, where the number of incidents in monotony can be individually appreciated with 319 in week 1, 277 in week 2, and 308 in week 3, presenting few incidents with concentration with 103 in week 1, 81 in week 2, and likewise 84 in week 3, finally in physical damage where there are incidents with more Frequently we have 399 in week 1, 374 in week 2 and 416 in week 3, as illustrated in figure 3.

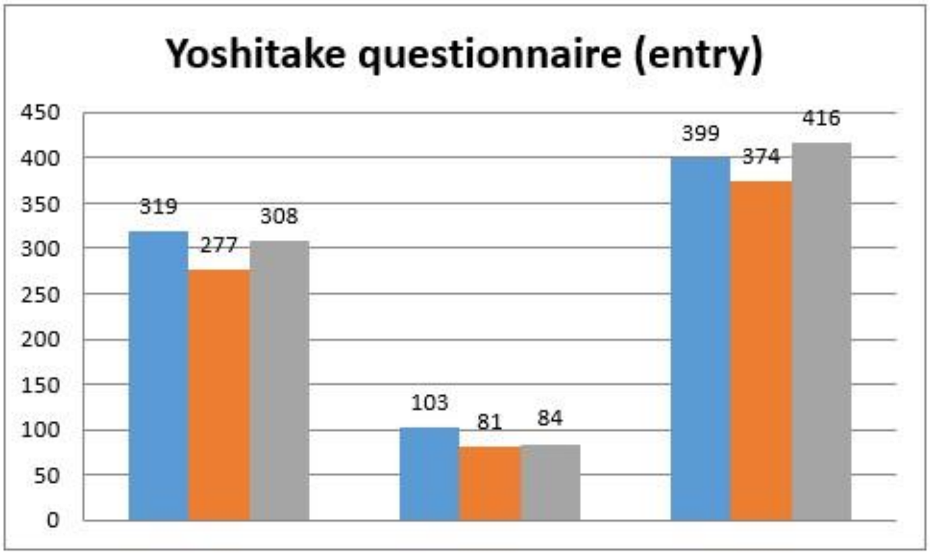

Figure 3: Yoshitake questionnaire (entry)

In figure 4 it is easy to see the large difference between values according to the entries with a number of incidents in monotony with 624 in week 1, 469 in week 2, and 496 in week 3, presenting few incidents with concentration with 143 in week 1, 141 in week 2, and likewise 125 in week 3, finally, in physical damage where incidents occur more frequently we have 721 in week 1, 627 in week 2 and 706 in the week 3.

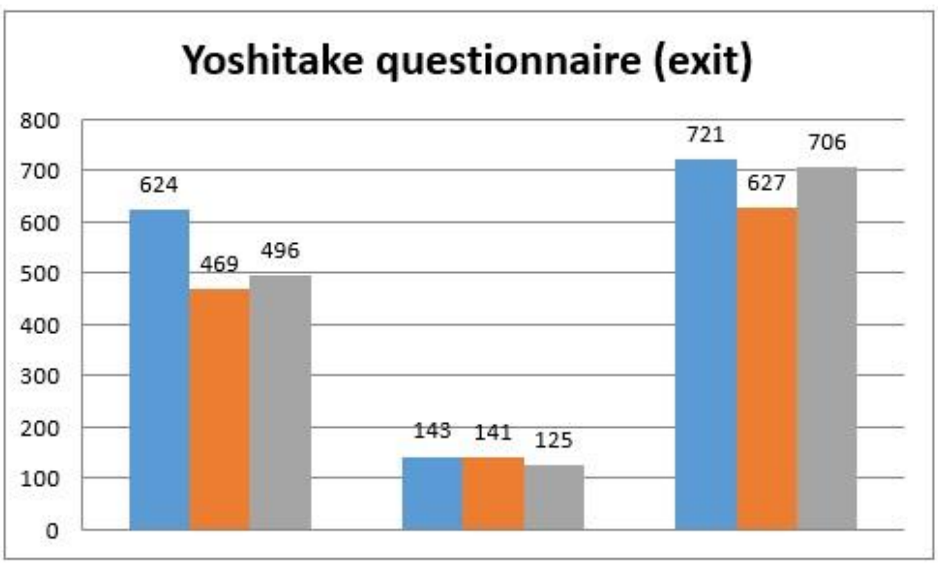

Figure 4: Yoshitake questionnaire (exit).

Through the subjective method Corlett and Bishop, the frequency of discomfort referred by commercial assistants during the study period is shown. The discomfort then presented higher incidence, while the discomfort in head and back were the symptoms that appeared in second place, as illustrated in figure 5.

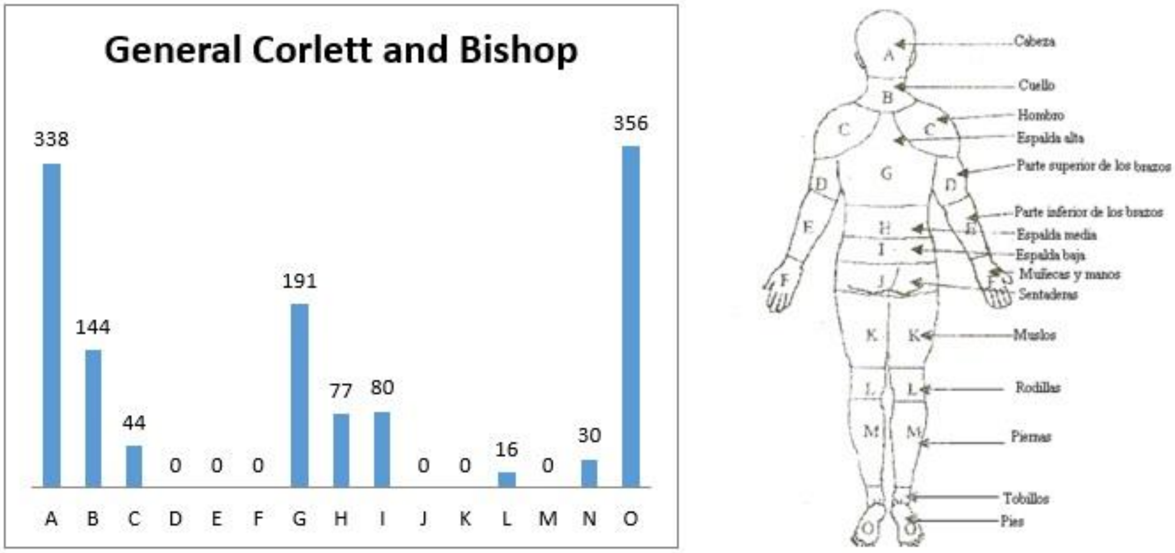

Figure 5: Results obtained with the Corlett and Bishop method.

Figure 6 shows the percentages that indicate in which part of the body most of the discomfort occurs due to the activities that take place during the workday of the commercial assistant, being able to observe those that have the most impact, and the parts where there is no discomfort any.

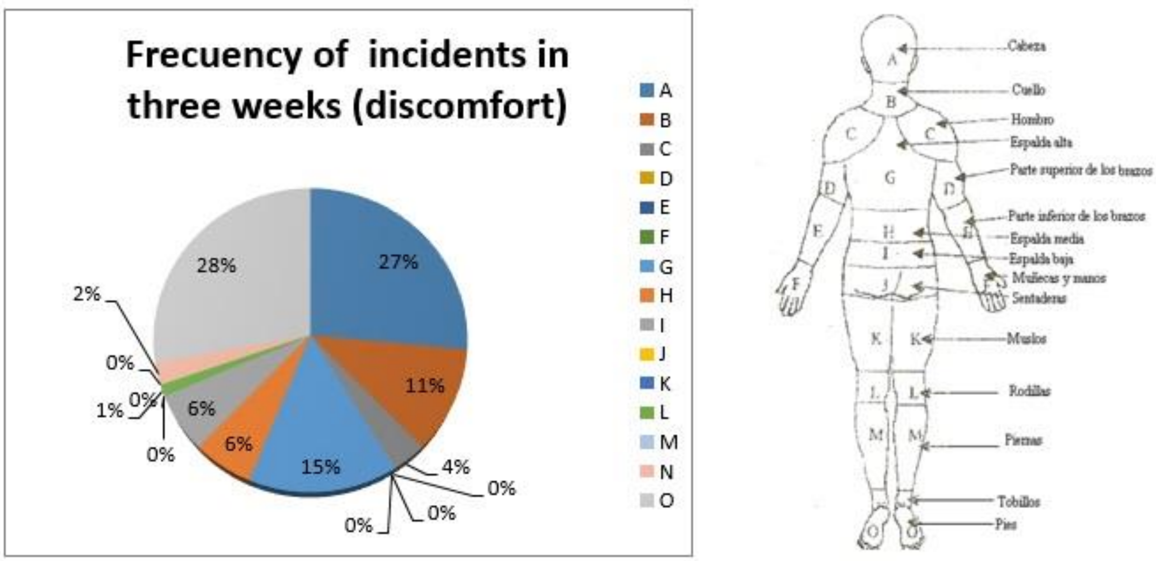

Figure 6: Frequency of incidents in three weeks (discomfort)

6. CONCLUSIONS

In labor fatigue and its factors, information was identified, highlighting the importance at a personal, social, family and business level. Generating a culture of prevention in the company, you get higher quality in the production and sale of your service, also reduce the risks that cause the suffering of diseases and accidents, which leads to work disabilities that affect the company economically. With the results obtained, it must be taken into account, that developing or generating preventive measures of fatigue implies taking into consideration the occupational groups and the sociodemographic characteristics of the employee. Before this, an effective process of evaluation and diagnosis is necessary.

The studies carried out concentrated on describing the different manifestations of work fatigue in the auxiliaries of the commercial area analyzed. The results support the initial hypothesis in relation to the development of occupational fatigue they present. The main problems focused on the physical deterioration of workers in different grades, as well as the most affected parts of the body.

According to the test applied to determine the levels of work fatigue (Yoshitake questionnaire), the results obtained are based on the evaluation made with CFE commercial assistants related to three subjective symptoms: a) drowsiness and monotony, b) difficulty in mental concentration and c) projection of physical deterioration. The measurements showed that the main problems are focused on monotony and physical damage, obtaining percentage of presence of 40% and 50% respectively, emphasizing that there is fatigue that are linked to these two categories, on the other hand with the Corlett and Bishop method. They highlight the most affected parts of the worker's body where the physical damage has an impact and is closely linked together with the physical damage category of the Yoshitake questionnaire, stating that there is fatigue in these workers.

Finally, the next intervention plan was suggested a order to prevent the development of work fatigue:

Incorporate breaks of ten minutes per day to hydrate, rest, plan work and not fall into monotony that lead to headaches normally as presented in the results.

Internal health programs a medical day or other activities, it should be noted that at this point every day there is a meeting to start the day where you can incorporate activities to improve performance and see the status of the worker.

More frequent rotation of activities, commercial assistants have several tasks where they are not always performed, the problem is that some workers have more workload than others, so it is recommended to make a list of tasks uniform and even for all the workers are in optimal conditions to work.

CFE has recreational and sports programs to include all workers to share an area ti looking for a distraction, like spend tensions and reduce stress.

Trainings programs (talks, workshops, seminars, etc.) on good nutrition and health.

If the said recommendations are followed, it is probable that the levels of labor fatigue in CFE commercial assistants will remain low, and this company will obtain good results in the productivity. Finally, it is worth noting that the validity and reliability of this study is evidenced in the moment in which the results obtained correlate with each other in order to identify and specify in a complete and integral way the dynamics of work fatigue with all the variables that are configured in and around it.

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Workload and fatigue in operators of a rotomolding company in Mexico City. A practical case.

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Resumen: Resaltando la importancia del estudio de la ergonomía en el ambiente industrial, este proyecto se centró en evaluar la carga de trabajo mental y la fatiga en el personal de una empresa manufacturera.

Dicha empresa se dedica a la fabricación de tanques industriales de polietileno, mediante la técnica de rotomoldeo. Durante el proceso, se identificaron riesgos ergonómicos, ya que el personal experimenta exigencias físicas y mentales propias de la actividad de trabajo que pueden tener repercusiones en la salud de los trabajadores, siendo la fatiga una de esas consecuencias.

Ante este escenario, se decidió hacer un estudio sensorial de los 11 puestos de trabajo que conforman el proceso de manufactura y se identificaron 5 puestos críticos para la aplicación de instrumentos de medición de la carga global de trabajo (NASA TLX) y fatiga laboral (YOSHITAKE) con el objetivo de crear el perfil de carga mental y los síntomas de fatiga en esta población para poder proponer medidas de control de riesgos ergonómicos al trabajador.

Se describieron las características de cada puesto de trabajo, sus actividades y se identificaron sus riesgos disergonómicos, así como los síntomas presentados como consecuencia de cada una de ellas. Finalmente se proponen estrategias para la organización de las actividades para minimizar al máximo las repercusiones de dichos factores de riesgo.

Palabras clave: carga de trabajo, fatiga, industria manufacturera, ergonomía.

Relevancia para la ergonomía: La evaluación permite tener un registro de los riesgos disergonómicos que pueden presentarse en los puestos de trabajo, además de ayudar a las empresas con el cumplimiento del inciso I del art. 42 del Reglamento Federal de Seguridad y Salud en el Trabajo (2014).

Abstract: Highlighting the importance of the study of ergonomics in the industrial environment, this project focused on evaluating the mental workload and fatigue in the personnel of a manufacturing company.

This company is dedicated to the manufacture of polyethylene industrial tanks, using the rotomolding technique. During the process, ergonomic risks were identified, since personnel experience physical and mental demands related to the work activity that can have an impact on the health of the workers, fatigue being one of those consequences.

Due to this scenario, it was decided to make a sensory study of the 11 jobs that make up the manufacturing process and identified 5 critical positions for the application of instruments for measuring the global workload (NASA TLX) and labor fatigue (YOSHITAKE) with the aim of creating the profile of mental load and symptoms of fatigue in this population in order to propose ergonomic risk control measures to the worker.

The characteristics of each job position, its activities and its disergonomic risks were identified, as well as the symptoms presented as a consequence of each of them. Finally, strategies are proposed for the organization of activities to minimize the repercussions of these risk factors.

Keywords: workload, fatigue, manufacturing industry, ergonomy.

Relevance to Ergonomics: The evaluation allows to have a registry of the disergonomic risks that can appear in the places of work, in addition to helping the companies with the fulfillment of the clause I of the art. 42 of the Federal Regulation of Health and Safety at Work (2014).

1. INTRODUCTION

With the intention of supporting companies in the evaluation of ergonomic factors, the following project was developed focused on the mental work load and fatigue in its personnel. The manufacturing company is dedicated to the manufacture of polyethylene industrial tanks, through the rotomoldeo technique, its process implies an overload of work and possible effects to the physical and mental health, because what was necessary to analyze the disergonomic risks of each stage of the process and the presence of fatigue in five jobs.

The workload is considered multidimentional (O'Donell and Eggemeier, 1986), which is understood as a subjective approach to the result that exists between the demands of the task and the capacities that the person has (Young and Stanton, 2001); These demands may be of a cognitive nature (reasoning, memory, perception, attention, learning), factors of the physical environment of the organization or tasks (Arquer, 1999).

2. OBJECTIVE

Aim: Identify workload and fatigue in rotomoulding boiler operators in Mexico City during the period from August to December 2018.

Specific objectives

- Describe the disergonomic risks of a manufacturing Company in Mexico City.
- Evaluate the worload in the operators of the study manufacturin Company.
- Categorize the subjective symptoms of fatigue presented by the operators of a manufacturin Company.
- Create the profile of mental load and possible subjective symptoms of fatigue of five jobs as a measure of worker damage control.

3. METHODOLOGY

The evaluation was a case study applied in Mexico City during the period from August to December 2018 with five jobs, permits were obtained from the manufacturing company and the participants.

4. MATERIALS

Three measuring instruments were applied, the first was the ad hoc Sociodemographic and Labor data Questionnaire, the second was the Yoshitake Fatigue Subjective Symptoms Test (1978) adapted to the Mexican population by Barrientos and Martínez (1999), which consists of 30 items, which identifies symptoms of emotional, physical or cognitive type, the results are classified into physical demands, mental requirement, mixed demand or neurosensory. The last questionnaire was the NASA-TLX of Hart and Staveland (1988) that evaluates the workload through six dimensions: mental, physical, temporal, effort, performance and frustation demand. The descriptive analysis of the data is executed in excel version 1902 of Office 365.

4. RESULTS

Figure 1. The disergonomic risks of the manufacturing company's work environment were represented, which highlights that the operators are exposed to high temperatures, work in confined spaces, postural overwork, poor lighting, exposure to noise, dust and fumes.

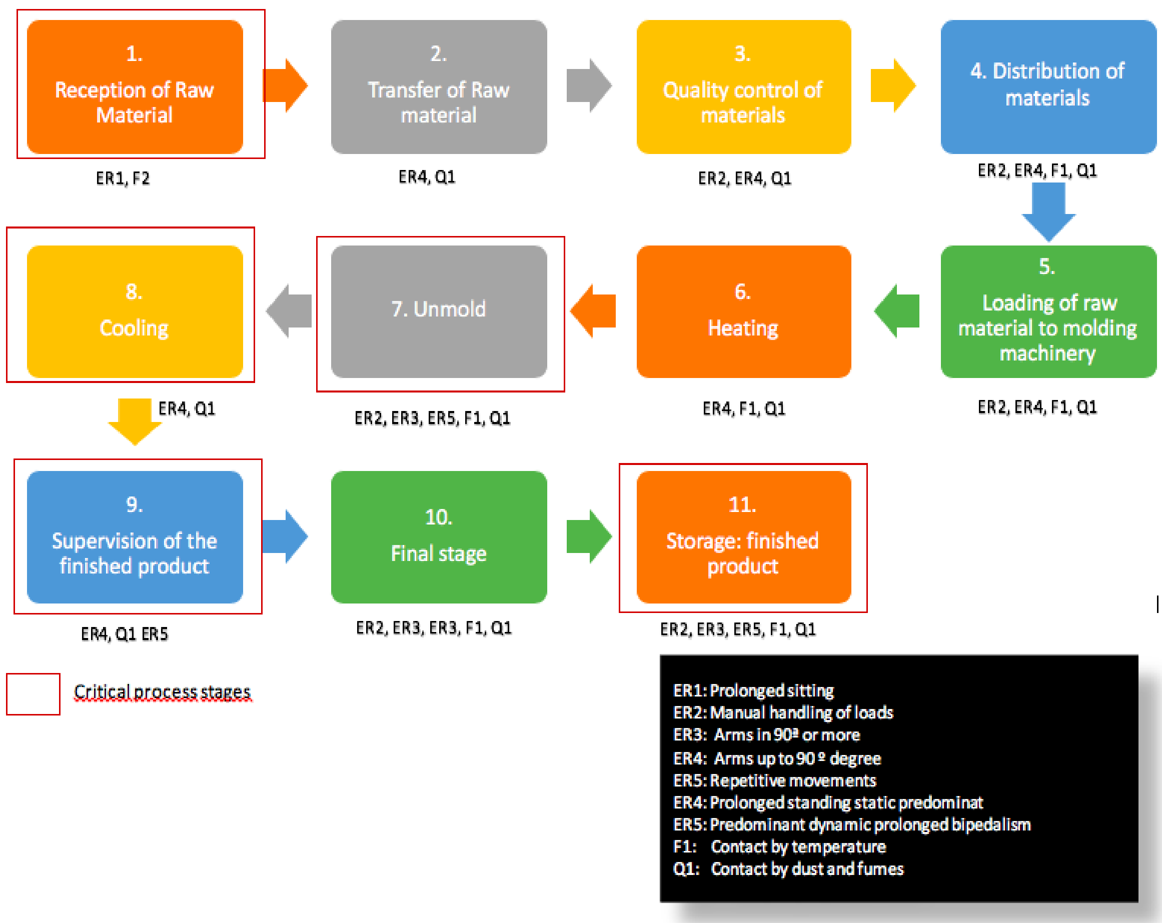


Figure 1. Disergonomic risks present in the rotomolding process

Table 1 shows the record of workload requirements in the five evaluated positions, identifying that the predominant activities are physical, temporary and frustration.

Table 1. Description of the workload according to the characteristics of the work station.

Dimensions	Forklift operator	Thermoformer screen printing	Operator A	Operator B	Weigher
Mental demand	High level of attention	Minimum mental requirement to perform the activity	Little chance of making mistakes	Supervisor of two areas at the same time	Little mental wear to develop sack filling.
Physical demand	Handling of loads to stow products.	Push or pull of cylindrical products.	Make quick movements	Areas with risk of explosion	Move from one machine to another to fill sacks of different sizes.
Temporary demand	Average rhythm	Average rhythm with the possibility of breaks	Accelerated rhythm with the possibility of pauses	Accelerated rhythm without the possibility of pauses	Accelerated rhythm with the possibility of pauses
Physical effort	Support of machinery to handle weights greater than 10 kg		Use of arms to move objects	Use of both arms to manipulate objects with high temperatures	Use of both arms to manipulate objects.
Performance		Compliance with the production goal			
Frustration					

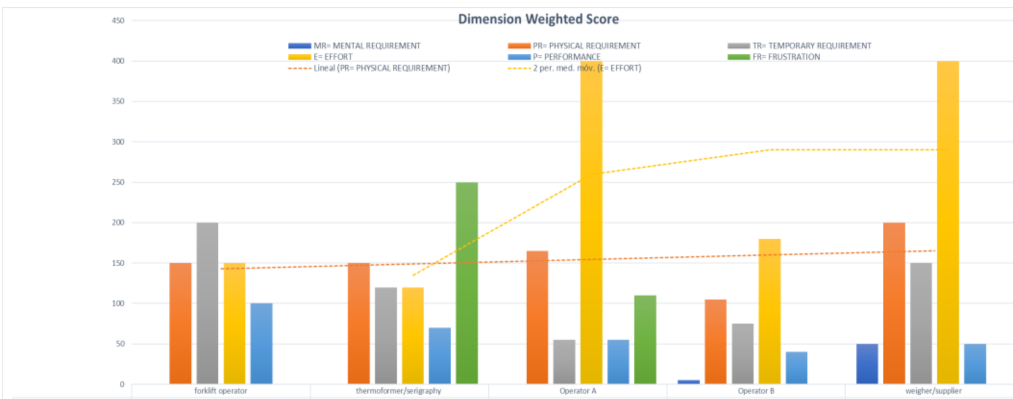
Source: Own elaboration, 2019.

The work demands were identified by the repetitive cutting of heavy parts greater than 10 kg, handling of parts in environments with high temperatures, handling and pushing of bulky objects, which is causing physical wear, mainly in three places: the first was the serigraphist, the second was operator B, and the third was the weigher.

The presence of fatigue was observed in the position of forklift operator and operator A, the main symptoms were the presence of thirst, difficulty in maintaining the same posture, tired eyesight, tired body.

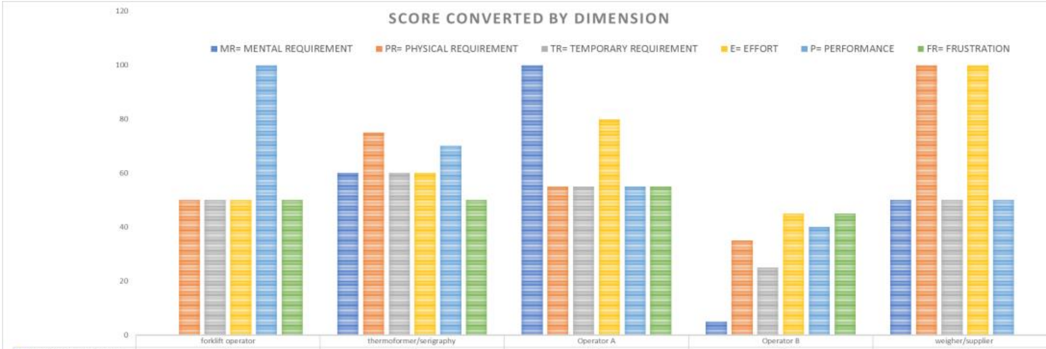
Figure 2. It is highlighted that the dimension of effort, frustration and physical demand are the highest recorded; the first two dimensions resulted in levels higher than the average in the position of weigher/supplier and of operator A and B, while frustration is only recorded in the post of thermoformer/serigraphy raised to the average; It is worth mentioning that the temporary requirement rises from the average in the position of freerider.

It is therefore that weigher / dispenser, hoist and thermoformer / silk screen are the positions that present the highest data in the 6 dimensions. Figure 3. In the converted score of the dimensions of the NASA TLX instrument, physical effort and demand continue above the average, while other dimensions such as performance is present and elevated in several of the work positions, in a uniform way frustration and performance seem to save relationship, at very similar levels of score; It should be noted that despite being even absent in one of the jobs (forklift operator), mental demand rises above the average operator A and thermoformer / screen printing.



	forklift operator	thermoformer/serigraphy	Operator A	Operator B	weigher/supplier
MR= MENTAL REQUIREMENT	0	0	0	5	50
PR= PHYSICAL REQUIREMENT	150	150	165	105	200
TR= TEMPORARY REQUIREMENT	200	120	55	75	150
E= EFFORT	150	120	400	180	400
P= PERFORMANCE	100	70	55	40	50
FR= FRUSTRATION	0	250	110	0	0

Figure 2. workload by dimension



	forklift operator	thermoformer/serigraphy	Operator A	Operator B	weigher/supplier
MR= MENTAL REQUIREMENT	0	60	100	5	50
PR= PHYSICAL REQUIREMENT	50	75	55	35	100
TR= TEMPORARY REQUIREMENT	50	60	55	25	50
E= EFFORT	50	60	80	45	100
P= PERFORMANCE	100	70	55	40	50
FR= FRUSTRATION	50	50	55	45	0

Figure 4. In the global weighted score of the NASA TLX, for this population of workers, effort, performance and physical demand, are the most affected dimensions of this labor process, and even performance is presented with high overall weighted levels in more than three posts of the 5 respondents, and that although it has a downward trend, it remains constant; on the other hand, frustration and mental exigency are shown bordering on simultaneous fall, suggestive of connection between one and the other. It is observed that the demand imposed on the person and the interaction that the worker has with the task, both are affected, with a tendency to physical fatigue and fatigue, then to mental fatigue.

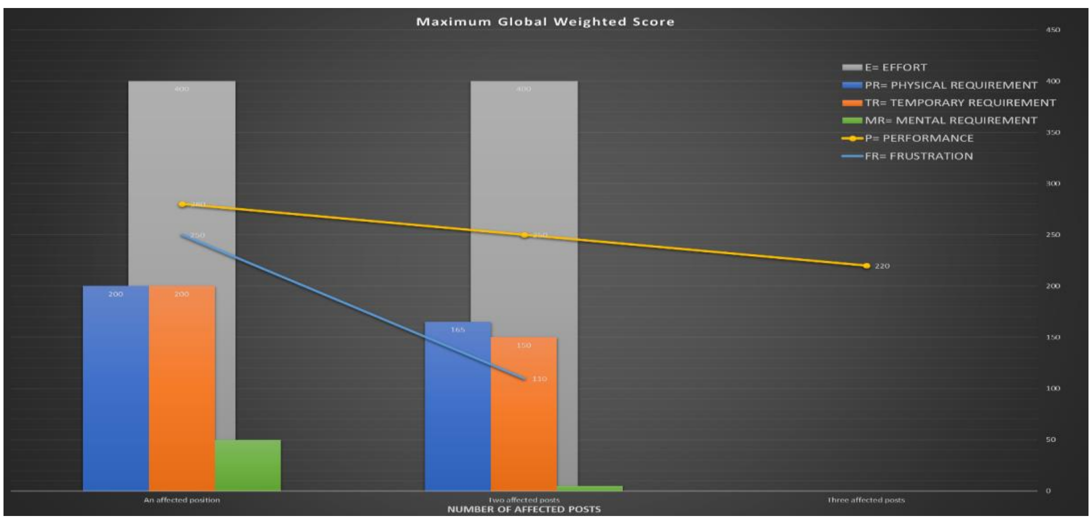


Figura 4. Global Weighted Maximum Score

Figure 5. The sensations mostly reported in the Yoshitake instrument are those related to physical fatigue and bodily symptoms, resulting in low levels related to mental fatigue and psychosocial stress.

In both instruments, both in NASA TLX and in Yoshitake, the trend in the positions analyzed is clear to the physical workload that generates symptoms and sensation of corporal fatigue, rather than a mental or psychosocial burden.

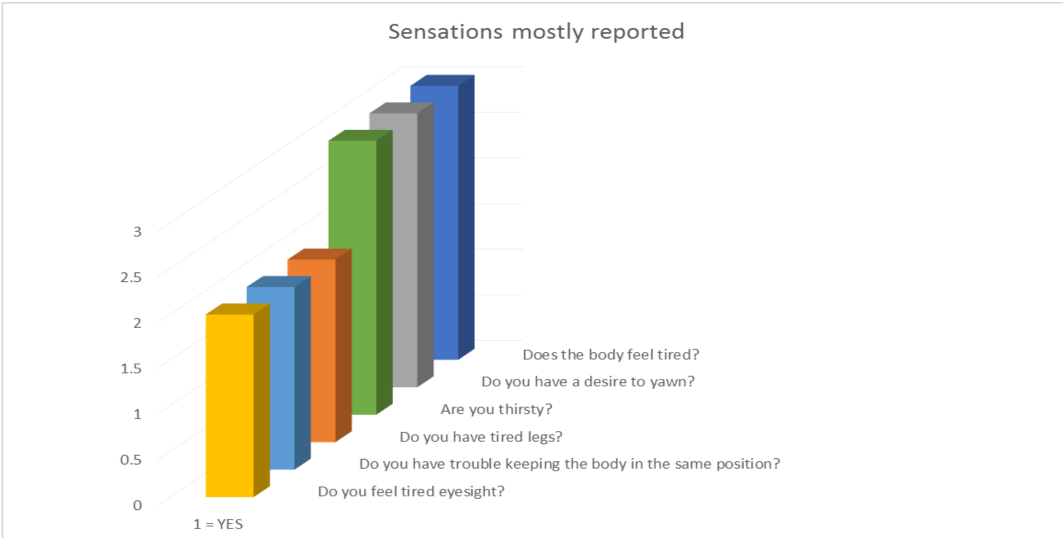


Figura 5. Symptoms more frecuently in operators

6. CONCLUSION

There are risks mainly due to physical demands, performance and frustration when carrying out the activities of the rotomolding process.

It is recommended to make changes in the distribution of activities and rest periods to reduce the presence of fatigue in workers.

It is necessary a medical and safety surveillance to diminish the physical and mental symptoms, as well as to keep track of the conditions according to the workplace.

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ERGONOMIC ANALYSIS OF THE PROCESS OF PACKING OF VAGETABLES IN THE AREA OF PRODUCTION OF A DISTRIBUTION CENTER IN THE CITY OF LOS MOCHIS, SINALOA.

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Resumen: Los movimientos repetitivos de las actividades de cocina influye en el desempeño laboral, con el riesgo de ser causante de molestias y lesiones al realizar un trabajo prolongado. Por esta razón se pretende realizar un análisis ergonómico y costo/beneficio del proceso de embolsado de verduras para detectar y evitar los riesgos ergonómicos para los trabajadores. La investigación tiene como objetivo determinar el nivel de fatiga y DTA´s, analizando sus actividades referentes al proceso de embolsado de verduras para aumentar la eficiencia, seguridad y bienestar en los trabajadores.

Palabras clave: Análisis ergonómico, análisis beneficio/costo, fatiga, DTA’s.

Relevancia para la ergonomía: El contenido de la presente investigación resulta útil para las empresas de servicio dedicas al proceso de vegetales y alimentos, en donde se desea evaluar y evitar los principales riesgos ergonómicos a los que están expuestos los trabajadores, además se describe el análisis beneficio/costo que permite conocer la factibilidad de inversión en propuestas de mejora, resultando benéficas para la empresa y los trabajadores.

Abstract: The repetitive movements of the kitchen activities influence the work performance, the risk of being the cause of injuries and injuries in the prolonged work. For this reason, an ergonomic and cost / benefit analysis of the process of bagging vegetables is sought to detect and avoid ergonomic risks for workers. The research aims to determine the level of fatigue and DTA's, analyze their activities in the process of bagging vegetables to increase efficiency, safety and welfare in workers.

Keywords: Ergonomic analysis, benefit / cost analysis, fatigue, DTA's.

Relevance to Ergonomics: The content of this research is useful for service companies dedicated to the process of vegetables and food, where you want to evaluate and avoid the main ergonomic risks to which workers are exposed, also describes the benefit / cost analysis that allows know the feasibility of investment in improvement proposals, being beneficial for the company and the workers.

1. INTRODUCTION

There are a large number of establishments dedicated to the preparation of food in the city of Los Mochis Sinaloa, to date there are no ergonomic studies that demonstrate its impact on workers, which is why the decision was made to perform an ergonomic analysis applied to process of food preparation in a CEDIS of a Franchise of Restaurants of Oriental Food, where the level of fatigue, symptoms of pain and discomfort in the body was measured, the Frequency of Complaints of Fatigue (FQF) was evaluated, the RULA method in search of corrections and modifications in the activities of the process, work posts were evaluated such as tables, tools, material handling and metabolic energy expenditure through the ERGOTEC method, a statistical data base of anthropometric measurements was made of 23 workers, with the purpose of redesigning and adapting the work stations to the workers, finally it was analyzed the benefit / cost of the improvement proposals to make a documented decision of the improvement to be implemented, this according to the results of the ergonomic analysis.

2. OBJECTIVES

Analyze from the ergonomic point of view the process of bagging stews in the production area in order to increase the efficiency, safety and welfare of workers. As specific objectives, it is intended to analyze the activities of the bagging process of stews through ergonomic, subjective methods, evaluation of jobs, anthropometric measurements and analyze the results through the benefit / cost factor.

3. METHODOLOGY

Fatigue and DTA assessments were performed on the workers in the bagging process with the Corlett & Bishop, Four points Luke and Yoshitake methods for physical, psychic and monotony factors. As well as evaluations to the work stations through RULA and Ergotec. Along with the evaluations, anthropometric measurements were made that would serve as a complement for future actions. A study / analysis was carried out in relation to the benefit that would be obtained by the implementation of some investments (benefit-cost), and finally alternatives and recommendations for the results obtained from the evaluation methods were presented.

4. RESULTS

When performing the analysis in the Distribution Center, the first thing that was done was to identify the area and the process in which it was going to work according to the needs of the operators. The decision was made to choose the process of bagging vegetables within the production area, because the workers said they felt very exhausted by the movements, the handling of materials and the postures adopted by the design of the job.Once the needs of the workers were determined, the ergonomic and quantitative methods corresponding to the needs of the analysis carried out in the company were selected. During the first 4 weeks of the study, the subjective methods 4 points of Luke, Corlett & Bishop and Yoshitake were implemented in search of fatigue and possible DTA's, in which 5 days during 4 weeks were applied once before starting work and another after to finish. In addition to evaluating the symptoms presented by the operators, they were also asked about the activities they perform before going to work and after leaving. This information is useful in cases where the detected problem is not found in work activities, but outside of them, such as at home, extra work, responsibilities, food and the means of transport they use on a daily basis. Based on the activities that were evaluated with the RULA method, it was observed that the postures and efforts that represent the greatest risk for the worker are in the path from the cold room area (place where the vegetables are stored) to the area of production to be processed, so it is recommended to carry out a second analysis where the loading, unloading and transport activities of the product are evaluated. To better understand the application of the RULA method, the selected images of the sampling performed are shown, which represent greater significance of physical risks and efforts for the study of postures.


Picture 1

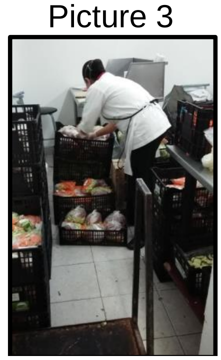

Picture 2


Picture 3


Picture 4


Picture 5


Picture 6


Picture 7


Picture 8

The ERGOTEC method was applied during 4 weeks evaluating the execution sections in the work, the risks of injuries by DTA's, injuries by manual handling of materials and the metabolic energy expenditure, applied to two people who are exposed in the process of bagging of stews, which resulted in a higher level of DTA injuries caused by the repetitive movements of the activities they perform.

The improvement proposal was the result of observations that were determined during the application of ergonomic methods, anthropometric measurements and job evaluation, taking as a reference the inclusion, in such a way that the majority of employees can take on the job. vegetable bagging station, this in case the person in charge of the position is absent or staff turnover occurs. Regarding the benefit / cost analysis, it was found that by investing an amount of $ 15,374.34 pesos in the improvement proposals, an expense of $ 84,700.00 pesos in labor risks can be avoided.

A second analysis was also carried out in which the amount of $ 10,500.00 pesos was invested in a stainless steel table and two anti fatigue mats, to improve productivity, resulting in an increase in productivity of 22.2%.

Given the feedback that was acquired with the workers, it was possible to know that the mood, the motivation to get to work and the corporal symptoms improved due to the implementation of improvements, the fact of feeling heard and cared for in each opinion, as well as suggestions they shared during the application of the analysis.

It is worth mentioning that the knowledge, experience and skills acquired during the evaluation in the company of the advisor's advice, as well as the employment relationship with the workers, is pleasing due to the fact that sufficient information was collected to detect risks and make proposals for improvement for the future tracing. As an apprenticeship, it was understood that what makes a company work are its workers, so it is always advisable to maintain a good quality of life, listen to their suggestions and make decisions in conjunction with employees, because they are the ones who are directly linked to the activities carried out by each of them in their areas of work.

5. CONCLUSIONS

During the first 4 weeks, subjective methods were applied: 4 points from Luke, Corlett & Bishop and Yoshitake in search of fatigue and DTA's, in which 5 days during 4 weeks were applied once before starting work and another after finishing. According to the results of the Yoshitake questionnaire, it is recommended to start another investigation to determine the optimal number of breaks and the amount of time needed in each rest during the day, in order to counteract the fatigue during the course of the day and specifically to attack with this causes the symptoms of somnolence and monotony. With regard to fatigue due to physical damage, it is recommended to educate the workers so that they assume postures that avoid discomfort, exercises to reduce discomfort and pain in the parts of the body that afflict them, as well as a postural hygiene education and for all this recommends developing an ergonomics education program that covers these aspects.

Based on the activities that were evaluated with the RULA method, it was observed that the postures and efforts that represent the greatest risk for the worker are located in the area of the cold room where the vegetables are stored, until reaching the area of production to be processed, so it is recommended to carry out a second analysis where the loading, unloading and transport activities of the product are evaluated. The ERGOTEC method resulted in a higher level of DTA injuries caused by the repetitive movements of the activities performed.

Regarding the benefit / cost analysis, it was found that by investing an amount of $ 15,374.34 pesos in the improvement proposals, an expense of $ 84,700.00 pesos in labor risks can be avoided. A second analysis was also carried out in which the amount of $ 10,500.00 pesos was invested in a stainless steel table and two anti fatigue mats, to improve productivity, resulting in an increase in productivity of 22.2%.

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Design of ergonomic template for manual crimping process

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Resumen: En una empresa de ensambles de componentes electrónicos, se detectaron problemas en muñecas de operadoras que manejaban tenazas de crimpado.

Se requirió realizar un análisis de riesgos ergonómicos a los operadores de la estación y de analizar aplicación de carga con las tenazas, por lo que las operadoras fueron evaluadas en su antropometría, para cumplir con nuestro objetivo.

Se diseñó un dispositivo mecánico para tenazas de crimpado, analizado y evaluado con los factores de riesgo ergonómico, para disminuir las lesiones en muñecas al operar la tenaza, la cual tuvo un impacto en la productividad, para dos operadores de ensambles de los 2 turnos

Es importante tomar en cuenta siempre la antropometría de los operadores al diseñar, instalar o utilizar herramientas que requieren esfuerzos para ser operadas manualmente

Palabras clave: Diseño antropométrico, Crimpado manual

Relevancia para la ergonomía:
Se debe tomar en cuenta siempre, la opinión y antropometría de los operadores, al comprar, diseñar, instalar o utilizar herramientas que requieren esfuerzos para ser operadas manualmente

Los esfuerzos al aplicar las cargas, se redujeron para los operadoras, por ser más confortables, aunque las herramientas de evaluación no validen, los riesgos ergonómicos medidos.

El diseño se podrá adaptar a otras áreas de la empresa, donde emplean tenazas de crimpeo, tomando en cuenta las alturas de confort de las operadoras correspondientes, conforme la herramienta empleada y los dispositivos ensamblados

Abstract
In a company of electronic components assemblies, were detected problems on wrists of operators who drove crimping pliers

Required an analysis of ergonomic hazards to the operators of the station and analyze implementation of load with the tongs, so operators were evaluated in its Anthropometry, to achieve our objective.

We designed a mechanical device for pliers crimp, analysed and evaluated with ergonomic risk factors, to reduce injuries in wrists to operate the iron, which had an impact on productivity, for two operators of 2 shifts-assemblies

It is important to always take into account the Anthropometry of the operators by designing, installing, or using tools that require efforts to be operated manually

Keywords: anthropometric design, manual crimping

Relevance for the ergonomics: You must take in account always, opinion and Anthropometry of the operators, to buy, designing, installing, or using tools that require efforts to be operated manually

Efforts to apply loads, shrank for the operators, being more comfortable, though not to validate assessment tools, measured ergonomic hazards.

Design can be adapted to other areas of the company, where to use crimping pliers, taking into account the heights of comfort of the corresponding operators, as the tool used and assembled devices.

1. INTRODUCTION

In an electronics Company, in an area of components Assembly two shifts are worked with two operators in each turn, detected problems on wrists of operators who drove crimping pliers.

Required an analysis of ergonomic hazards to the operators of the station and analyze implementation of load with the tongs, so operators were evaluated in its Anthropometry, to achieve our objective.

A mechanical device for pliers crimp, analyzed and evaluated with ergonomic risk factors, to decrease injuries in dolls to operate the iron, which had an impact on productivity, for the two rounds was designed

Considered opinion and Anthropometry of the operators when designing, installing or using tools that require efforts to be manually operated by them.

Required analysis of ergonomic risk, analyze the application of load and Anthropometry of operators, and obtained the computer-aided design was to design the template tailored to the Anthropometry of operators, with positions ergonomic to loads applied of crimping

You must consider the Anthropometry of the operators to purchase, design, install and use tools that require efforts to be operated manually

2. OBJECTIVE

Design of mechanical device for crimping pliers, analyzing and evaluating ergonomic risk factors, to decrease injuries in wrists when operating the tool

3. METHODOLOGY

3.1 Ergonomic risk analysis

Ergonomic risk evaluation methods of analysis were the OCRA, RULA and Suzanne Rodgers, photographs, videos from the station, the anthropometric measurements of the operators; as well as ergonomic checkpoints, questionnaire, historic clinic work, including step zero were applied in table 1 and table 2.

Table 1. Questionnaire of health and step 0

Operador	Fatiga	Desorden por Trauma Acumulativo					
Numero	Lentes	Cuello	Hombro	Mano	Brazo	Dorso Lumbar	Rota
1	Si	No	Si	Si	Si	Si	No
2	Si	No	Si	Si	Si	Si	No
3	Si	No	No	No	No	Si	No
4	Si	No	No	No	No	Si	No
5	Si	No	No	Si	No	Si	No

Table 2. Questionnaire of health and step 0

Paso 0									
Op	Peso	Talla	Frutas y verduras /sem	Agua Lt	Deporte	Tabaco	Alcohol	Edad	Antiguo Años
1	70	1.6	2 o 3	1.5 o 2	No	Si	Si	54	5
2	90	1.63	2 o 3	1	No	No	Si	49	3
3	59	1.6	2 o 3	1	No	No	No	47	13
4	55	1.57	2 o 3	0.5	No	Si	Si	50	1 mes
5	68	1.53	2 o 3	0.5 L	No	No	Si	30	5 meses

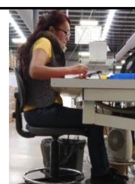
Once determined the health of workers was analyzed by each method ergonomic risk: Results from the method Suzanne Rodgers focused on table 3. The results are moderate in arm, hand, and wrist

Table 3. Suzanne Rodgers method for crimping

MÉTODO SUE RODGERS Crimpado					
	Opción 1 y 2				
	Intensidad	Duración	Por minuto	Puntaje	Análisis
Cuello	1	2	2	**2**	**Bajo**
Hombro	1	2	2	**2**	**Bajo**
Espalda	1	2	2	**2**	**Bajo**
Brazo y Codo	3	1	2	**7**	**Moderado**
Muñeca, mano, dedo	3	1	2	**7**	**Moderado**

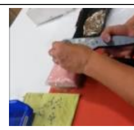
The RULA method of table 4, gives as a result: required a study in depth and correct posture as soon as possible, especially in the hands and wrists

Table 4. RULA method to crimping

MÉTODO RULA Crimpado		
	Operación crimpado opción 1	Operación crimpado Opción 2
GRUPO A. Análisis de brazo, antebrazo y muñeca		
Puntuación de Brazo	2	2
Puntuación de antebrazo	1	2
Puntuación de la muñeca	4	4
Puntuación giro de muñeca	2	1
Tipo de actividad muscular(Grupo A)	1	1
Puntuación de carga/Fuerza (Grupo A)	3	3
GRUPO B. Análisis del cuello, tronco y pierna		
Puntuación del cuello	2	2
Puntuación del tronco	1	1
Puntuación de las piernas	1	1
Puntuación del tipo de actividad muscular (Grupo B)	0	0
Puntuación de carga/Fuerza (Grupo B)	0	0
NIVELES DE RIESGO Y ACTUACIÓN		
Puntuación Final RULA	**5**	**5**
Nivel de Riesgo	**3**	**3**
Actuación	**Necesario realizar un estudio en profundidad y corregir la postura lo antes posible**	**Necesario realizar un estudio en profundidad y corregir la postura lo antes posible**

The OCRA method of table 5, gave as a result: non-acceptable high level, with 35.5 Max, where stands once again wrists and fingers

Table 5. OCRA method for crimping

MÉTODO OCRA. Factores de riesgo Crimpado				
	Opción de Crimpado 1		Opción de Crimpado 2	
	Derecha	Izquierda	Derecha	Izquierda
Tiempo de recuperación insuficiente	**4**	**4**	**4**	**4**
Frecuencia de movimientos	**0**	**0**	**0**	**0**
Aplicación de Fuerza	**24**	**0**	**24**	**0**
Hombro	1	1	1	1
Codo	0	0	0	2
Muñeca	4	2	2	4
Mano-dedos	4	2	4	4
Estereotipo	1.5	1.5	1.5	1.5
Posturas Forzadas	**5.5**	**5.5**	**5.5**	**5.5**
Factores de riesgo complementario	**2**	**2**	**0**	**2**
Factor de duración	**1**	**1**	**1**	**1**
Índice de riesgo y valoración	Derecha	Izquierda	Derecha	Izquierda
Indice de Riesgo	**35.5** No aceptable nivel alto	**9.5** Muy leve o incierto	**33.5** No aceptable nivel alto	**11.5** No aceptable nivelleve
Escala de valoración del riesgo				
Muy leve o incierto	7.6-11			
No aceptable nivel leve	11.1-14			
No aceptable nivel alto	≥22.5			

3.2 Analysis of application of load and Anthropometry

Location and equipment of Anthropometry: in the crimp stations operators were measured to determine if their anthropometric measures that were compared to the dimensions of chairs, tools and equipment location (Prado León, Ávila Chaurand, Herra Lugo, 2005).

Lighting, and noise are within the levels permitted in the corresponding workstation to 300 lux (Consorcio ambiental , 2006), however, we consider that they should validate 500 lux, by type of work.

Table 6. Analysis of lighting and noise

Data	1	2	3	4	5	6	7	8	9	10	11
Ilumination Lux	707	886	1032	566	507	688	708	580	630	530	437
Noise	87.7	83.1									

The adjustment tool is outside the optimum, recommended 55 to 60 mm, and crimp adjusting tool has 75 to 80 mm. (TBT5 MANUAL TOOLS)

To check if it is covered with load in pounds of the crimp clamp, manual equipment dynamometer test was validated (Baseline evaluation Instrumens), as shown in table 7, it can be seen that operators cover the required load, while the tool is great for them. (Jashimoto 2009)

Table 7. Comparative between required loads and load capacity as opening tool

Operador	Crimpeo	derecha	izquierda	Requerimiento
	20	60	55	
	27.5	55	55	
	26	50	50	
1	19	52.5	47.5	
	27	50		
	28			
	24.5833	53.5	51.875	47.4%
	25	50	35	
	30	40	42.5	
2	25	50	40	
	27	47.5		
	30	50		
	27.4	47.5	39.16667	70.0%
		60	45	
		60	40	
		60	45	
3		62.5	55	
		62.5	50	
		60		
		60.833333	47	58.3%

3.3 computer-aided design

Design computer aided design meets the expectations of the operators, held as they took the tool and inserted components, prototypes were tested and Figure 1, was optimal for them, now pushing the tool with one or two hands.

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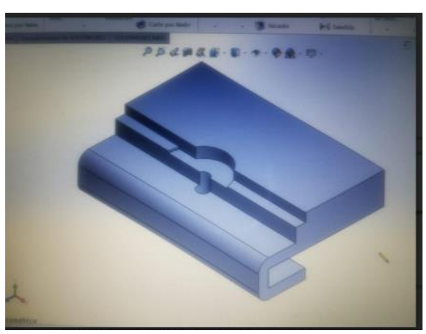

Figure 1. Template design

4. RESULT

Table 8. OCRA method for improved crimping

MÉTODO OCRA. Factores de riesgo Crimpado								
Opciones de Crimpado	Operación crimpado1		Operación crimpado 2		Operación crimpado nueva		Mejora	
	Derecha	Izquierda	Derecha	Izquierda	Derecha	Izquierda	Derecha	Izquierda
Tiempo de recuperación insuficiente	**4**	**4**	**4**	**4**	**4**	**4**		
Frecuencia de movimientos	**0**	**0**	**0**	**0**	**0**	**0**		
Aplicación de Fuerza	**24**	**0**	**24**	**0**	**16**	**0**	**33.3**	**0**
Hombro	1	1	1	1	0	0		
Codo	0	0	0	2	0	0		
Muñeca	4	2	2	4	0	0	100	100
Mano-dedos	4	2	4	4	2	2	50	50
Estereotipo	1.5	1.5	1.5	1.5	1.5	1.5		
Posturas Forzadas	**5.5**	**5.5**	**5.5**	**5.5**	**3.5**	**3.5**	**36.4**	**36.4**
Factores de riesgo complementario	**2**	**2**	**0**	**2**	**2**	**2**		
Factor de duración	**1**	**1**	**1**	**1**	**1**	**1**		
Índice de riesgo y valoración	Derecha	Izquierda	Derecha	Izquierda	Derecha	Izquierda	Derecha	Izquierda
Indice de Riesgo	**35.5**	**9.5**	**33.5**	**11.5**	**25.5**	**9.5**	**28.1**	**17.4**
Escala de valoración del riesgo								
Muy leve o incierto	7.6-11							
No aceptable nivel leve	11.1-14							
No aceptable nivel alto	≥22.5							

Table 9. Suzanne Rodgers improved crimping method

MÉTODO SUE RODGERS Crimpado											
	Opción 1 y 2					Opción Nueva					
	Intensidad	Duración	Por minuto	Puntaje	Análisis	Intensidad	Duración	Por minuto	Puntaje	Análisis	Mejora %
Cuello	1	2	2	**2**		1	2	2	**2**	**Bajo**	**0**
Hombro	1	2	2	**2**		1	2	2	**2**	**Bajo**	**0**
Espalda	1	2	2	**2**		1	2	2	**2**	**Bajo**	**0**
Brazo y Codo	3	1	2	**7**		2	1	2	**4**	**Bajo**	**30**
Muñeca, mano, dedo	3	1	2	**7**		3	1	2	**7**	**Moderado**	**0**

Table 10. RULA method for improved crimping

MÉTODO RULA Crimpado				
Opciones de Operación de crimpado	Operación crimpado1	Operación crimpado 2	Operación crimpado Nuevo	Mejora %
GRUPO A. Análisis de brazo, antebrazo y muñeca				
Puntuación de Brazo	2	2	2	0
Puntuación de antebrazo	1	2	2	0
Puntuación de la muñeca	4	4	2	50
Puntuación giro de muñeca	2	1	1	50
Tipo de actividad muscular(Grupo A)	1	1	1	0
Puntuación de carga/Fuerza (Grupo A)	3	3	3	0
GRUPO B. Análisis del cuello, tronco y pierna				
Puntuación del cuello	2	2	2	0
Puntuación del tronco	1	1	1	0
Puntuación de las piernas	1	1	1	0
Puntuación del tipo de actividad muscular (Grupo B)	0	0	0	0
Puntuación de carga/Fuerza (Grupo B)	0	0	0	0
NIVELES DE RIESGO Y ACTUACIÓN				
Puntuación Final RULA	**5**		**5**	**0**
Nivel de Riesgo	**3**		**3**	**0**
Actuación	**Necesario realizar un estudio en profundidad y corregir la postura lo antes posible**		**Necesario realizar un estudio en profundidad y corregir la postura lo antes posible**	

1. Reduction of effort to apply load with crimping iron
2. Template requires length of lever adapted to operators
3. Height of load application adaptable template
4. Installing template at table for application of load in comfortable position
5. Tables 8, 9 and 10 show in its analysis an improvement on wrists and hands

5. DISCUSSION/CONCLUSIONS

1. The ideal is to buy the tool that you can use to operators under their Anthropometry
2. The designed template is adapted to the comfort and Anthropometry of operators
3. Pliers for crimping of other areas of business can be adapted
4. Must take into account the heights of comfort of the corresponding operators, to install templates

5. Efforts to apply climpeo loads were reduced, to the operators and which have required the template
6. Ergonomic wrist postures, have been improved to loads applied

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RANGES OF ERGONOMIC ADJUSTMENT DEFINED IN FUNCTION TO ANTHROPOLOGICAL CHARACTERISTICS OF WORKERS IN AGUA PRIETA, SONORA.

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Resumen: El trabajo repetitivo establece un impacto negativo en los trabajadores, lo que incrementa la posibilidad de presentar un Desorden Músculo Esquelético. Para disminuir este impacto es necesario establecer medidas de ajuste ergonómicas a las estaciones de trabajo, sin embargo, estas medidas deben ser referenciadas a percentiles de la población laboral de la región donde se enmarca la actividad, siendo estas medidas altamente influenciadas por las características antropológicas del operador. El objetivo de la presente investigación es: desarrollar un modelo de correlación multivariante que permita definir los rangos de ajuste ergonómico en las estaciones de trabajo repetitivas, en función a la heterogeneidad biológica de este segmento poblacional. El proceso investigativo define tres fases: fase uno enmarca los estudios antropológicos teóricos para la compresión transversal y holística de la biología humana de cada región en análisis; fase dos encuadra las medidas antropométricas de la población y fase tres desarrolla el modelo de correlación multivariante. La aplicación del modelo permite la validación concurrente y predictiva de los datos obtenidos. El conjunto de datos validados ha sido utilizado por la industria para el diseño de estaciones de trabajo repetitivas con ajustes ergonómicos, esto ha disminuido el impacto negativo de estas tareas sobre el operador.

Abstract: The repetitive work establishes a negative impact on the workers, which increases the possibility of presenting a Skeletal Muscle Disorder. To diminish this impact, it is necessary to establish ergonomic adjustment measures to the work stations, however, these measures should be referenced to any percentile of the labor population of the region where the activity is done, being these measures highly influenced by the anthropological characteristics of the operator. The objective of this investigation is to develop a multivariate correlation model that allows defining the ranges of ergonomic adjustment in repetitive work stations, according to the biological heterogeneity of this population segment. The investigative process defines three phases: first phase consider the theoretical anthropological studies for the transversal and holistic understanding of the human biology of each region under analysis; second phase study the anthropometric measurements of the population and phase three develops the multivariate correlation model. The application of the model allows the concurrent and predictive validation of the obtained data. The validated data set has been used by the industry for the design of repetitive work stations with ergonomic adjustments; this has diminished the negative impact of these tasks on the operator.

Key words: Ergonomic adjustments, anthropology, correlation.

Ergonomics relevance: The research work presents the ranges of ergonomic adjustment to work stations with manual assembly, based on the anthropological characteristics of the population, which allows the design of work stations that intrinsically carry ergonomic guidelines, thereby reducing considerable the possibility that the operator develops a Skeletal Muscle Disorder and in turn improves the productive efficiency of the work station. What is considered as a contribution to ergonomic.

1. INTRODUCTION

The complex dynamics of the social structure in which human beings nowadays evolve entails a high demand in the development of daily activities. These demands are established in each and every one of the tasks that are necessary for the subsistence and progress of man. Day by day great advances are observed in each discipline, being an increasing demand on the operative performance of the muscular - skeletal system of the worker, who works in the modern systems of productive operations.

In the operativeness of the productive systems a harmonious conjunction between the productive capacity of the machinery and the performance of the operator is framed, this generates a convolution that determines the efficiency of the productive line, understanding as efficiency the fulfillment of the standard times in each season of work. The term convolution reflects that the productive capacity of the machinery is a function of the skill and aptitude that the operator develops in the handling of it, in the same way the skill and aptitude of the operator is a function of the capacity and ease in the handling of the machinery.

This convolution is precisely what occurs in the repetitive tasks of the work stations with manual assembly, which is object of study of the present investigation. Work stations with manual assembly are part of the production processes with online flows. These maintain characteristics and requirements of high demand for the operator who performs the assigned tasks, which generates an accelerated increase in fatigue, the possibility of developing occupational diseases, and increase the cycle time required to achieve the task and a decrease in production volume.

One of the fundamental characteristics to reduce the negative impact of repetitive work is the effective application of ergonomic guidelines and principles, which entails a descriptive analysis of the population that performs the activity and the mechanical requirements through which the processes perform its function. However, the ability to adapt the mechanisms, tools and work environment to the anatomical characteristics of the population that uses them, ensures the effectiveness of ergonomic applicability.

The adaptability of the mechanisms is developed from adjustment structures that contemplate a range of mobility in terms of height and reach in the operational management of the mechanism. However, the range of mobility must be adjusted to margins where two fundamental aspects are considered: The technical and operational feasibility of the interval, and the cost associated with said viability. Since, if the mobility interval maintains a very wide margin, the cost of the mechanism increases considerably, and if the mobility interval maintains a very small margin, it does not achieve a positive impact on the correct adaptation of the work to man. Due to the above, it is necessary to optimally define the range of mobility that should be implemented in the work stations, being necessary to analyze the anatomical characteristics of the population that will carry out its activity in the work stations under study.

The application of anthropometry allows us to establish the physical characteristics of the population that will use the mechanisms of work with adjustments according to these characteristics. However, a productive extrapolation of the anthropometric application gives us the feasibility of stratifying the intervals according to parameters of anatomical resemblance of the population. These parameters of similarity are established from the studies developed by the physical anthropology, framing the anatomical characteristics of the different defined groups, in a holistic conceptualization of their description that contemplates not only the anatomical aspects, but also the sociocultural, nutritional aspects , hereditary, of adaptability to the conditions of the environment, education, health, which as a whole allows to establish population segments with great similarity in their physical and social characteristics.

These population segments give us the possibility of structuring the mobility or adjustment intervals according to the anatomical characteristics of the segment, which maximizes the potential to improve the adequacy of the work to the operator and considerably reduces the cost associated with maintaining ergonomic work stations.

The present investigative work develops a multivariate correlation between an anthropological segmentation and the anthropometric measurements of these segmentations, in specific two: total height (code 805) and middle finger to back (code 80), to define the mobility intervals for adjusting the chairs and work tables used in manual assembly work.

2. OBJECTIVES

2.1 General objective

Establish ergonomic adjustment intervals in work stations with manual assembly, based on the correlation of anthropological segments and their anthropometric measurements

2.2 Specific objectives

1. Assess the scientific theoretical aspects related to the adjustment intervals, anthropological and anthropometric characteristics of the population that works in work stations with manual assembly.
2. Correlating the anthropological segments with their anthropometric measurements, to establish ergonomic adjustment intervals in work stations with manual assembly.
3. Validate the functionality of the adjustment intervals with the ergonomic adaptation of the work to the operator.

3. METHODOLOGY

The present investigative work carries with it a set of methodologically pragmatic actions that are divided into three main points:

3.1. The first action is a study of physical anthropology that determines the somatology and provides a population, dynamic and changing, non-static view of the human populations involved in the study, thus allowing establishing a set of population segments with anatomical, physiological characteristics, sociocultural and similar heritage.

3.2. The second part of the methodology consists of establishing an anthropometric measurement procedure that maintains a statistical sustenance with high significance for each segment defined in the anthropological study. This procedure contemplates two specific measurements, those corresponding to codes 805 and 80, used mainly for the design of work tables and in the design of chairs. With these measurements it is possible to determine the percentile necessary in the ergonomic designs of the tables and work chairs used in the operations that contemplate the manual assembly.

From the anatomical measurements of each defined population segment, a multivariate correlation is developed that defines the necessary adjustment interval so that the chairs and work table are ergonomically adapted to the anatomical characteristics of each defined segment.

3.3. As a third point of the present methodology, a concurrent validation study is carried out in which the adjustment intervals defined for each population segment are compared with the anatomical requirements of the population that performs the function. The study establishes the effectiveness of the adjustment interval with the anthropometric measurements of the worker circumscribed in a certain segment and the work station designed with the parameters defined by the study.

It is important to establish that at all times of the investigation the main scientific tools of the research methodology were considered, describing each of them, in form and action:The analysis of the general to the particular to define the anthropological characteristics of the segmentation and its anthropometric measurements; from the abstract to the concrete for the theoretical foundation of the scientific problem; analysis - synthesis, which is used throughout the research process to examine the specialized literature and synthesize the results; the inductive - deductive method, which is used to make generalizations about the object of study and to conform the theoretical framework that is used as the basis for the present investigation; from the simple to the complex to establish the ergonomic adjustment intervals according to the development of the correlation between the anthropological characteristics and their anthropometric measurements; the concurrent validation that determines the degree of improvement and acceptance of adjustment intervals by the operators that carry out their activities in work stations with manual assembly.

4. RESULTS

In order to establish the precise follow-up of the proposed methodology, the actions of the project begin with the development of the anthropological study in the region. For this, it is defined that the area of influence of the present research project is defined geographically in the northeastern zone of the State of Sonora and contemplates the activities that take place in the manufacturing industry and export maquiladora located in this area. The main turns of this industry are the manufacture of harnesses, electronic components, and automotive components, among others. Being repetitive tasks in work stations with manual assembly one of the main tasks assigned to workers in this industry.

In addition to the above, the population that works in these operational systems maintains a high staff rotation due to the migratory phenomenon that occurs in the area, which has allowed finding well-defined population segments in terms of the requirements established by anthropological studies.

It is important to mention that the anthropological study retakes, for its analysis, the population structure that at the time of data collection is working in the maquiladora industry and that the results are limited in this space of time and place. Consideration that is defined by the migratory phenomenon that maintains high recurrence in the region of influence of the project. The migratory phenomenon contemplates the arrival to the company of operators that in their planning of life is defined to move to the neighboring country, United States of America, being a pressing need for them to substantially increase the capital with which they will carry out the process migratory, feeling obliged to establish a working relationship with the company for a short time. However, the high productive demand framed in the production plans of the maquiladora industry requires a high volume of personnel, which includes the hiring of this population segment to meet production specifications, being simple tasks, but with great repetitiveness in the movements necessary to carry out the activity.

Table 1 shows the stratification of the population segments that were formed in the anthropological study and that contemplate the environmental, sociocultural and hereditary conditions that characterize each defined population segment. In turn, the total number of workers included in the segment is framed.

Table 1. Population segments, define on anthropological study

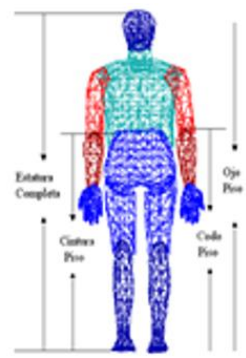
Population segment	Cities of workers origin, belonging to the segment	Total of workes
Local area 1	Agua Prieta, Cananea, Naco, Nogales, Esqueda, Moctezuma	268
local área 2	Hermosillo, Caborca, Obregón, Navojoa, Huatabampo, Zona Serrana	194
Northeast area	Chihuahua	148
Center area	Sinaloa, Aguascalientes, Zacatecas, Durango	230
Southern area	Chiapas, Ciudad de México, Michoacán, Jalisco, Guanajuato	180

The result of the anthropological study generates the set of population segments with similar anatomical, physiological, sociocultural and inheritance characteristics, which is used as a basis for the anthropometric measurements of each element of the population segment and with this the ranges in the percentiles to calculate.

The second moment of the methodology establishes the development of anthropometric measurements for each segment of the defined population, for which the specific anthropometric protocol is applied in two essential measures for the design of chairs and work tables. In accordance with the protocol, measurements are taken in reference to total height (code 805) and middle finger to back (code 80). Table 2 presents the protocol for measuring the two codes required.

The measurements are made to each worker circumscribed in the population segments already defined, obtaining the measure of the 95th percentile, its standard deviation and the 95 percent confidence interval. With this information, the statistical parameters that describe the anatomical characteristics of the elements of each population segment are maintained and with this, the necessary and sufficient conditions are established to carry out the development of the multivariate correlation, a situation that is carried out from the application of the multivariate analytical hierarchical tree, which presents as a final statistical result a graphic description of the population segments, the number of workers included in the segment and the confidence intervals at 95% of the percentiles of each measure used for the study , which in its last configuration establishes the necessary parameters to define the range of mobility that must be framed to adapt the chairs and work tables to the operators who will carry out their activities in the work stations with manual assembly.

Table 2. SEMAC Protocol of anthropometric measurements

Anthropometric measure and code	Physical measurement
Middle finger to back (code 80)	
Total height (code 805)	

The adjustment mobility intervals to the chairs and tables used in the work stations of manual assembly, are the main contribution of the present investigation, with this the company is able to adapt the working conditions to the operators that carry with them this type of tasks.

Figure 1 shows the multivariate analytical hierarchical tree for each of the measurements made for what is defined as total height. Similarly, in Figure 2, the multivariate analytical hierarchical tree is presented for each of the measurements made for what is defined as the middle finger to back.

As a whole, the two figures define the characteristics of each population segment established in the anthropological study, and are precisely the confidence intervals presented in the tree, which serve as a basis for the calculation of the mobility ranges of adjustment of chairs and tables of work that are used in work stations with manual assembly.

The procedure defined to carry out the third point of the methodology used in the present investigation, establishes as a starting point that in the process of recruitment and selection of personnel should include the questioning about the place of origin of the person considered as candidate to fill the vacant position.

The second point that establishes the procedure is to maintain an inventory of 5 chairs with the adjustment parameters that respond to the adjustment intervals presented in the tree of multivariate hierarchy in each population segment, in the same way the work stations must maintain 5 types of work tables with their respective adjustment parameters

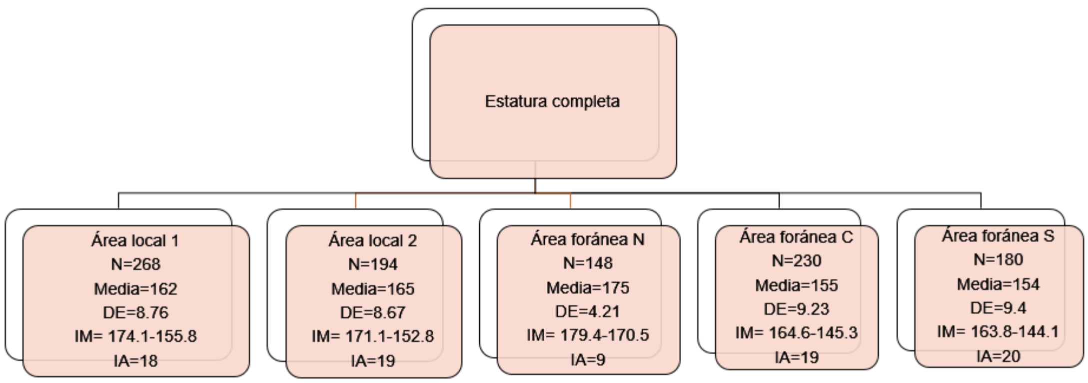


Figure 1. Multivariate hierarchy tree for total height measurements.

The third point of the procedure is to tie the worker hired with the chair and work station that corresponds to the population segment of their place of origin.

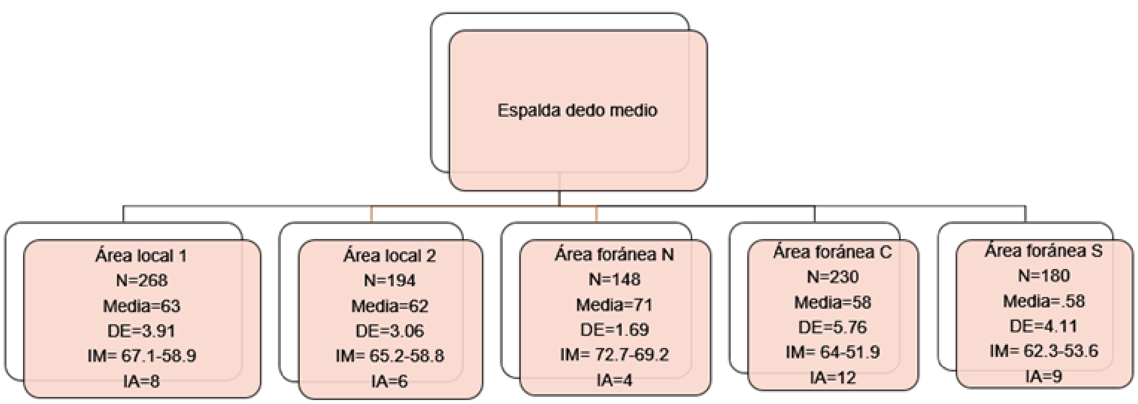


Figure 2. Multivariate hierarchy tree for mid-finger to back measurements.

Up to this moment 232 applications have been made of the procedure established in the methodology of the present investigation. With the cardinality of applications, the concurrent validation of the research result is defined, since each worker is assigned in the work station with the adjustment intervals defined for each population segment and the quantitative assessment of the level of ergonomic adjustment of the worker and the work station.

As a result of the above it is observed that, of the 232 applications in 214 of them, an ergonomic adjustment has been observed between the work station and the operator selected by the recruitment mechanism, in the case of the remaining 18, 7.75% of the applications, presented differences in the levels of adjustment required to ensure that the workstation is considered ergonomic. The final result of the concurrent validation defines that there is sufficient evidence to consider that the procedure establishes the necessary and sufficient conditions for the assignment of the hired worker to the work station designed in accordance with the established by the adjustment intervals in each population segment It results in an effective adaptation of the work to the operator.

5. CONCLUSIONS

The work stations with manual assembly of the manufacturing industry and export maquiladora, located in the border area of northeastern Sonora, maintain characteristics of high repetitiveness of movements, static postures, short cycle times, contact stress, which in Together they generate the necessary conditions for an increase in the possibility of the operator to develop a Skeletal Muscle Disorder.

The populations that works in the work stations described above contemplate different anatomical characteristics, mainly due to the migratory phenomenon that occurs in the area of influence of the project. Being 5 geographic areas in which there is predominance of origin in the population, these 5 areas are defined in the present research project from the anthropological study carried out with this objective.

The anthropological study contemplated a total of 1020 workers, who were divided into 5 population segments and 2 anthropometric measurements were made, total height (code 805) and middle finger to back (code 80). With this information, a multivariate analytical hierarchical tree was generated, which results in the adjustment parameters of the chairs and work tables belonging to the work stations with manual assembly.

The concurrent validation of the research contemplates the application of the adjustment intervals to 232 work stations with manual assembly, resulting in 92.25% of the workers performing their work in work stations appropriate to their anatomical characteristics.

The establishment of the ranges of ergonomic adjustment to work stations with manual assembly, based on the anthropological characteristics of the population, allows the design of work stations that intrinsically carry with them ergonomic guidelines, thereby considerably reducing the possibility that the operator develops a Skeletal Muscle Disorder and in turn improves the productive efficiency of the work station.

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ERGONOMIC RISK FACTORS IN THE WORK-IDENTIFICATION, ANALYSIS, ERGONOMICS COMMITTEE, PREVENTION AND CONTROL.

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Resumen: Al detectar el Aumento de número de incidentes relacionados con lesiones musculo esqueléticas en 2018 y probables enfermedades laborales a futuro, debido a tareas repetitivas y cargas manuales; Además del próximo margen de implementación de la NOM-036-STPS-2018 en octubre del 2019. Se realizo una investigación de los factores de riesgo ergonómico dentro de la planta de Kimberly Clark con la meta de mejorar las condiciones de trabajo y salud del trabajador.

Palabras clave: Movimientos repetitivos, carga y enfermedades profesionales.

Contribución a la Ergonomía: El proyecto puede usarse en el futuro como un método de investigación de las causas fundamentales de las enfermedades ocupacionales informadas y como prueba del cumplimiento de las normas oficiales aplicables y las normas corporativas para futuras auditorías internas y externas dentro de la empresa. De la misma manera, se puede utilizar como base para la aplicación dentro de cualquier otra empresa que tenga situaciones similares dentro de sus áreas de trabajo.

Abstract: When detecting the Increase in the number of incidents related to musculoskeletal injuries in 2018 and probable occupational diseases in the future, due to repetitive tasks and manual charges; In addition to the next implementation margin of NOM-036-STPS-2018 in October 2019. An investigation of the ergonomic risk factors within the Kimberly Clark plant was carried out with the goal of improving working conditions and worker health.

Key Words: Repetitive movements, load and occupational diseases.

Ergonomic Contribution: The project may be used in the future as a method of investigation of root causes of reported occupational diseases and as evidence of compliance with applicable official standards and corporate standards for future internal and external audits within of the company. In the same way it can be used as a basis for the application within any other company that has similar situations within their areas of work.

1. Introduction

One of the most valuable assets of all the organization is the human resources and having an employee who feel in a total comfort state, whether in their interpersonal relationships, furniture, tools, work areas and logistics tasks can affect productivity levels.

The analysis of the systems and working conditions consists of studying the environment in which the workers find themselves, seeking to detect, reduce and eliminate unsafe conditions that could lead to dangerous situations, such as: injuries, accidents, illnesses and discomforts. We understand as a work condition any aspect of the occupation with possible negative consequences for the health of the workers, including, in addition to the environmental and technological aspects, the questions of organization and order of work. The objective of the analysis of systems and work conditions is to coordinate the demands of the tasks with the physical, mental and psychosocial capacities of the individuals.

The project arises from the need of the organization to establish a diagnosis of the current situation and create a plan projection of risks in working conditions. Due to the number of injuries of repetitive movements and loads in the company that generates future occupational diseases whose cost is considerable.

2. Objectives

2.1 General

Improve working conditions and health of the worker that will lead to reduce critical risks and increase the welfare and comfort of users and the active participation of all personnel involved in the activities analyzed.

2.2 Specifics

2.2.1 Identify and evaluate problems in the workplace.
2.2.2 Develop an effective, understandable and functional ergonomics program.
2.2.3 Train, organize and schedule monitoring of work systems analysis and ergonomic improvement plan by the Ergonomics Committee.
2.2.4 Develop and conduct Kaizen and improvement projects.
2.2.5 Create a culture of injury and risk prevention.

3. Delimitation

The present project will be carried out within the production area of the company K-C AFC MANUFACTURING. S DE R.L. DE C.V. Nogales plant.

3.1 Applicable Organization: Nuevo Nogales.

3.2 Business Unit: Personal care: Adults and female care: Tampons: personal care: Adults and female care: Pessary.
3.3 Applicable departments: Engineering; Maintenance; Operations; planning; supply chain.
3.4 Generating Department: Hygiene, safety and environment.

4. Project development.

4.1 Diagnosis of the current situation and future projection.

4.1.1 Initial determination of internal and external demands.

A work team was formed whose participants are specialists of each work area that influences the production process either directly or indirectly. In order to have greater clarity and organization in the study. This working group has knowledge about: Ergonomic methods, ergonomic risks, musculoskeletal injuries, anthropometry, work conditions and activities considered fundamental for research. The members of the work team that participated in the application of the procedure that were selected are:

- Process engineer.
- Safety, hygiene and environmental personnel.
- Maintenance engineer.
- Supply chain leader.
- Maintenance glider.
- Platform leaders.
- Financial supervisors.
- Project and development specialist.
- Specialist in human resources management.
- Nursing staff.

Each expert is selected taking into account their experience, knowledge of the subject, level of commitment and willingness to participate in the research. When the number of experts was defined and the selection of experts, the work schedule for the activities to be developed was determined and the procedure to be applied was thoroughly studied, as well as the commitment of the center's top management, as well as the specialists of the involved areas to provide the data and documents necessary for the investigation. The determination of the external demands was made from the documentary review, mainly the one referred to the demands of the higher organisms, which were listed as shown below:

- Each piece of product must be certified according to the requirements established by the company K-C AFC MANUFACTURING S. DE R.L. DE C.V.
- The company must comply with the requirements established in ISO13845: 2016 Referring to the quality management of medical devices.
- The product must comply with the requirements and quality parameters established by customers.

- The supply chain must comply with what C-TPAT refers to.
- It must comply with the requirements of the Mexican Social Security Institute.

For the determination of the internal demands of the process, the analysis of the negative effects that affect the work system in the storage process, operations, offices, supply chain, maintenance is performed.

In the period of 2016-2018, seven occupational diseases were reported, all of them diagnosed with tendinitis in the forearm, wrist, elbow, shoulder and thumb. In 2018, 39 people were disabled due to probable risk of work, with the main causes being musculoskeletal injuries.

Based on the increase in occupational diseases in recent years, the work team that makes up the ergonomics committee took the decision to perform ergonomics evaluations to the work areas of the entire company, where a skeletal muscle lesion can be generated, accidents or occupational disease, applying techniques specially designed to evaluate ergonomics factors.

From the analysis of the indicators shown above, an ergonomic evaluation plan was generated, considering injuries records that allow obtaining an overview of the problems that affect the work systems of the business.

A brainstorm was made by the specialists on the possible causes, the following list being based on the similarities and repetitions:

- Working methods: Inefficient technology in production. The U by Kotex area is considered manual, Poise Impressa and Hi Tech is considered a semi-automatic process, in the supply chain there is a deficiency of correct manual loading methods.
- Working conditions: Bad working conditions for the workers, significantly affecting the inadequate posture.

4.2 Analysis of work systems.

The analysis of the work systems was carried out using the structure presented in NOM-036-STPS-2018:

- Realization of simple estimation of risk level or rapid evaluation. Initial assessment of the conditions in which the work is carried out.
- Specific evaluation of the level of risk. Evaluation of the ergonomic risk factors to determine the magnitude of the risk derived from the activities or tasks. Making use of scientifically validated methods that allow a detailed risk assessment of the conditions in which the activities are carried out.

The methods used are presented below:

- REBA. Method that allows the joint analysis of the positions taken by the upper body members (arm, forearm, wrist), trunk, neck and legs. It allows to evaluate both static and dynamic postures and incorporates as a novelty the possibility of signaling the existence of sudden changes in posture or unstable postures.
- Strain Index Revised. Method used for repetitive movements of the distal upper extremity. The RSI Revised Voltage Index is a physical assessment model based on: intensity of effort, frequency of exercise, duration of effort, hand / wrist posture and duration of the task per day. RSI is a substantially improved model for the design, intervention and analysis of the task.

- Rula. Called thus by its abbreviations in English Rapid Upper Limb Assessment or rapid evaluation for superior members. Its objective is to evaluate the exposure of workers to risk factors that cause a high postural load and that can cause disorders in the upper limbs of the body. For the evaluation of the risk the method is considered the position adopted, the duration and frequency of this and the forces exerted when it is maintained.
- QEC. In its acronym in English Quick Exposure Check, which is a checklist to be used quickly in pestos work, in different areas of the body. Evaluate the change in exposure to osteo-muscular risk with factors before and after an ergonomic intervention.
- MAC. Evaluates the most common risk factors in the operations of lifting, descending, transporting and handling cargo. The objective of the evaluation is to identify and then reduce the overall risk level of the task.

All the evaluations carried out are presented in Annex 1.

4.1.2 Presentation of results of analysis of work systems.

Once all the ergonomic evaluations have been carried out using the FORM-33169 ergonomic evaluations, it can be localized in the organization's document control system. They were physically located in the areas evaluated so that they are available to workers. The total of outstanding evaluations to be carried out in 2019 was presented to the company's managers in December of 2018.

These results will be communicated.

4.3 Formulation of ergonomic action strategies.

4.3.1 Ergonomic intervention program design PR-27555 Ergonomics.

To design the ergonomics program, it is necessary to make a comparison of the corporate standard and NOM-036-STPS-2018. Against the existing ergonomics program. Two internal audits are performed on Element 11. Ergonomics. Whose adequate design strengthens the safety, hygiene and environment system, preparing it for the audits scheduled in September 2019 by the GOSH / GET team. Whose auditors will be:

- Leader auditor: Chrissi Park (Leader of environmental engineering / Beech Island mill)
- OSH Auditor: Lizette Sheffield (Owner of the non-manufacturing security program, Roswell)
- OHS Audit Trainer: Elaine Chambers (EHS Consultant, Safety and Sustainability, Roswell)
- Auditor: Amanda Katzoff (Environmental Engineering Leader, Chester Mill).

Compliance with the occupational safety and hygiene standard

4.4 Implementation and evaluation of ergonomics action strategies.

The purpose is to minimize or eliminate exposure to risk factors in employees. The solutions can be found in employees, supervisors, safety and hygiene team, specialist engineers and in jobs where similar tasks are performed.
The recommendations will be evaluated based on these classifications of ergonomic interventions:

1. Engineering: Focused on reducing exposure to physical risks.
2. Administrative: Focused on changing the way work is organized and designed.
3. Behaviors: Focused on the worker's behavior and ability.

An accurate evaluation of an action strategy would allow selecting the most convenient according to the variables to be taken into consideration. For this, it will be necessary to measure the impact that each proposal has, first for that job and then for the productive system.

You must answer the questions:
Do you solve the problem partially or completely?
Is the cost / benefit ratio favorable?

• Justification: Health, economic and production indicators should be used.

For the implementation of these should follow the procedure 27555- Ergonomics point 6.5 and 6.6.

5. Results

As results of the project is a compliance with the requirements of the official Mexican standard NOM-036-1-STPS-2018 analysis of the risk factors ergonomic by the manual handling of loads taking the prevention measures and/or control of the factors Ergonomic risk for manual handling of loads, monitoring of workers health and qualification of staff. In the same way we can achieve a reduction of the company's risk in the future.

6. Conclusions

The project is expected to be able to visualize an improvement within the company, which is expected to be reflected in the increase of productivity, reduction of turnover of personnel, errors, time lost by accidents, injuries and illnesses, etc. Mainly the last mentioned, which is counted with the reduction of the time lost by the cost of labor per unit of time.

The advantage is that most ergonomic improvements require low and fast-application budgets with short-term beneficial results.

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CORRELATIONAL STUDY OF MECHANICAL STRENGHTS DEVELOPED DURING THE USE OF SAFETY FOOTWEAR IN 12 HOURS LABOR

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Resumen: Como parte de las iniciativas de seguridad e higiene, muchas empresas de manufactura requieren que sus trabajadores utilicen zapatos de seguridad, los cuales son utilizados por largos periodos de tiempo, a saber, esta condición puede conducir a la aparición de ciertas molestias y en algunos casos a lesiones en los pies, las cuales pueden estar relacionadas con diversos aspectos, entre ellos, con un calzado estrecho, con el peso del mismo e incluso la forma, que en ocasiones roza con la piel causando ampollas. Existen varios estudios que muestran que las lesiones por deformación repetitiva (RSI) están relacionadas con el uso de zapatos de seguridad y en otros estudios se menciona que la mitad de las lesiones ocupacionales y desórdenes músculo-esqueléticos relacionados con los pies están conectados con el uso de ciertos zapatos; también se dice que se han observado otros efectos en las rodillas, cintura, espina dorsal e incluso en el cuello. Un soporte inadecuado del talon, es asociado a la fascitis plantar, debido principalmente a la pronación del pie, en la que el arco del pie colapsa y se incrementan las deformaciones en los ligamentos, nervios y músculos del pie. Este estudio nos ayuda a conocer los síntomas de molestias en las partes del pie, que experimentan trabajadores que usan zapatos de seguridad por al menos 12 horas continuas a través de un índice, así como los esfuerzos mecánicos asociados al peso del zapato. Se plantea un análisis multivariante con el propósito de establecer la relación que existe entre el índice de molestias experimentadas, los esfuerzos mecánicos en las tres partes del pie y el peso del zapato.

Palabras clave: Zapato, esfuerzo, correlación

Relevancia para la Ergonomía: De acuerdo a la revisión del estado del arte, en relación con las molestias y esfuerzos generados por el uso de zapatos industriales, no fueron encontradas referencias relevantes, por lo que este estudio, presenta información que nos permite comprender cómo es que el peso del zapato industrial

es una variable que tiene una relación estrecha con las molestias experimentadas, las cuales son una premisa para las lesiones de tipo repetitivo en los pies.

Abstract: As a part of the occupational health initiatives, most manufacturing plants require to their workers the use of safety footwear, that are worn for a large part of labor hours, this condition may lead to certain feet injuries that could have relations with different issues, including the shoe tightens, weight and if the shoe is rubbing with some parts of the feet. There are several studies that show that RSI (Repetitive Strain Injury) is related to the characteristics associated with the safety footwear, there are other studies that indicate that half of occupational injuries are related to the feet and musculoskeletal disorders such plantar fasciitis are also connected with the use of certain shoes, some other effects are observed in knees, hips, spine and even in the neck. Poor sole or bad heel support is one of the major causes of plantar fasciitis due to over-pronation of the foot, where the arches collapse, putting excess strain on ligaments, muscles and nerves in the foot. This study aims us to better understand what are the discomfort symptoms experienced by the workers that are using working footwear for an average time of 12 hours in a large manufacturing plant through the development of an index, and also the mechanical strengths suffered in the forefoot, midfoot and the hindfoot. A multivariate analysis is developed in order to determine if there is a relation between the discomfort symptoms (index), the mechanical strength in the foot and the weight of the safety footwear.

Keywords: Footwear, strength, correlation

Relevance to Ergonomics: According to the revision made to the state of the art in regard to this ergonomic issue, there were not found relevant studies in this matter. This study presents important data to understand how the shoe weight is an important variable that has a strong relationship to discomfort symptoms, which are a premise to repetitive strain injuries.

1. INTRODUCTION

According to Seeley et al (1996) It is a normal pattern, not to think about our feet, unless pain and some muscle-skeletal discomfort appears, and in a workplace, this can lead to have a low productivity . Footwear also, takes an important role in the feet discomfort, and there are two major categories of work-related foot injuries in the industrial sector, one is associated with impact and compression and the other one is related to slips, falls, where footwear may have played a role.

Some of the injuries include aching feet, blisters, calluses, corns, rheumatism, arthritis, fallen arches, bunions and sprains, which can result from standing for long periods of time, and also for the weight of shoe and the time that the workers walk from one site to another, especially on hard floors and also by poorly fitting footwear (Robbins,2000). According to the Bureau of Labor Statistics (BLS), of the 917,060 private industry nonfatal occupational injuries and illnesses involving days away from work during 2013, twenty two percent involved injuries to the lower extremities and more than 89,000 of these cases involved injuries to the ankle or foot.

The occupational Safety and Health Administration requires employers to eliminate or reduce exposure to hazards, however, when the strategies to reduce them are economically infeasible, it has required the use of protective equipment; in the United States of America, the requirements for protective footwear are referenced in Title 29 of Code of Federal Regulations, specifically in 29 CFR 1910.136 which establishes that the employee shall wear protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, and where such employee's feet are exposed to electrical hazards.

This document incorporates as a reference the ASTM F2412-05 standard, which let us make tests for protective footwear and the American National Standards Institute standard ANSIZ41-1999 which was replaced by ASTM F2412-11 (Standard Test Methods for Foot Protection) and ASTMF2413-11 (Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear).

It is important to understand that most OSHA, ASTM and ANSI requirements are followed by the foreign companies located in the city of Hermosillo, Sonora, México, however, despite of this important standard, the shoes that are worn by workers are purchased from local suppliers and national manufactures that are not necessarily in agreement with such standards, so, there are several feet discomfort symptoms that could be associated with the safety footwear used by workers.

In this research, we developed a discomfort symptom survey in order to understand what are the discomfort symptom associated to the wearing of safety footwear and also to determine the level of strength in the barefoot, midfoot and the hindfoot, due to the weight of the shoe, then an experimental design was developed to understand the relation between foot strength parts, the weight of the shoe. The mechanical strengths in the feet are calculated from a biomechanical model which has two main variables: the weight supported by feet and the foot length and the foot weight, the strengths are calculated having as a reference point the feet joint.

2. OBJETIVES

There are three main objectives in this research:

To determine a measurement of the discomfort (Foot Discomfort Index) experienced by the workers that use safety shoes during a twelve hour shift.
To define a biomechanical static model of the foot, in order to calculate strengths in foot.
To determine if there is a relationship between the weight of the safety footwear and the mechanical strengths in the foot and the foot discomfort index calculated for the workers that use safety shoes during a period of time of 12 hours.

3. METHODOLOGY

There was performed an exploratory study which consisted of the design, application and validation of foot discomfort symptom survey of 53 male workers from a stratified sample from four departments: manufacturing, warehouse, quality and maintenance. Two Anthropometric measurements were taken (weight and height) in order to estimate foot weight and foot length. A biomechanical model was developed in order to calculate mechanical strengths in the foot. Proposed model lets us calculate the forces acting on foot during walking. The weight of each safety shoe was taken using a calibrated scale, a total of four categories of weights was found, that were identified as 1,2,3,4 for the purposes of statistical study. Data obtained was processed with SPSS v13 software, a MANOVA test was conducted in order to understand the relationship between variables: shoe weight, discomfort symptom index and mechanical strength acting on foot.

3.1 Equipment and materials

It was developed a foot discomfort index survey, which has three categories of discomfort: one for the midfoot, another for the barefoot and the last one for the hindfoot, which tell us for every category the type of symptoms that can be felt when using the safety shoes. There is a total of fifteen symptoms divided between the three categories. There was developed an index called Foot Discomfort Symptom which is composed from a percentage of total affections.

It was used a calibrated scale and a calibrated rule for measuring weight and height of 53 subjects of study, in order to estimate the biomechanical model variables: foot segment weight and foot mass center. There was also needed another variable in the biomechanical model: the coefficient of friction, which was taken from the ASTM recommendations and from OSHA which also recommend to use a coefficient of 0.5 or higher for polished surfaces, which are the floor type, used In the industrial sector.

3.2 Measurements

As we explained above, there were taken the weight and the height from al study subjects, and biomechanical model variables were estimated according to the model proposed by Crowninshield (1978). The estimated variables were the foot segment and the foot mass center, they were estimated from a model developed by Chaffin et al (1984).

The weight of each shoe used in manufacturing site was taken using a calibrated scale, and only one the right side foot was considered for modeling and calculating the acting force under the foot.

3.3 Procedure

Once the weight and height measurements were taken, there were estimated two of the variables of biomechanical model: foot segment weight and foot mass center, the other variables used in the model, where the coefficient of friction of the floor that was 0.5, the subject weight and the safety shoe weight. The biomechanical model proposed for this study is the shown in the figure 1:

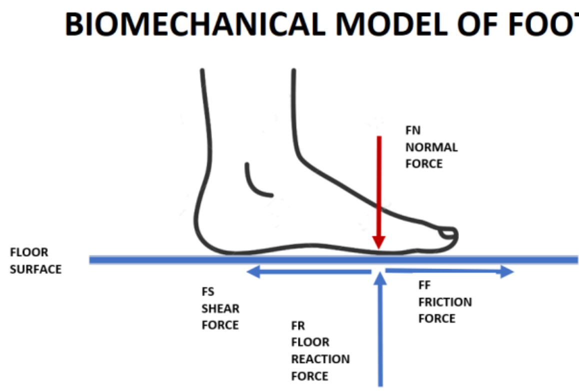

Figure 1. Biomechanical Model of Foot

The coefficient of friction is the ratio of maximum force acting parallel to a contact surface that resists motion of one body on the other, divided by the normal force acting on the contact surface. The contact surface is assumed to be the manufacturing floor and the ball of the foot.

The normal forces (FN and FR) are considered to be vertical and equal in magnitude, and the shearing and friction forces (FS and FF) are considered to act horizontally and also, are equal in magnitude. In the static case, the normal forces are equal to body weight (mg) and shoe weight and the horizontal forces depending on the contact surface conditions and the normal forces, in general the maximum values are proportional to the normal forces. Frictional force is equal to μFR, and the values of μ under static conditions will normally range from 0.2 for wet and smooth surfaces and 0.7 for rough and dry surfaces. We selected a μ to 0.5 according to ASTM and OSHA recommendations.

It was applied the developed Foot Discomfort Symptom Survey for the total sample of subjects, which was self answered according to their experienced symptoms related to the feet.

Three main variables had been developed in this research: Shoe Weight, Foot Strength and the Discomfort Symptom Index, and a multivariate analysis of variance (MANOVA) is performed in order to statistically analise and determine the equally assumption of variance between the four groups of categories of shoe weights for the two dependent variables: foot strength and discomfort symptom index.

4.RESULTS

4.1 Foot Discomfort Symptom Survey.

According to the results of Foot Discomfort Symptom Survey, they were found the following results, are shown in the table 1:

Table 1 Descriptive Statistics Foot Discomfort Index

AREA	Mean	Std. Deviation	Minimum	Maximum	N	% of Total N
MANUFACTURING	64.1026	17.54116	40.00	93.33	13	24.5%
MAINTENANCE	71.9048	13.88071	46.67	86.67	14	26.4%
WAREHOUSE	63.5556	13.53811	33.33	86.67	15	28.3%
QUALITY	71.5152	18.87760	40.00	93.33	11	20.8%
Total	67.5472	15.90773	33.33	93.33	53	100.0%

Which show us the Foot Discomfort Index means for every department considered: manufacturing, maintenance, warehouse and quality.

4.2 Research Variables

Two dependent variables were considered in this study: Discomfort Symptom Index and Foot Strength and a main factor that is the shoe Weight; this factor, has four categories: 1,2,3,4 which represents in ascendant way, the different safety shoe weights found in the study, table 2 shows the descriptive statistics for the explained variables:

Table 2 Research Variable Descriptive Statistics

	Shoe Weight	Mean	Standard Deviation	N
Discomfort Symptom index	1	57.1429	13.51524	14
	2	56.4103	10.75498	13
	3	79.3939	10.09050	11
	4	78.2222	11.94343	15
	Total	67.5472	15.90773	53
Foot Strength	1	537.7743	19.35001	14
	2	533.1302	33.12176	13

3	568.7744	51.23742	11
4	547.3894	19.10871	15
Total	545.7904	33.46334	53

As we can observe from the table, for the first dependent variable: Discomfort Symptom Index we can say that for the shoe weight categories 3 and 4, we have the highest level of discomfort symptom index and for the second dependent variable, we have also, the highest levels of foot strength for the shoe weight categories 3 and 4, however, there is needed to perform a MANOVA test in order to statistically probe that means are different between categories of weight safety shoes.

4.3 Multivariate Analysis Test

It was developed a MANOVA test (significance level of 0.05) where the independent variable is the Shoe Weight and the two dependent variables are the Discomfort Symptom Index and the Foot Strength as show table 3:

Table 3 Multivariate Analysis Test

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Discomfort Symptom Index	6381.0	3	2127.0	15.3	.000
	Foot strength	8832.4	3	2944.1	2.9	.043
Intercept	Discomfort Symptom index	240360.2	1	240360.2	1737.6	.000
	Foot strength	15635304.3	1	15635304.3	15509.6	.000
Shoe Weight	Discomfort Symptom index	6381.0	3	2127.0	15.3	.000
	Foot strength	8832.4	3	2944.1	2.9	.043
Error	Discomfort Symptom index	6777.8	49	138.3		
	Foot strength	49396.8	49	1008.0		
Total	Discomfort Symptom index	254977.7	53			
	Foot strength	15846251.2	53			
Corrected Total	Discomfort Symptom index	13158.9	52			

As we can infer from the MANOVA test table, due that p-value for Discomfort symptom index is 0.000<0.05 the test is significant, which mean that the four categories of shoe weight are significantly different on Discomfort symptom index and also for the Foot Strength, where the p- value is 0.043<0.05.

4.4 Post Hoc Duncan Test

Tables 4 and 5 shows the results for the two Post Hoc Duncan Test developed for the discomfort symptom index and foot strength:

Table 4. Discomfort Symptom index Post Hoc Duncan Test

Shoe Weight	N	Subset	
		1	2
2	13	56.4103	
1	14	57.1429	
4	15		78.2222
3	11		79.3939
Sig.		.874	.800

According to table 4, there are two homogeneous subsets displayed based on observed means and the group sizes are unequal, so type I error levels are not guaranteed., the first one shows that the mean of discomfort index are equally for shoe weights one and two, and also between shoe weights three and four. However, p-values are higher than 0.05.

Table 5 shows the results for the Foot Strength Post Hoc Duncan Test, there are two homogeneous subsets displayed based on observed means, we found strength is greater in categories three and four, and the level of significance is less than 0.05. However, the group sizes are unequal, so type I error levels are not guaranteed.

Table 5. Foot strength Post Hoc Duncan Test

Shoe Weight	N	Subset	
		1	2
2	13	533.102	
1	14	537.774	
4	15	547.389	547.389
3	11		568.774
Sig.		.285	.091

5.CONCLUSIONS

According to descriptive statistics of Foot Discomfort Symptom Survey, we can establish that is the maintenance area that refer more discomfort experience, however the other areas have an overall mean index value too close to the index found in the maintenance area, this could tell us that almost all workers experiment the same amount of discomfort symptoms.

Another important finding from the research variables table, is that it is clearly stated that for the shoe weights three and four, that are the greatest sizes, we found the greater foot strength and the discomfort symptom index.

According to results from MANOVA Test we found that the p-values for both, foot strength and the discomfort symptom index are less than α=0.05, that tell us undoubtedly that for the four shoe weight categories the discomfort symptom index and the foot strength are significantly different.

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ANTHROPOMETRIC STUDY FOR THE DESIGN OF A WORK STATION IN MAQUILADORAS OF TEHUACAN, PUEBLA.

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Resumen Hoy en día, la mayoría de personas permanecen sentadas durante la mayor parte del tiempo que están despiertos, mientras toman el desayuno, trabajan, viajan en los coches, en los autobuses, mientras están en las aulas de la escuela, en las reuniones, en las oficinas, durante la cena, y en la casa mientras ven televisión.

Algunas personas también permanecen sentadas mientras trabajan operando maquinaria y/o equipo industrial que la nueva tecnología ha desarrollado para sustituir el trabajo manual. Sin embargo, la importancia de diseñar adecuadamente puestos de trabajo, máquinas, herramientas, muebles, etc., tiene como objetivo mejorar el desempeño laboral del trabajador. Derivadas éstas del uso cotidiano y permanente de sillas improvisadas y poco convencionales que actualmente se emplean para desarrollar las actividades industriales en el ámbito de la maquila de ropa industrial, en la Ciudad de Tehuacán; Puebla.

Cabe mencionar que asociado a la ergonomía, la antropometría, definida como la disciplina que estudia las medidas del cuerpo humano, con el fin de establecer diferencias entre individuos, grupos, razas, etc. Permitirá a través de las dimensiones antropométricas que tienen que ver exclusivamente con una posición sentado, conocer los datos necesarios para establecer los espacios y dimensiones que el operador requerirá para realizar su trabajo confortablemente.

Palabras clave: Antropometría, Maquiladora, Estación de trabajo.

Abstrac: Today, most people remain seated for most of the time they are awake, while they eat breakfast, work, travel in cars, on buses, while they are in school classrooms, at meetings, at the offices, during dinner, and at home while watching television.

Some people also remain seated while working by operating machinery and / or industrial equipment that the new technology has developed to replace manual labor. However, the importance of properly designing jobs, machines, tools, furniture, etc., aims to improve the worker's work performance. Derived from the daily and permanent use of improvised and unconventional chairs that are currently used to

develop industrial activities in the field of industrial clothing maquila, in the City of Tehuacán; Puebla.

It should be mentioned that associated with ergonomics, anthropometry, defined as the discipline that studies the measurements of the human body, in order to establish differences between individuals, groups, races, etc. It will allow, through the anthropometric dimensions that have to do exclusively with a sitting position, to know the necessary data to establish the spaces and dimensions that the operator will require to carry out his work comfortably.

Key words: Anthropometry, Maquiladora, work station

Relevance to ergonomics: This design Project encompasses occupational ergonomics and the multidisciplinary field of industrial engineering, especially those related to chairs and seats used in work stations of everyday activities, culminating with the development and design, impacting on the improvement of the position of the workers of the maquila sector that exists in the city of Tehuacán, Puebla.

1. INTRODUCTION

Developing a job in a sitting position would seem an easy and desirable task for all those who carry out their work activities walking during the day between one and another work station. Walking or standing in a work activity, will always lead to problems in the body, which will affect the productivity of the company. (This is due to the fact that over time the body deteriorates gradually).

The operators of sewing machines will be particularly addressed in a maquiladora in Tehuacán, Puebla. In which despite the fact that the operators work operating machinery and /or industrial equipment that the new technology has developed to replace the manual work, its analysis is necessary. Hence the importance of properly designing an ergonomic workstation, which reduces potential problems in the company, both work and health, derived from the daily and permanent use of improvised and unconventional chairs that are currently used.

1.1 General Objetive:

The elaboration of this project aims to design and manufacture an ergonomic chair derived from an anthropometric study of the operators of sewing machines of the "Impresiones Logisticas" maquiladora dedicated to the manufacture of trousers in the city of Tehuacán Puebla, always looking to demonstrate that an ergonomic design based on anthropometric tables eliminates the possibility of discomfort and injury, as well as increasing worker productivity and quality of life.

1.1.1 Specific Objetives:

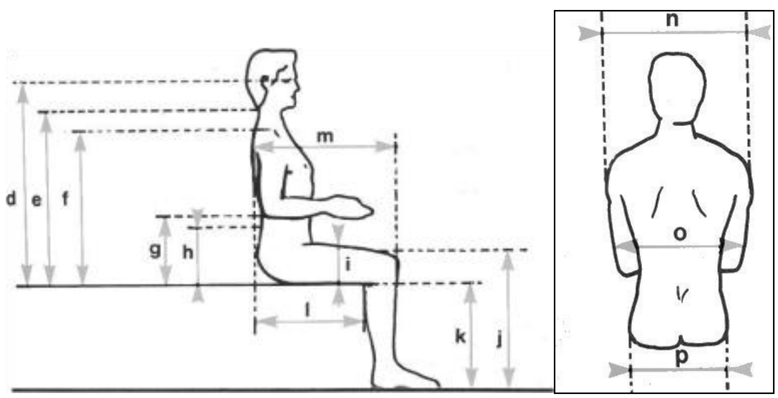
Design and manufacture an ergonomic work station in a seated position, which meets the requirements of the population.

1.2. Delimitation:
1.3.

This study is limited to a population of 240 "Impresiones Logisticas" trouser maquila workers in the city of Tehuacán, Puebla, with a representative sample of 30 workers.

2. METHODOLOGY

Anthropometric measurements were taken from a representative sample of the population, of 30 workers of a population of 240 people, the anthropometric measurements are listed below: 1 (k) Popliteal height; 2 (l) Buttock length - popliteus; 3 (g) Elbow height rest; 4 (f) Shoulder height - seat; 5 (o) Elbow-elbow width; 6 (p) Width hips; 7 (n) Shoulder width.



With the data obtained, an ergonomic chair that included the 95th percentile of the population was created and elaborated.

Considering the criteria of ergonomics regarding the use of static and dynamic anthropometric studies, structural and functional information of the operators was obtained. Deriving this in a more thorough analysis of human activity including the capabilities and limitations that could arise.

The project to create a workstation is a critical step in preventing problems for people who work in a sitting position. So it is essential to recognize that a work station for one person, does not fit all people who in the future occupy that same work station.

The sitting posture is the most comfortable working position, since it helps reduce body fatigue, decreases energy expenditure and increases stability and precision in the actions developed. (Pedro Mondelo, 2000).

However, this position can also be harmful to health if the elements involved in carrying out the work are not taken into account, mainly, in the work station in a sitting position (chair), or the work plan and if not you have the possibility of changing positions from time to time. Designing a workstation in a sitting position in order to reduce fatigue and the suffering derived from an inadequate body posture, must comply with the ergonomic requirements recommended below:

1. It should be easily adjustable to the height and depth of the back, as well as to the height of the seat.
2. The distance between the floor and the seat will be varied between 0.35 m., And 0.50 m.
3. The work stations in standing position are theoretically more recommendable if they are fixed, but the functions of some users that require frequent changes of sites could be more practical for mobile wheelchairs.
4. In the case of using chairs, the edges should be rounded and their platform should be tilted slightly backwards (3 to 7 degrees with respect to the horizontal).
5. The backrest should offer support as complete as possible and be a little tilted back forming an angle between 105 and 110 degrees with respect to the horizontal.
6. If necessary support for short arms to allow free forearm movement. If support for arms is not available, the work area of the station will have space for their support.
7. Very important element of the workstation in sitting position, it must be adapted to the length of the legs and to the height of the chair, we recommend a support surface of 0.40x0.50 m., With variable angle between 10 and 20 degrees (preferably 15 degrees) and a non-slip surface.

On chairs there is much written especially in English and German, Spain is the nation that has worked the most in ergonomics. With respect to the design profiles, Kirchner and Rohmert (Melo 2009) established six types identified with Roman numerals from I to VI, the same ones that are represented in figure 1. With respect to the types of postures and the seating schemes by type they are presented in table 1, and in table 2 the anthropometric measurements of the seat are shown.

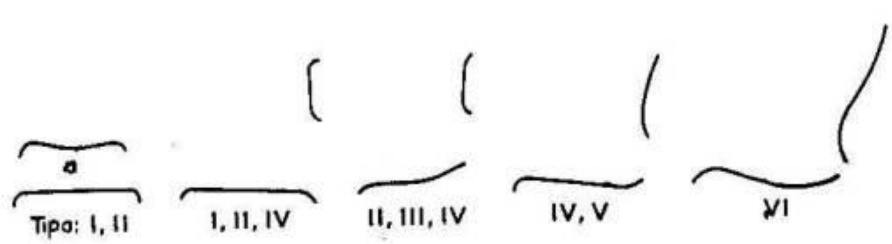


Figure 1.- Types of seats according to Kirchner and Rohmert

Table 1.- Types of postures and seating schemes by type.

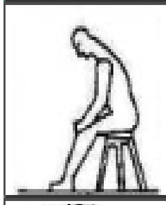
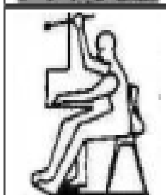
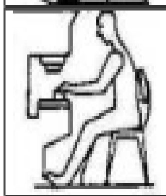
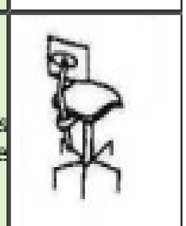
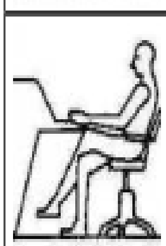
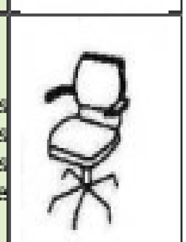
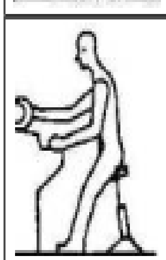
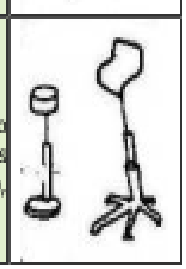
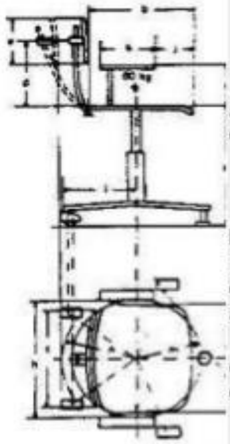
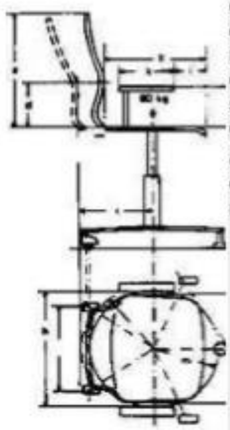
TIPO DE POSTURA	DESCRIPCIÓN DEL TIPO DE POSTURA	EJEMPLO DE ASIENTO
	**TIPO I** Breve u ocasional descanso después de realizar un trabajo: Empleo cuando se debe aguardar, apoyo natural de nalgas y muslo	
	**TIPO II** Trabajos con esfuerzo escaso con brazos o piernas, con ligera inclinación de la dirección visual: Montajes de piezas grandes, cajas, clasificar, etc.	
	**TIPO III** Trabajos con esfuerzos livianos, movimiento de las manos hacia delante, enmarcar o montaje de grandes piezas	
	**TIPO IV** Trabajos de concentración con uso del antebrazo, inclinado tomando fuerte, con carga visual: pruebas o montaje de piezas chicas	
	**TIPO V** Trabajos con pequeños movimientos con ocasionales descansos esfuerzos horizontales con las manos o pies, tareas con necesidad de visión: pequeños montajes, tipeo, trabajo en máquinas.	
	**TIPO VI** Trabajos con pequeños movimientos, uso de la visión con pequeñas inclinaciones, pruebas con participación activa, movimientos de las manos hacia el pecho horizontalmente, pequeños esfuerzos con las manos: prueba de piezas pequeñas, montaje mecanizado, tableros de comando, etc.	
	**TIPO VII** Trabajos de pie durante largo tiempo, deben transmitir movimiento con el tronco, con fuerza, además con movimiento de las manos (es apoyo auxiliar), trabajo sobre mesas, máquinas, tareas sobre tablero, etc.	

Table 2.- Anthropometric measurements of a seat.





Componente diseñado	Silla giratoria de oficina, con regulación de la altura del respaldo [1]	Silla giratoria con regulación de altura de respaldo [2]	Silla giratoria de trabajo [3] Altura de la silla		Observaciones
			570 mm	500 mm	
a) Altura del Asiento	420 a 530[4]	420 a 530[4]	120 mín. [5]	180 mín. [5]	Presión a ejercer sobre el relleno para 64 Kg de peso
b) Profundidad del asiento	380 a 420[5] respectivamente 380 mín. 440 máx.	380 a 420[5] respectivamente 380 mín. 440 máx.	380 mín[6] 440 máx	380 mín[6]	Desde la parte anterior hasta el apoyo del respaldo
c) Ancho del asiento	400 mín. 480 máx.	400 mín. 480 máx.	400 mín. 480 máx [7]	400 mín. 480 máx [7]	En medio del asiento
d) Altura del centro del respaldo desde la superficie del asiento	170 a 230[5] respectivamente 170 mín. 215 máx.	170 a 230[5] respectivamente 170 mín. 215 máx.	170 mín. 215 máx [8]	170 mín. 215 máx [8]	Apoyo lumbar
e) Altura del respaldo	220 mín.	320 mín.	220 mín. [9]	220 mín. [9]	En medio del respaldo, corto respaldo en la zona lumbar, adaptación según la altura, regulación de la altura del respaldo.
f) Ancho del respaldo	360 mín. 480 máx.	360 mín. 480 máx.	360 mín. 480 máx	360 mín. 480 máx	

3. RESULTS

The result of this study is summarized in the design of an ergonomic chair, that is, a work station in a sitting position, captured in a 1:10 scale plane, dimensions in meters with superior, frontal and lateral views.

It is worth mentioning that the operators were personally surveyed, finding in more than 50%, desirable characteristics of the new furniture such as: height adjustability, enough area to house the person, tilt adjustability, comfort of the front edge.

4. CONCLUSIONS

The final product of this study is an ergonomic chair for operators of sewing machine manufacturers of pants in the City of Tehuacán, Puebla. Designed taking into account all the requirements of the maquila group. Whose main task was to offer a postural improvement to the user and guaranteeing comfort during the work days.

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EVALUATION DISERGONOMIC FACTORS AND MUSCULOSKELETAL COMPLAINTS ROTOMOLDING COMPANY

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Resumen: El caso práctico se desarrolló durante el periodo de agosto a diciembre de 2018 en una empresa de rotomoldeo ubicada en la Ciudad de México. La primera etapa consistió en realizar el reconocimiento sensorial de toda la empresa, posteriormente, se seleccionó un grupo piloto de cinco puestos de trabajo (operador de montacargas, operadores A, operador B, terminador y montacarguista) distribuidos en las áreas correspondientes a almacén de materia prima, nave 1, nave 2, terminado y almacén de producto final, puestos de trabajos que intervienen directamente en la fabricación de contenedores de agua tipo “tinaco”. La fase de evaluación incluyó la medición del área y grabación de los ciclos de cada actividad (mín=20, máx= 40), posteriormente, se realizaron las mediciones antropométricas (somatometrías, plicometrías), signos vitales, pruebas de condición física, fuerza, flexibilidad y riesgo a la salud, así como la aplicación del Cuestionario Nórdico de Kuorinka (1987) que detecta síntomas músculo esqueléticos. Finalmente, se realizó el análisis con métodos ergonómicos seleccionados según la exposición de la tarea: OWAS, RULA, NIOSH y Método de Fatiga muscular de Suzanne Rogers. La captura y el análisis de los datos fueron realizados mediante el programa Excel de Office 365.

Palabras clave: factores disergonómicos, antropometría, lesiones musculoesqueléticas, industria manufacturera.

Relevancia para la ergonomía: Permite a las empresas replicar el modelo de evaluación de factores ergonómicos y la identificación de las lesiones músculo esqueléticas. Otorga un panorama general de cómo pueden iniciar una valoración tanto del contexto situacional desde una perspectiva de riesgos, así como de sus condiciones laborales, las características del puesto de trabajo y de los trabajadores. También, genera una sensibilización a las áreas de salud ocupacional en realizar análisis de tipo integral y desde un enfoque multidisciplinario.

ABSTRACT: The case study is maintained during the period from August to December 2018 in a rotomolding company located in Mexico City. The first stage was to perform the sensory recognition of the entire company, then a pilot group of five jobs (forklift operator, operators A, operator B, terminator and forklift) distributed in the areas corresponding to a warehouse were selected. raw material, ship 1, ship 2, finished and warehouse of final product, jobs that intervene directly in the manufacture of "tinaco" type water containers. The evaluation phase included the measurement of the area and the recording of the cycles of each activity (min = 20, max = 40), subsequently, the anthropometric characteristics (somatometries, plicometries), vital signs, physical condition tests are shown, Strength, flexibility and risk in health, as well as the application of the Kuorinka Nordic Questionnaire (1987) that detects musculoskeletal symptoms. Finally, the analysis was performed with ergonomic methods, according to the task statement: OWAS, RULA, NIOSH and Muscular Fatigue Method of Suzanne Rogers. The data was captured and analyzed using the Office 365 Excel program

KEYWORDS: Disergonomic factors, anthropometry, Skeletal muscle injuries, manufacturing industry.

Relevance to Ergonomics: It allows companies to replicate the ergonomic factors assessment model and the identification of musculoskeletal injuries. It gives a general overview of how they can initiate an assessment of both the situational context from a risk perspective, as well as their working conditions, the characteristics of the job and workers. Also, it generates awareness in the occupational health areas in performing comprehensive type analyzes and from a multidisciplinary approach.

1. INTRODUCTION.

The present work was carried out in a Mexican company during the manufacture of tanks and cisterns through the rotomolding process. Located in Mexico City with 30 years of operation, with a workforce of 223 employees distributed in personalities and administrative personnel, who work in shifts of 8 hours, from Monday to Saturday.

The rotomolding process, also known as rotational molding, is a widely spread method in several parts of the world, with a high diversity production of hollow plastic products of high resistance ranging from containers to auto parts, the present work addressed the tinaco production.

Historically, the rotomolding process was first developed at the beginning of the 20th century, but it was not until the 1970s, when the linear low density polyethylene for rotomolding was introduced and in the 1980s it brought the incorporation of non-resins. -polyethylene, such as nylon, polypropylene and polycarbonate for rotomolding. The process consists of introducing a certain amount of plastic powder in a hollow mold, the mold is rotated on two axes with low speed at the same time that it is heated in such a way that the plastic adheres to the surface of the mold and forms a uniform layer, followed by a cooling phase to reach solidification and be able to remove the final product from the mold.

According to information provided by the company, an average production of between 40 and 42 tinacos is estimated per station per shift, in addition to other tanks and cisterns of different capacity, with the highest production being the 1100 liter tanks.

This work was developed during the period from August to December 2018, in which the pilot group was evaluated of five work positions that directly intervene in the manufacture of water containers type tinaco, described in a practical way as operator of forklifts, operators A and operators B, as supplier and terminator.

Making the anthropometric measurements, as well as the sites and tools with which the aforementioned workers interact, included operational criteria of the environment, such as the temperatures to which they are subjected, the times of interaction with them and the handling of loads.

2. OBJECTIVES.

2.1 General objective

To identify the disergonomic risks and the musculoskeletal symptoms that occur in a manufacturing company in Mexico City.

2.2 Specific objectives

- To recognize the work process and the working conditions to which the workers of a manufacturing company are exposed.
- To analyze the disergonomic factors of the rotomolding process in accordance with national and international ergonomic norms and procedures.
- To classify the musculoskeletal symptoms according to the characteristics of the jobs of the rotomolding process.
- To develop the risk profile of five workplaces to prevent or control worker damage.

3. METHODOLOGY.

The evaluation was a non-profit case study and the result of the training of the students of the Master of Science in Occupational Health, Safety and Hygiene of the IPN, in the discipline of Ergonomics. The manufacturer of plastic products authorized the access and gave the permits under an informed consent, as well as the participation of workers on a voluntary basis. The study was conducted in Mexico City during the period from August to December 2018 with five jobs.

4. MATERIALS.

4.1 Instruments

The set of instruments includes an ad hoc Sensory Recognition Guide, which allows registering and identifying the agents, factors, acts or unsafe conditions of each work area, the Kuorinka Nordic Questionnaire (1987) of the National Institute for Occupational Health and Safety (NIOSH, for its acronym in English), the VICORSAT Certificate, section IX that corresponds to the anthropometric and physiological indicators of Herrera, Wong. & Garza (2005).

4.2 Analysis of data

The electronic tool Surveillance and Control of Health Risks and Work Accidents (VICORSAT, for its acronym in Spanish) was used to assess health risk. In the ergonomic analysis, the OWAS, RULA, NIOSH methods and the Muscular Fatigue Method of Suzanne Rodgers were used, according to the risk identification criteria and in accordance with the recommendation of Table 1 of ISO 11228-3-2007, of the UNE-EN 1005-5: 2007 and of the NOM-036-1-STPS-2018, with the support of the software ErgoIntelligencie of the Upper Extremity Assessment (UEA, 2017) in its free version.

5. RESULTS.

The areas of greatest disergonomic risk were: warehouse of raw material, warehouse 1, warehouse 2, finished, and warehouse of final product. The analysis was performed in five work stations, directly involved with the production, operation of the rotomolding equipment, considered as the most representative areas of the process (Table 1).

Table 1. Areas with disergonomic risk in the rotomolding process.

Area	Features	Job title	Occupationally exposed personnel*	Observations
Raw material warehouse	Filling sacks with automated equipment	Pump	1	Repetitive movements of torsion of the trunk and manual handling of loads above the shoulders were identified when placing bags of powder in the pallets.
Industrial ship 1	Production of water tanks	Operator A	3	Exposure to extreme temperatures was identified, while operating two work stations alternately. In one of the positions also handles a manual crane to disassemble the tank - cistern (10,000 liters) and roll it down the floor.

Industrial ship 2	Production of water tanks	Operator B	9	The exposure to extreme temperatures was identified, while operating two work stations alternately.
Finishing area	Sealing and labeling	Terminator	4	Forced positions were identified when maneuvering the pneumatic driller and when moving the tanks, within this process the contact with fumes produced by the heat-sealing process was observed.
End product warehouse	Transfer of products of different weights	Forklift operator	1	It was identified that despite having established the main position of forklift operator, he carried out other activities, such as collaborating with the operators.

* OEP per work shift

The sample studied is represented by men (100%), who have an age range of 23 to 50 years, with an average of 7.72 in the company (min = 2 years, max 21 years). The average body mass index (BMI) was 25.53, of which there was a minimum trend of 21.56 and a maximum of 29.05 kg / m2, that is, 40% had a BMI within normal parameters, the rest was They are overweight, none with obesity in any of their grades. Regarding physical condition, two workers had a poor physical condition compared to the rest that resulted in the desirable level, in terms of flexibility were obtained from regular to bad, in addition to three workers were at high risk of developing a chronic degenerative disease (Table 2).

From the measurements of the work area, it was identified that the design is not according to the complexity of the worker in the areas of rotational molding, raw material storage, in the finishing area. The forced postures observed in the spout of the force of the trunk for the filling of the raw material, the rotation of the shoulders to reach an object in the maximum storage of 1.50 meters, repetitive movements in the arms, prolonged standing throughout the day labor, so it was determined that the position had a level of risk. In the position of operator B, it is seen that the risk of exposure is greater than that of the activities evaluated, exposure to extreme temperatures is identified, the handling of two machines at the same time. In this position, we have detected repetitive movements in the shoulders for the extraction of the final product, such as its handling and transfer of the material, as well as the dynamic prolonged standing. In the position of operator A, in addition to the conditions encountered by operator B, a height work exhibition was presented

Regarding the position of terminator, presented dynamic prolonged standing, lifting of shoulders to manipulate a pneumatic hammer with repetitive movements in wrists and overexertion to generate pressure of the final product. Of the forklift, it was located that the worker performs additional activities to the position, which is observed that is exposed to different areas where there are high intensity sound levels, temperature changes (hot and cold), prolonged sitting. The symptoms that occurred in the workers were 20% predominantly right shoulder pain, 20% long-term low back pain related to manual handling of loads, however, it cannot be ruled out that the remaining 60% do not suffer from some type of musculoskeletal discomfort.

Table 2. Antrophometric indicator.

VICORSAT Results									
Job title	**Gender**	**Labor old (Yers)**	**BMI**		**ICC**	**Physical condition**	**Flexibility index**	**Force index**	**Cardiac risk**
Forklift operator	Male	5	29.05	Overweight	0.83	3.4	40.3	Bad	Increased
Terminator	Male	2	26.02	Overweight	0.98	4	24.34	Bad	Increased
Pump	Male	5.6	21.56	Normal	0.85	0	1.64	Bad	Increased
Operator A	Male	21	24.67	Normal	0.94	0	26.01	Bad	Low
Operator B	Male	5	26.38	Overweight	0.98	4	-13.78	Bad	Increased

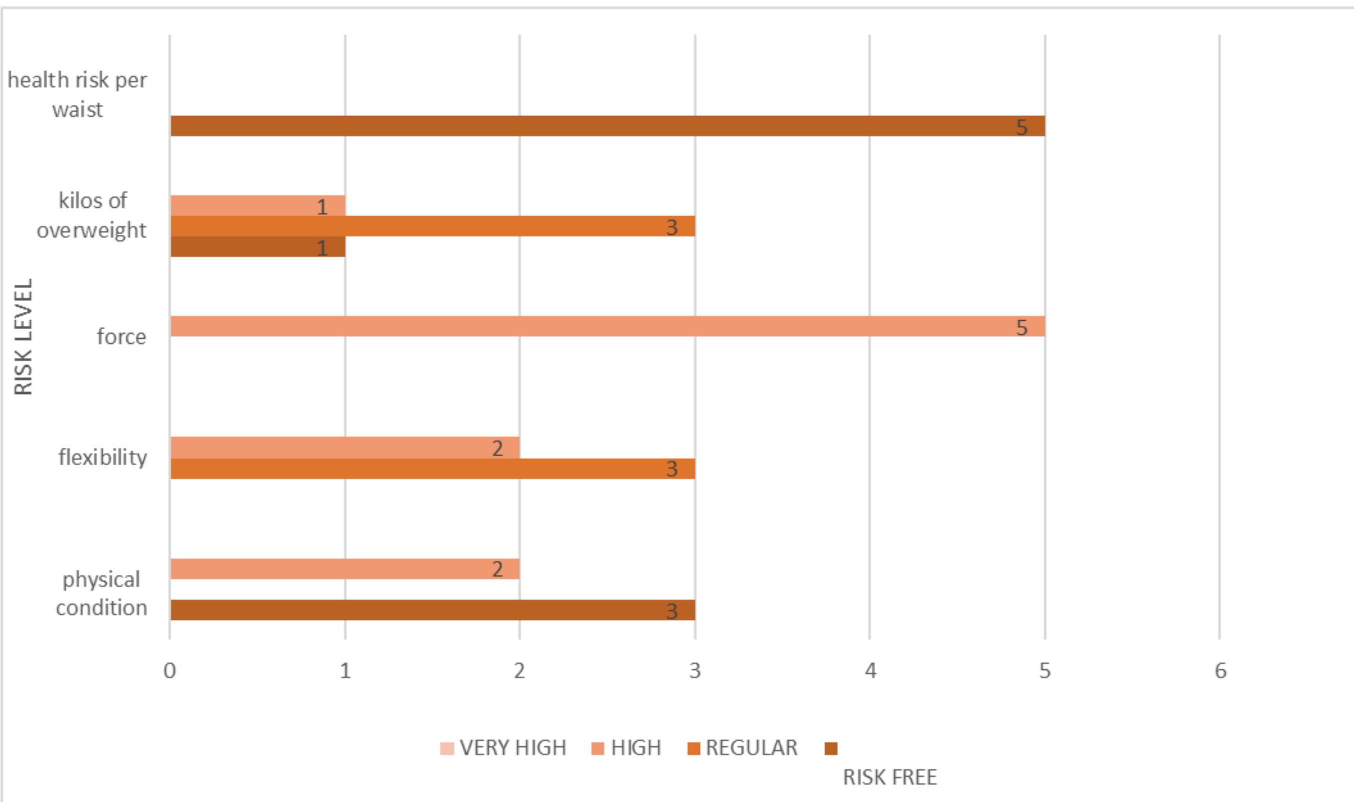

Figure 1. Health risk indicators.

|According to the evaluation according to the method it is observed that the operator A and B forced postures in the back and arms with the use of force to push an object greater than 20 kg repeatedly, applying pauses between movements, in a time greater than four hours. The filler, the terminator and the rider were placed at a medium level, the first of them presented risk by forced postures on the back and prolonged bipetation, on the second back and arms, and the rider on the back and neck.

Table 3. Ergonomic analysis of five jobs

Area	Activities	Job Titule	Ergonomic method applied	Score	Explication
Raw material warehouse	Filling sacks with automated equipment	Pump	Ergonomic Evaluation of Susan Rodgers	Moderate	Accepts a degree of satisfaction but some cycles should be modified to avoid skeletal muscle discomfort
Industrial ship 1	Production of water tanks	Operator A	NIOSH	Unacceptable	Reduce the angle of twisting. Reduce the distance between starting and end lift.
Industrial ship 2	Production of water tanks	Operator B	NIOSH	Unacceptable	Reduce the angle of twisting. Reduce the distance between starting and lift.
Finishing area	Sealing and labeling	Terminator	RULA	Level 3 Final score 6	The redesign of the task is required; it is necessary to carry out research activities.
End product warehouse	Transfer of products of different weights	Forklift operator	OWAS	Cat. 2	Postures with the possibility of causing skeletal muscle damage mainly in the neck and back

6. CONCLUSIONS.

It was observed that the workers as a whole presented high disergonomic risks, a high physical demand for the manipulation of raw material and the final product, the design of the areas must be modified according to the profiles of the workers to avoid musculoskeletal injuries or diseases. of work. It is suggested to carry out activities that favor the preservation of health.

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ERGONOMIC ANALYSIS OF THE WORKSTATION OF A SPECIALIST IN HYDROSTATIC TESTS OF A VALVE WORKSHOP OF AN OIL COMPANY

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Resumen: La presente investigación se realizó en un taller de pruebas hidrostáticas, en particular en válvulas de proceso para la industria petrolera, ubicado en Ciudad del Carmen, Campeche. Se analizaron los riesgos ergonómicos presentes, mediante herramientas ergonómicas como: el modelo del cubo y el método OWAS. El tipo de investigación fue No-experimental, descriptiva y transversal, con enfoque cuantitativo. Se analizaron los puestos de trabajo de 3 bancos de pruebas hidrostáticas con sus respectivos trabajadores. Los resultados obtenidos muestran que existen condiciones inaceptables de trabajo en uno de los bancos estudiados, así como de causar mayor nivel de riesgo ergonómico en los trabajadores que realizan su trabajo en ese sitio. Debido a ello, se determina que es necesario rediseñar el puesto de trabajo lo antes posible, considerando cuestiones antropométricas de los trabajadores y la implementación de nuevas tecnologías.

Palabras clave: Análisis ergonómico, pruebas hidrostáticas e industria petrolera.

Relevancia para la ergonomía: La ergonomía implica confort, la adaptación del trabajo al hombre y no del hombre al trabajo. Este principio básico debe imperar en gran medida, en los diferentes puestos de trabajo, para fomentar una buena calidad de vida laboral en los trabajadores.

Abstract: The present investigation was carried out in a hydrostatic testing workshop, particularly in process valves for the oil industry, located in Ciudad del Carmen, Campeche. The present ergonomic risks were analyzed by means of ergonomic tools such as the cube model and the OWAS method. The type of research was non-experimental, descriptive and transversal, with a quantitative approach. The workplaces of 3 hydrostatic test benches were analyzed with their respective workers. The results obtained show that there are unacceptable working conditions in one of the benches studied, as well as causing a higher level of ergonomic risk in the workers who perform their work on that site. Because of this, it is determined that it is necessary to redesign the workplace as soon as possible,

considering anthropometric issues of the workers and the implementation of new technologies.

Keywords. Ergonomic analysis, hydrostatic testing and oil industry.

Relevance to Ergonomics: Ergonomics means comfort, the adaptation of work to man and not man to work. This basic principle must prevail to a large extent, in the different workplaces, to promote a good quality of working life in workers.

1. INTRODUCTION

It is the obligation of companies to continually improve their processes, implement changes that reduce operating costs and maximize their competitive advantages in a global way, this implies obtaining the largest amount of possible benefits, maximizing their production and reducing the resources they use, such as: inputs, labor, among others (Cubillos, M & Rozo, D, 2009)

In the same way, productivity is of great importance, however; special emphasis should be placed on the environment in which workers carry out their activities. This is because inadequate conditions will favour the emergence of work-related diseases, which will cause social and economic burdens for workers, enterprises and health services (Sabina et al, 2012)

In Mexico, the Federal Regulation on Safety and Health at Work (2014), defines ergonomic risk factors as: Those that may involve physical effort, repetitive movements or forced postures in the work performed, with the consequent fatigue, errors, accidents and occupational diseases, derived from the design of facilities, machinery, equipment, tools or work station.

The industrial companies generate an exposure to ergonomic risk factors of diverse nature, being the oil company one of them.

Acording to Latin American Institute for Quality (2013), the use of valves generates competitive advantages in the oil industry, the good functioning of them is crucial to achieve the expected results. This industry brings together a variety of functions in technical aspects of all branches of engineering, being of vital importance, the production and transport of hydrocarbons in their different phases (liquid and gaseous), for which, the use of the valves they have a preponderant function. The hydrostatic test consists in the application of a pressure to an equipment or pipe line out of operation, in order to verify the hermeticity of the fittings flanged or welded and joints of welding, using as main element the water or in its defect a non-corrosive fluid.

The valve workshop is located in the industrial zone of Cd. del Carmen, which provides the service of hydrostatic tests to valves (new and repaired) used in substitutions for maintenance in lines and/or equipment of processes of the installations of land and offshore production, which range from ½ to 48 "diameter (Ø), for which there are 3 test benches located in the following way:

a).-One on the outside for valves of ½ to 4 "(manual manoeuvre).

b).-One inside for valves of 4 to 24 "(maneuver with manual crane and type flag).

c).-One more on the outside for valves greater than 20 "(maneuver with telescopic crane support).

Depending on the type of valves, an average day has the capacity to carry out the following quantities of hydrostatic tests during the working day:

aa).-For valves ½ to 2 "-30 tests.

bb).-From 4 to 10 "-20 tests.

cc).-12 to 48 "-10 tests.

For this type of work, by the level of specialization of the same, only one person works in each one of the banks.

The present ergonomic study was carried out to the workers who run the hydrostatic tests of the valve workshop located in the Industrial zone of Cd. del Carmen, Campeche, of a company of the oil area.

2. OBJECTIVE

To analyse the postures and loads to which the workers who perform the hydrostatic valve tests are subject to identify the risks and to establish control measures aimed at preventing musculoskeletal injuries that contribute in the increase of the quality of service and production through ergonomic improvement of the workstation.

3. METHODOLOGY

It is an applied research, non-experimental, descriptive and transversal, with a cuantitative approach. It was observed the activities of the workers in situ determining the positions and efforts of each one of them. Each test is carried out in an approximate time of 1hr 30 min from the valve hauling and flanges to the end and removal of the valve in the area. In the field activity the test of a valve was observed in each of the 3 types of banks, analyzing a worker by workbench.

The CUBE model was used to identify the existence of ergonomic risk factors and the OWAS method for evaluating postures and efforts.

In relation to the model of the cube, it was made based on an interview with the workers of maneuvers and the observations made as support for the application of other methodologies more specific for postures and efforts.

For the OWAS method, it was considered to carry out the study of two phases:

1.-Field activity:

a).-Information was raised interviewing at the end of hydrostatic tests.

b).-Photographs of the work cycle were taken.

c).-The most risky cycle was identified.

d).-It was taken video of the activity.

2.-Cabinet Analysis:

a).-The postures were analyzed according to the methodology.

b).-The encoding was assigned.

c).-Statistical treatment and elaboration of the report was carried out.

3.1 Model of the cube

The cube model, for ergonomic evaluation of workplaces, incorporates strength, posture and time, like the three axes of the cube. A subcube is configured for each combination of requirements. The model is based on 27 subcubes.

The evaluated individual must be asked for an opinion and according to this a three dimensional rating is issued. These can be grouped as follows:

1. Low Requirements.
2. Average Requirements.
3. High Demands.

The combinations of the variables determine the level of risk of development of musculoskeletal problems (International Labour Organization, 1998).

3.2 OWAS Method

The OWAS method assesses the physical load by observing the work. It classifies the postures in 252 combinations of back, arm and leg positions, while the subject performs his/her work. These postures result in codes of postures that allow to obtain categories of risk, as they are:

1. Normal posture
2. Posture likely to cause damage to the musculoskeletal system
3. Posture with harmful effects on the musculoskeletal system
4. Posture with obvious harmful effects on the musculoskeletal system (Diego-Mas, 2015).

4. RESULTS

According to the analysis carried out by the model of the cube, it was obtained that for the external work benches (manual bank and bank with crane support), the situation of the work turned out to be "conditionally acceptable"; While for the internal labour bank, the result was "unacceptable". This means that the worker of the internal bank is who has the most unfavorable conditions and is exposed ergonomic risks (see table 1).

Table 1. Working condition

External		Internal
Manual Bank	Bank with crane	Labour bank
Conditionally acceptable	Conditionally acceptable	Unacceptable

In relation to the analysis carried out using the OWAS methodology, a total of 13 different positions were obtained for the personnel of the work area of the external bench manual; 10 positions for the outside bank with the aid of telescopic cranes and 37 positions for the internal bank. In relation to the categories of risk, it can be concluded that during the activity are presented postures that represent risks of musculoskeletal injuries because it was determined that 35% of the postures represent a level of risk 3, 10% represent a Risk Level 4 and 17.5% represent a level of risk 2, for the worker who carries out his activities in the internal bank. The posture most observed was the back flexed with 48.75%; One arm up and another down 51.25% and knees flexed with 36.25%. In the manual external bank and external bank with crane support, the results found were 19% and 3% respectively, at risk levels 3. No postures were found for risk level 4 in any of the above positions. In these areas of work, postures were most often observed that do not represent serious ergonomic risks for workers (see table 2).

Table 2. Postural risk level

Postural risk level	**Manual bank**	**Bank with crane**	**Labour bank**
1. Normal posture	65	93	37.5
2. Posture likely to cause damage to the musculoskeletal system	16	4	17.5
3. Posture with harmful effects on the musculoskeletal system	19	3	35
4. Posture with obvious harmful effects on the musculoskeletal system	-----	----	10
TOTAL	**100%**	**100%**	**100%**

5. CONCLUSIONS

The workstation should be redesigned considering the change of technologies to improve postures and efforts in the following stages of the working cycle: manual valve hauling, manoeuvring to or removal of the test area, fixing and interconnection of the valve in the test bench. In the same way, it will be necessary to change the cranes manual and type flag by a crane traveling considering the anthropometric measures of the workers to locate the electrical controls in such a way that the work do it standing or walking with straight back and arms down. likewise, the work bench must be changed or redesigned for hydrostatic testing, in such a way as to allow the horizontal movement of the table for the placement of the valve from the flag-type crane or the recommended travelling crane.

Figure 1. Internal bank

Figure 2. Test bench

Figure 3. Proposed test bench

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ERGONOMICALLY IMPRVEMENTS TO PRODUCTION LINE WORK STATIONS FOR PHOTON 1, WLT AND QUANTUM 1 AT MANUFACTURING FACILITY

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Resumen: La ergonomía ocupacional en la actualidad representa un foco muy importante de atención, ya que impacta directamente en salud física y cognitiva del operador. El presente proyecto está encaminado a la evaluación de riesgos en el lugar de trabajo dentro de la empresa de manufactura, ubicada en Tijuana, Baja California. El objetivo es Evaluar y mejorar ergonómicamente estaciones de trabajo de las líneas PHOTON 1, WLT y QUANTUM 1 mediante métodos ergonómicos para disminuir el nivel de riesgo ergonómico. El procedimiento aplicado se dividió en etapas para su mejor desarrollo e implementación. Se obtuvo un análisis por línea de producción, se implementaron mejoras

Palabras clave: Evaluación, RULA, Suzanne Rodgers

Relevancia para la ergonomía: Introducción y aplicación de métodos ergonómicos para mejoras del proceso de producción en una empresa de manufactura

Abstract: Occupational Ergonomics nowadays represents an important topic of attention, with direct impact to cognitive and physical health to the operator. The following project is aiming the evaluation of risks in the work area of a local manufacturing company, located in Tijuana, Baja California. The objective is to evaluate and improve ergonomically the work stations of the production lines PHANTON 1, WLT y QUANTUM 1 trough different methods that will result in the reduction of ergonomic risks. The applied procedure was divided in different stages to improve the development and implementation. An analysis was obtained for each production line and improvements were implemented.

Key Words: Evaluación, RULA, Suzanne Rodgers

Relevance to Ergonomics: Introduction and application of ergonomics methods for the improvements of a work process of a manufacturing process.

1. INTRODUCTION

This Project aims risk analysis in a manufacturing work area that is stablished in Tijuana, Baja California.

The project was divided into 4 stages: preparation, ergonomic evaluation, implementation and results. Stage 1, was to have all of the documentation, required authorizations, tools, evidence is taken like photographs, videos or any questions. Stage 2 for ergonomic evaluation is mainly focused on analyzing the evidence by performing evaluations trough software and detecting the ergonomic risk in the work station that is being evaluated. Stage III aimed the implementation of the proposed improvements that will reduce the risk and ensure that the changes are effective. Stage IV are the results of the before and after pictures of each ergonomic evaluation performed and of the improvement made with its percentages of the targeted objectives. The ergonomic evaluation was performed using the RULA and Suzanne Rodgers methods. In this project a total of 70 work stations were analyzed from which 10 were detected as high and very high risk level. Changes were made to 5 work stations this allowed the risk to go down to a medium level. Photo evidence are presented to show the improvements.

2. OBJECTIVES

Ergonomic evaluation and improvement of the PHOTON 1, WLT and QUANTUM work areas to reduce the risk level trough ergonomic methods by December 14, 2018 in a manufacturing facility in Tijuana.

3. LIMITS

The Company proposal was performed is located in Tijuana, Mexico. The Company manufactures portable and auto speaker. The plant is divided in to business units: transducers and Electronics. Currently has a work force of 2000 employees (direct labor and administrative). The project will mainly be focused on the transducer plant where the portable speaker's products are manufactured on production lines: PHOTON 1, WLT, QUANTUM 1.

4. METHODOLOGY

For the development of this project which is based in three phases, initially an analysis was performed with the objective of visualizing all the possible factors that

do not have value added to the process, taking into consideration the operators movements.
The ergonomic analysis is based on this three phases:

4.1 Stage 1 Preparation

a. Production plan is reviewed and the (MP) manufacturing processes are printed for the area that is going to be evaluated.
b. Verification was done to the production plan to correlate the model and the amount of time that the model will be in production with the objective to include all of the models, all lunch breaks and other activities were established so that the evaluation could be performed without interruptions.
c. 3. The objective of the activity is communicated to the supervisor, line lead and operator.
d. In the first analyzed work station we observed the process and asked questions to the operator about complicated body movements or uncomfortable positions, also tools used and time of breaks and activity change.
e. Video is taken for each model operation that is being evaluated which is analyzed to be ergonomically evaluated in the computer.

4.2 Stage 2 Ergonomic Evaluation

a. Video is reproduced for each operation, according to the analyst criteria the ergonomic method is determined, the RULA method is selected.
b. An analysis is made for each movement in the video and the characteristics required by the method are answered.
c. A screen shot is done to capture the most critical movement of the operation, another screen shot is made from the resulting method and they are placed together, if the operation has a high risk level the image is marked with red pointing at the results.
d. The characteristics of the evaluation are placed on an Excel spreadsheet (e.i ergonomic method, dates, evaluator, ergonomic issues and improvements)
e. In the method format the results are placed for the risk levels to separate them according to the magnitude of the risk.

4.3 Stage 3 Implementation

a. For the improvement, we start on the cases with high risk level which is analyzed by a team with the line lead, operator, supervisor and the engineer that is giving follow-up to the evaluation.
b. Once analyzed the issue, we return to the production floor were the improvements are implemented and the criteria is unified to change the operator technique.
c. Whit the implemented changed done, the ergonomic evolution is performed again with the RULA method to analyzed with the previous excel sheet to compare the results and emphasize the improvements.

4.4 Stage 4 Results

a. A comparison is made between the ergonomic evaluation of the before and after of the improvement.
b. The risk level position is identified and the percentage are presented.

5. RESULTS

In this section the results are presented in graphs, the results of the analysis performed on the production line WLT, CUANTUM II Y PHOTON 1; Table 1 show the results of the current scenario of the work area, low risk are in Green, yellow are medium risk, red is for the high level risk and black represent the highest risk level. Graph 1 shows the percentages for each risk level.

Table 1. Risk Level before improvements

RISK LEVEL					
line	**Cases**	**Highest Risk Level**	**High Risk Level**	**Medium Risk Level**	**Lowest Risk Level**
WLT	26	1	4	21	0
QUANTUM II	28	0	4	24	0
PHOTON 1	16	0	1	15	0
Total	70	1	9	60	0
		1.4%	**12.9%**	**85.7%**	**0.0%**

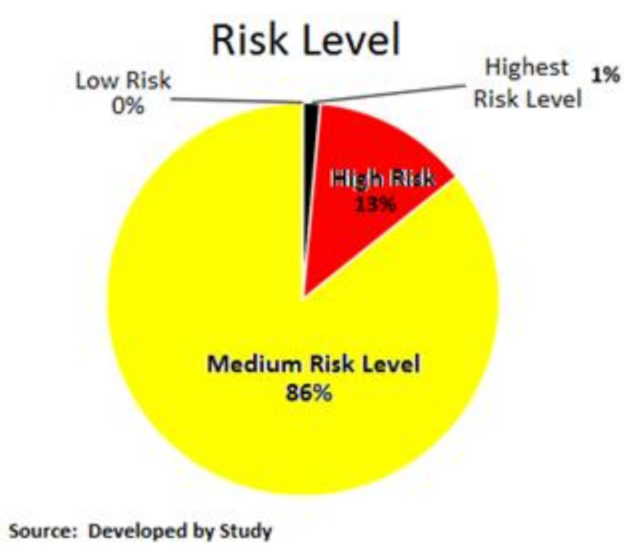
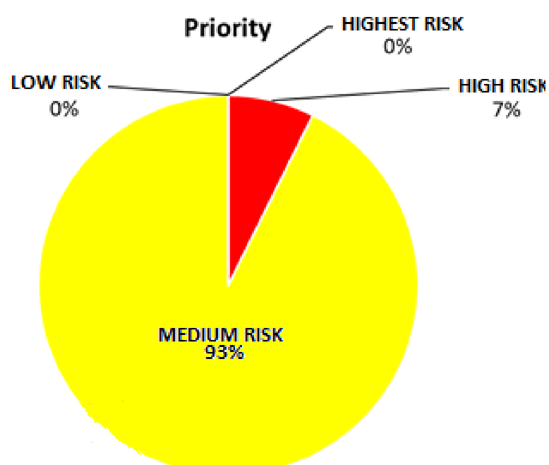


Figure 1. Risk level Graph of Stations without improvements

Table 2. Production Quantities are presented for each production line, in the WLT the cases with highest risk level are reduced from 1 to 0, the cases for high risk level are reduced from 4 to 1, the QUANTUM II production line cases with high risk level were reduced from 4 to 3 and for the production line PHOTON 1 were reduced from 1 to 0. In the graph presents a change in the high risk category from 1% to 0% and in the high risk level from 13% to a 6% and there was an increase of the medium risk level from 85.7% to 90%

Table 2. Risk Levels after Improvements

line	Cases	RISK LEVEL			
		Highest Risk	High Risk	Medium Risk	Low Risk
WLT	26	0	2	24	0
QUANTUM II	28	0	3	23	0
PHOTON 1	16	0	0	16	0
Total	70	0	5	63	0
		0.0%	7.1%	90.0%	0.0%



Graph 2. Risk level after Improvements

6. CONCLUSIONS

While performing the ergonomic evaluation to the three production lines and referencing the RULA and Suzanne Rodgers technique, making the RULA method the most convenience for this evaluation, because the different analyzed operations have higher impact by using this method.

By performing the comparison of the before and after of the ergonomic analysis in 10 work stations, and find high and medium risk level, and by performing the improvements required in watch production line, there was a reduction of only 5 work station with medium risk level. This means a 50% decrease of the risks found on this evaluation.

LEAN ERGONOMICS PRACTICES: APPLICATION IN PORK MEAT INDUSTRY

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Resumen: Este trabajo se realizó en una empresa dedicada a la producción y comercialización de productos cárnicos, debido a la necesidad de mejorar el proceso de salchichas debido a los residuos generados durante su proceso, por lo que se evaluó el estado actual para ver la eficiencia. del proceso a través de herramientas Lean Manufacturing y evaluando los riesgos ergonómicos. Las principales herramientas Lean utilizadas fueron Value Stream Mapping (VSM), SIPOC y Kaizen, para la evaluación ergonómica se consideraron los métodos REBA y NIOSH. Como resultado, se obtuvieron las actividades más riesgosas, así como los desperdicios de tiempo y movimientos debidos a posturas y procedimientos inadecuados durante su proceso que afectan y retrasan el flujo del mismo proceso. Después de implementar las propuestas, cada actividad se evaluó nuevamente, se llevó a cabo un VSM futuro, donde se presentó una reducción del 33.18% del tiempo del ciclo, haciendo que este proceso sea más eficiente que antes.

Palabras clave: Residuos, Mejora, Lean Manufacturing, Evaluación, Riesgo.

Abstract: This work was carried out in a company dedicated to the production and marketing of meat products, this arises from the need to improve the process of sausages due to the waste generated during their process, so the current status was evaluated to see the efficiency of the process through Lean Manufacturing tools and evaluating the ergonomic risks. The main Lean tools used were Value Stream Mapping (VSM), SIPOC and Kaizen, for the ergonomic evaluation were considered the REBA and NIOSH methods. As a result, the most risky activities were obtained, as well as wastes of time and movements due to improper postures and procedures during their process that affect and delay the flow of the same process. After implementing the proposals, each activity was evaluated again, a future VSM was carried out, where a reduction of 33.18% of the cycle time was presented, making this process more efficient than before.

Keywords: Wastes, Improvement, Lean Manufacturing, Evaluation, Risk

1. INTRODUCTION

The continuous change and the client demand (fast deliveries, high quality and competitive prices) forces organizations to be constantly searching for solutions that generate greater productivity and efficiency, working daily to generate new competitive advantages, to respond to each one of the exposed challenges, to differentiate itself and thus to stay in market, (Pedraza, 2010). The organization under study is a benchmark nationwide of exportation and is dedicated to the production and marketing of pork, where efficiency for the company represents one of the most important elements of study.

Lean Manufacturing is a concept that appears more and more in companies that support human needs and their well-being. We evaluated 5 representative materials with different authors in order to analyze and identify each type of inclination in the production systems where they have implemented lean manufacturing tools and ergonomic methods that complement risk assessment in work stations. In the investigation of Koykoulaki (2014) discrepancies were identified between the practices of efficient manufacturing theory and reality (Relationship between JIT and the increase in stress and pressure among employees). Cullinane, Bosak, Flood, & Demerouti (2014) performed an identification of the employee in a positive reaction to feedback, the need for accountability of employees based on supply and demand through various training, motivation, promotion. Morse in 2014 found the need for quick participation of employees to adapt and meet demands, the right combination of security, and satisfaction to avoid conflicts. Arezes, Dinis, & Alves (2014) identified and implemented the Lean principles, misunderstandings of similar inappropriate solutions for all situations. The literature notification reports an improvement in stress reduction in lean manufacturing. Rose, Deros, Rahman, & Nordin (2011) added that to work properly with suppliers and customers, the implementation of Lean must be done from the inside, through the participation and collaboration of employees.

The model about the integration of ergonomics and lean manufacturing systems based on the various tools has been presented in various organizations: it is associated with the inclination of the manufacturing system procedures used in each phase of the ergonomic tools and methodologies that introduce an additional security perspective, (Srinivasa & Malay, 2016). A study carried out in the meat industry by Gastelo & Sandoval, (2016) where they applied a questionnaire on musculoskeletal injuries associated with repetitive movements where considerable results were obtained and, on average, 50% suffered from some injury or illness, generating costs for having safe and ergonomic working conditions. The search for improvements in the process of the different products brings the need to evaluate and measure the current situation during the manufacturing activities both with lean manufacturing tools and ergonomic methods, in order to achieve a better organizational performance and increase the competitive level to an international level, offering advantages in productivity, quality and safety. Given the situation, the following is stated: Will the implementation of Lean Ergonomics Approach in the process of ham in the processing area improve the efficiency of its operations.

Dombrowski, Reimer, & Wullbrandt, (2018), comment that the integration of new lean manufacturing methods and tools is necessary for the operational implementation of human factors and ergonomics. This allows employees and senior managers to implement human factors and ergonomics in their daily work routines, in particular they can integrate methods to assess and improve ergonomics. While Dos Santos, Vieira, & Balbinotti, (2015) mention that the application of lean manufacturing should make a direct correlation between the vision of working conditions with a support tool known as Ergonomics; Each continuous improvement made in any work environment, this correlation can be carried out to adapt the improvements to the operator. The combination of Lean thinking and ergonomics is the result of a system where not only the worker is the most efficient, but also safe and comfortable while trying to produce the best possible product, Mulyati, G., Suharno, & Muharom, MA (2015). The Lean theory helps to reduce stress in lean manufacturing through misunderstandings, internal collaboration between employees and managers. All this together represents an ergonomic perspective through LM, Cirjaliu, B., & Draghici, A. (2016).

1.1 Objective

Implement the Lean Ergonomics Approach in the manufacturing processes of the processing area to improve the efficiency of its operations.

2. MATERIALS AND METHODS

This research is observational, transversal, not experimental, 100% of plant operators will be evaluated in the process of making ham, without considering the worker who is covering any disability, absence or illness. The following describes the procedure carried out for the development of the research, the techniques, tools and instruments used for the collection of information.

2.1 Subject under study

This study is conducted on a company dedicated to process and market pork at national and international level, specifically the process of making ham has a capacity of 6 tons of daily production, it has 5 people working and its main customers are national.

2.2 Procedure

Elaboration of Current VSM: In this stage the operations are analyzed through the Value Stream Mapping (VSM) tool to know the current situation of the process, where the following elements should be considered:

- Elaboration of a Process Diagram. Analyze the supply chain in detail of the process through the SIPOC diagram.
- Identification of Ergonomic Risks. Identify risks in each one of the operations of the process using the Nordic questionnaire of Kuorinka (1986) and the BRIEF / BEST method, determining its risk condition.

- Evaluation of Ergonomic Risks. Evaluate the activities in the work station using ergonomic methods according to the results of the risk identification in order to define redesign options that reduce the risk and obtain acceptable levels of exposure for the worker.

Elaboration of future VSM: In this stage, ergonomic improvements will be integrated in a future VSM to compare the previous efficiency with the current one in the operations of the process and the assessment of the ergonomic risks found, it should be considered:

- Design of Improvement Proposals. Establish improvement actions using lean tools to reduce the waste that occurs during the process, considering the conditions and ergonomic factors.
- Evaluation of Ergonomic Risks. Evaluate the activities in the work station with the implementation of improvements to verify changes as interaction between the human being and the elements used in the operations of the process.

2.3 Materiales

- Photographic camera
- Software Ergo Soft Pro 4.0
- Microsoft Visio Professional 2016

3. RESULTS AND DISCUSSION

The identification of risks was carried out through the BRIEF / BEST method. It was evaluated (see table 1) to know the aspects that generate risks during the process.

Table 1. Risk identification using BRIEF/BEST method

	PROCESS	ACTIVITY	**Risk value**	**Priority**
BRIEF value	Ham sausage	1	27	Medium
Conversion factor				
BRIEF value		2	52	Very High
Conversion factor				
BRIEF value		3	26	Medium
Conversion factor				
BRIEF value		4	36	High
Conversion factor				
BRIEF value		5	72	Very High

Conversion factor				
BRIEF value		6	36	High
Conversion factor				

According to the method, all of the activities of the process have an evaluation, see Table 1, of medium risk are: Fill hopper and Prepare molds, high risk are Stuffing and weigh, and arrangement in a cage, and the highest risk are Prepare the machine and Mold and Cover. With the results of the Nordic questionnaire and the BRIEF / BEST it was determined that the methods applied for risk assessment are REBA (Rapid Entire Body Assessment) (see figure 1) and NIOSH (see figure 2), both in different postures

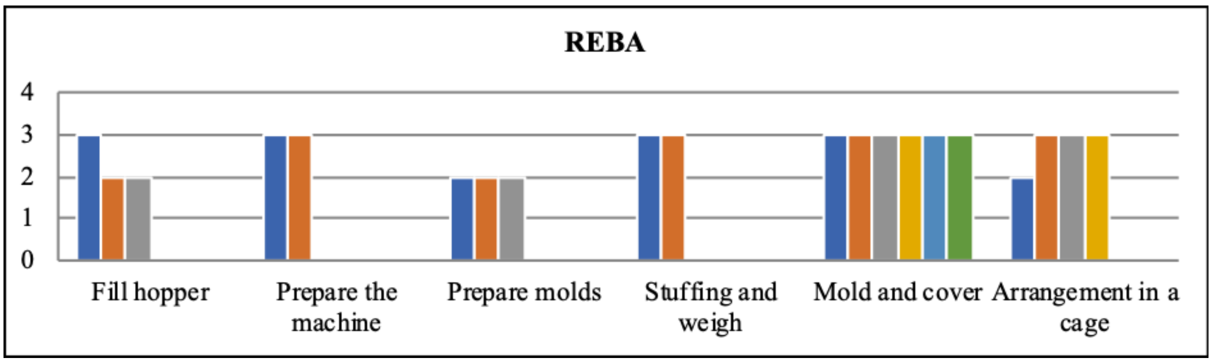

Figure 1. Activities evaluation with REBA method.

The action levels according to the REBA method are 1 = Not necessary; 2 to 3 = It may be necessary; 4 to 7 = Necessary; 8 to 10 = Needed soon; 11 to 15 = Immediate action.

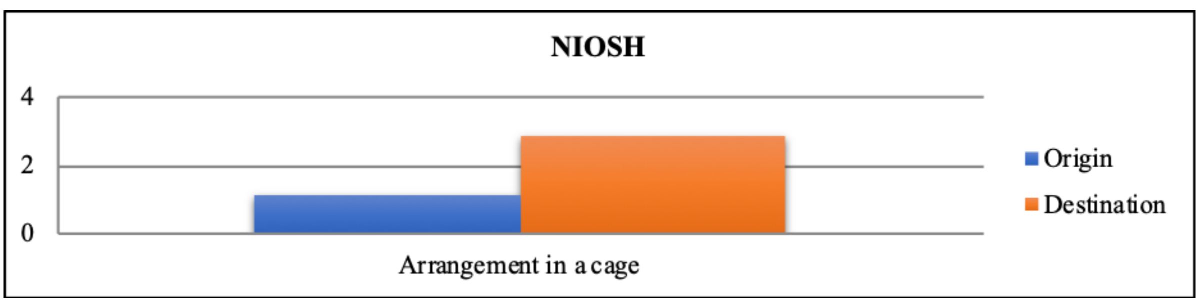

Figure 2. Activities evaluation with NIOSH method.

According to the NIOSH method, three risk zones can be considered according to the IL values obtained for the task. Limited risk (IL<1). Moderate increase in risk (1 < IL < 3). Accelerated increase in risk (IL > 3).

Table 2. Risk representation

NIOSH	REBA	RISK
1<	1-3	LOW
1-3	4-7	MEDIUM
>3	8-15	HIGH

Finally, in the evaluation a representation of the level of risk and the score that each method handles was made (table 2). In addition, all the ergonomic risks of the process that were obtained from the methods used in all the activities that are carried out in the processing of smoked sausages were graphically created using the value stream mapping tool. See figure 3.

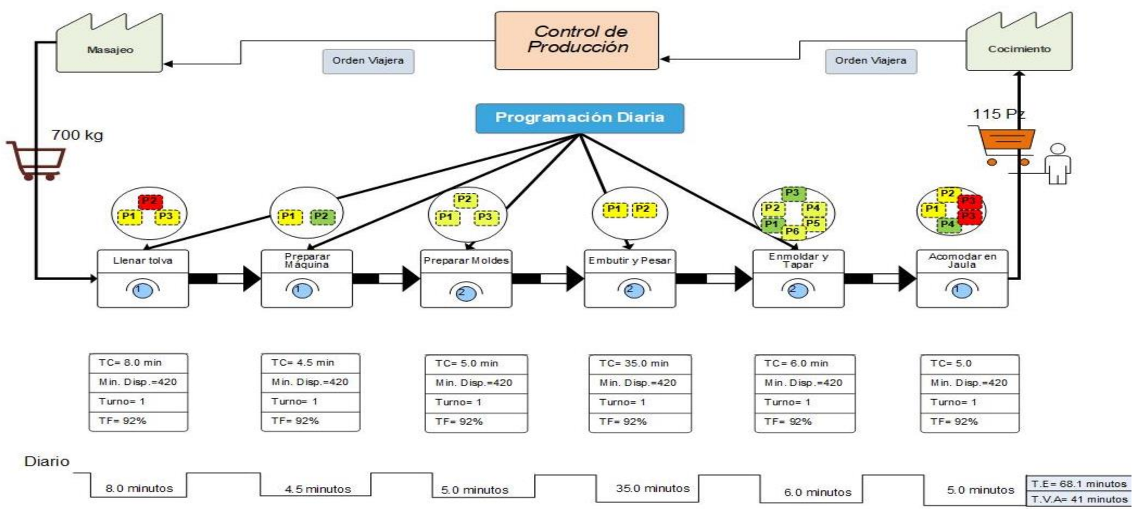

Figure 3. Actual VSM with Ergonomic Evaluation

The VSM represents the current situation of the ham process divided into its operations, indicating the way in which the process flows, the requirements and the flow of the customer information (cooking) to the supplier (massage). In addition, it shows the result of the ergonomic evaluation for each activity and its level of risk.

Improvement proposals design.

In the process there are six activities, which were divided into a total of 21 positions. The results of the evaluation showed that 4 positions are low risk, 14 are medium risk and the rest are critical with a high level of risk, which should be improved to avoid possible injuries, work diseases in the future. From the above, there is a need to generate proposals that help improve the process, as well as reduce risks. In the evaluation, critical positions were found that could damage the health of the operator, which is why you have the following proposals regarding postures per activity.

Fill hopper: To reduce the risk level in the three positions is suggested an adaptation to the cart (see Figure 4) in which the mixture is transported to be stuffed and thus the height is suitable for the operator so your body is not inclined to it and in such a way the operator will not have to lift over passing the maximum lifting level in his arms.

Figure 4. Cart folding adaptation

Prepare molds: There are three postures of medium level, so it is proposed that the pallet where the molds are placed at an optimum height for the operator, see figure 5.

Figure 5. Height proposal for the pallet.

Stuffing and Weighing: To minimize the variation of the sausage time, taking as reference 5,250 seconds that were obtained by means of samples taken in the process that give the specified weight, which is 5,250 + - 0.050, without wasting time adding or removing paste, for reach the correct kilograms.

Arrangement in a cage: It was observed that in positions 1, 2 and 4, an average level of risk was obtained and position 3 with a high level of risk, which suggests a poka yoke (see figure 6) to avoid errors in the accommodate molds and fully approve the space of the cage, the operator must perform its activity without exceeding the weight recommended by NIOSH method in addition to raising their arms to the height of their shoulders, it is important that the operator pivots at the time of making this activity, in this way there will be no angle of action and this avoids risk of injury.

Figure 6. Poka Yoke's representation.

The process was evaluated again with the same ergonomic methods, but now with corrections in the positions of the operators, see figure 7.

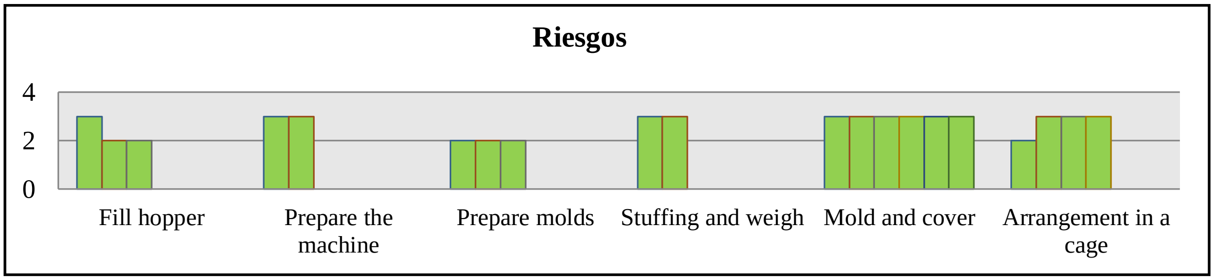

Figure 7. Risk processes are a new evaluation

With the new evaluation all risks where previously they were medium and high level were reduced and now they are of low risk. Next, the future enhanced VSM is represented, including the proposals, and the new ergonomic evaluation of the process was added, see figure 8.

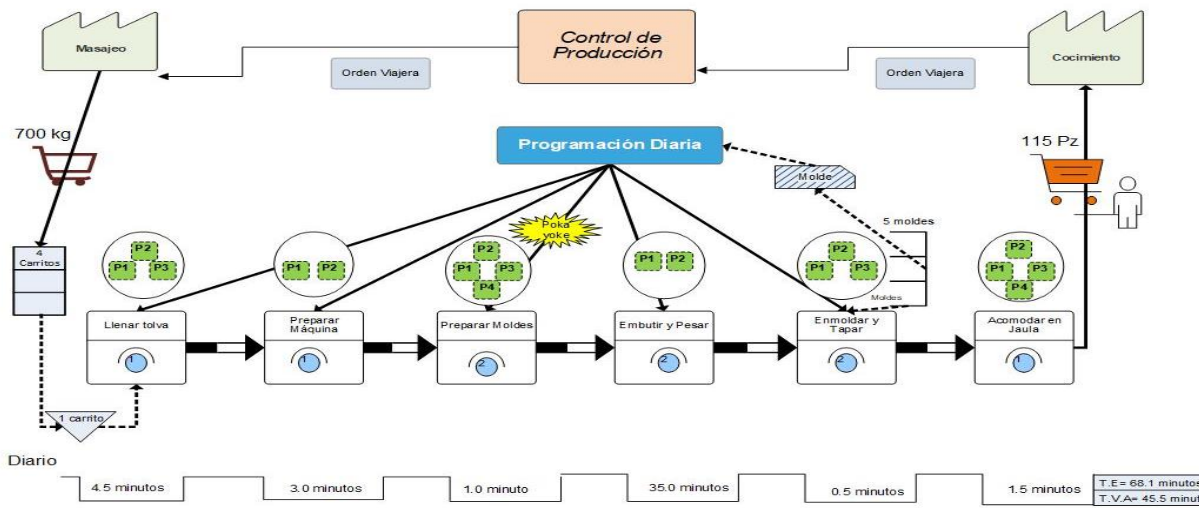

Figure 8. Future VSM with Ergonomic Evaluation

The process efficiency was calculated by making an estimate for the time reduction in the activities, which were considered by subtracting the time from the activities of each stage of the process that the operator performs and that do not add value during the process of a batch. A reduction of time of 22 minutes is calculated, which in percentage represents 33.18% for a batch of 115 pieces.

4. **CONCLUSION**

Based on the study and results of the Lean Ergonomics project applied to the ham sausage process, the objective is to increase efficiency through Lean tools and ergonomic evaluations, improving on average by 33.18% the operating times of each activity, In turn, it reduces and / or eliminates the level of risk, allowing the operator to work in adequate conditions and to do his job in a safe manner. Implementing the improvements has a cost, however, not meeting the needs of the process and the human factor generates accidents, illnesses that lead to days of disability and even death, causing a higher cost for the organization and damage to the operator.

Lean Ergonomics is a novel tool with scarce information, so with this project it was possible to contribute a little more information to the research about the application of this tool that is obtained by integrating lean manufacturing and ergonomics, which together contribute to the reduction of human activities that are considered as waste, making a process more efficient and free of ergonomic risks. This tool looks for the way to combine Lean with the ergonomic evaluation and apply them in different processes and in which a VSM was used to map the process where areas of opportunity to improve were found.

According to Kasper, (2017) Lean Ergonomics integrates work environment factors into a lean manufacturing "Value Stream Mapping" tool by identifying possible risks at the work station where it evaluates each work activity in the process. The risks that may exist when performing an operation are Physical; a) work postures, b) excessive weight / force, c) physical load, among others. And in a matter of Psychosocial Dimensions appear: a) Demands, b) control, c) communication, etc. However, Lean management and VSM analysis focus on waste to identify workflow issues and develop an improved workflow. The Lean mentality and waste analysis teach workers to perform their operations efficiently through lean training. On the other hand Winkel, Doubts, Harlin, Jarebrant, & Hanse, (2013) mention that ErgoVSM facilitates the development of an action plan that can result in greater organizational sustainability compared to traditional VSM. Jarebrant, Winkel, Hanse, Mathiassen, & Öjmertz, (2017) add that ErgoVSM is based on the VSM contributing to the identification and evaluation of the risks that can occur when introducing actions for greater efficiency.

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COST-BENEFIT ANALYSIS OF DEPOSIT HARNESS IN THE BLUEBERRIES COLLECTION

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Resumen: El siguiente documento presenta la realización de un estudio de análisis de costo-beneficio del diseño de un arnés para el depósito en la recolección de arándanos tomando como referencia las herramientas que los trabajadores utilizan para llevar a cabo su labor. Se realizó un estudio técnico, estudio de mercado y estudio económico para conocer la demanda que tendrá el producto, los costos de elaboración y la inversión inicial que se necesita, con base a esto decidir si es un proyecto factible o no.

Palabras clave: Análisis, factibilidad y productividad.

Relevancia para la ergonomía: Aumentar la seguridad de las personas dedicadas a la recolección de arándano permitiendo preservar su salud física en las labores propias del trabajo. Lo anterior haciendo uso de las mediciones antropométricas en el diseño del presente dispositivo.

Abstract: The following document presents the performance of a study of cost-benefit analysis of the design of a harness for the deposit in the collection of blueberries, taking as reference the tools that the blueberry collectors use to carry out their work. A technical study, market study and economic study was conducted to know the demand that the product will have, the costs of preparation and the initial investment that is needed, based on this, decide whether it is a feasible project or not.

Keywords: Analysis, feasibility and productivity.

Relevance to Ergonomics: Increase the safety of the people dedicated to the harvesting of cranberry allowing to preserve their physical health in the work. Therefore making use of the anthropometric measurements in the design of the present device.

1. INTRODUCTION

In recent years the cultivation of cranberry has positively impacted the economy of the state of Sinaloa, since the commercialization of this fruit has been increasing the income obtained in the agricultural area through the production of these. According to the report by journalist Javier Vega (2016), the planting area has been strengthened by more than 500 percent and 7,000 jobs have already been provided in the harvest, which have a positive impact on the habitants of rural communities.

Likewise they have been hiring people who perform this job of collectors, demanding a desired productivity without adequate equipment or material to perform the job correctly, this may cause some physical damage.

In addition to the above, a prototype design of a tool was carried out with the aim of helping day laborers in the collection of blueberries, taking care of the postures, reducing fatigue and increasing productivity. Therefore, a cost - benefit analysis will be developed in which a financial study will be carried out to guarantee its profitability. In addition to a technical study of the tool designed to know the performance of workers before and after using it.

2. OBJECTIVE

Know the economic and social profitability of a harness for the collection of blueberries, in a way that resolves a human need in an efficient, safe and profitable way, allocating the economic resources with which the best alternative is counted.

3. METHODOLOGY

To generate the present project it is necessary to carry out the following sequence of activities:

3.1 Plan of operations and resources for the elaboration of the harness (budget).

A list of the material resources necessary for the elaboration of 1 harness was made in table 1. In addition to a budget for the preparation of operations.

Table 1. Budget preparation of 1 harness

Materials	Quantity	Cost (MXN)	Total cost
Thick nylon	2.69 m	$2.50 m	$7.00
Thin nylon	6.28 m	$2.50 m	$16.00

Galvanized wire	6.28 m	$0.80 m	$5.02
Buckle	2 piezas	$3.00 piece	$6.00
Canvas tape	1 m	$8.50 m	$8.5
Metal buckle	1 pieza	$10.00 piece	$10.00
Oval metal ring	2 piezas	$2.00 piece	$4.00
Diverse Materials			
Lighter	1	$15	$15
Tape measure	1	$5	$5
Thread	1	$9	$9
Needles package (25 pieces)	1	$7	$7
Wirw cutting pliers	1	$85	$85
Scissors	1	$10	$10
Needles for machines	5	$5	$25
Various cost			
Labor (employee)	4 people	$150 per day	$16,800 per month
Delivery cost		$2,000	$2,000
Property income			$12,000
Electric bill			$1,500
Water bill			$150
Internet and telephone bill			$500
Salary			$20,000 per month
Sewing machines	2	$4,000	$8,000
Work tables	3	$2,500	$7,500
Printer	1	$1,200	$1,200

Desk	1	$1,500	$1,500
Computer	1	$12,610	$12,610
Desk chair	1	$1,000	$1,000
Chairs	3	$270	$810

3.2 Realization of a market study to determine the demand.

A survey was conducted in the northern area of Sinaloa to some blueberry producers, to know the interest of potential customers in the proposed product and its possibility of purchase, based on this was obtained that the demand is 4000 harnesses

Table 2. Survey format

Questions	Yes	No	Maybe
1.- Do you use any tool to collect?		100%	
2.- Do you think that the tools used are adequate?		50%	50%
3.- Do workers have pain in their body?	100%		
4.- Are you interested in a tool that reduces fatigue and increases productivity?	100%		
5.- How much are you willing to pay for a tool that offers these benefits?	a) 200-300(50 %) b) 300-400(50%) c) 400 or more		
6.- How many collectors does the company have?		The number of workers in each company totals: 4000	

3.3 Production study to determine how much it costs to produce a harness.

Based on table 1, which shows the costs of material and inputs for the preparation of 1 harness, plus the administrative expenses, it is calculated that the production price per harness is $ 78.56.

3.4 Technical study to ensure that it increases productivity and safeguards the worker's health.

A redesign of the tool was carried out according to the proposed prototype because the owners increased the number of containers per employee which are 4 (3 for harvest and 1 for lag) the same measures belonging to the article published in SEMAC were taken (Luna, Ramírez, Cubedo, Urias, & Verduzco, 2018).

Through the use of this device, the preservation of the health of the workers is sought by distributing the weight of the blueberry container equitably in the trunk of the human body, preventing physical injuries caused by an inadequate load of the container used for the harvest, together with the release of both upper extremities for the efficient harvesting of the blueberry, generating with this a greater productivity in the employees.

Figure 1. Harness front view

Figure 2. Harness side view

Figure 3. Harness back view

3.4.1 Result of previous interviews:

Table 3. Result of previous interviews

Users	Comments
Gatherers	The workers said that there is no tool to help them carry out this activity and

	therefore perform as a belt where the buckets are tied. They also informed us that some workers get to hang up to 7 buckets, this in order to produce more.
Manager	The person in charge of the place informed us that the correct number of buckets is 4 that are necessary to work. When placing more than this amount, it means losts, since the buckets for the weight tend to lean and therefore the blueberry falls to the floor which represents large losses. He said that in order to tie the buckets to the rope it is necessary to have two buckets, one that provides stability and another one to work. For the company to have a bucket without producing generates many expenses and for this reason the elimination of that extra bucket would greatly reduce the expenses

3.5 Investment analysis.

According to the budget made, what is shown in table 2 is obtained.

Table 4. Total inversión($MXN)

Units	Materials	Supplies	Total
4000	$226,080	$89,620	$315,700

3.6 Cost-benefit analysis to know if this tool is profitable to market.

Based on the results obtained in the budget shown in table 1 and what it costs to produce a harness, the sale price is $ 300 MXN per harness. Using the cost factor formula, it was obtained that the cost benefit factor is equal to 3.80, which means that it is profitable.

$$Factor\ cost\ benefit = \frac{(Expected\ utility)}{(Estimated\ costs)} \qquad (1)$$

Aplication of the formula

$$Factor\ cost\ benefit = \frac{1{,}200{,}000}{315{,}700} = 3.8010 \qquad (2)$$

Table 5. Expected utility

Units	Total inversion	Sale price	Expected utility
4000	$315,700	$300 per harness	$884,300

Table 5 shows the expected utility when selling the 4000 harnesses, which indicates that the project is feasible.

4 RESULTS

The cost - benefit analysis yields a positive result for the manufacture and commercialization of the harness for the harvest of blueberries. The studies carried out show that there is an increase in the market in the state of Sinaloa, which indicates that the results are favorable.

The redesign of the tool favored the collectors according to their experience testing it, they felt more comfortable working because of the equal distribution of weight in the trunk of the human body, they did not end up as tired as they regularly do, this improved productivity of thesem in addition to that they did not suffer discomforts by the weight since it was only concentrated in the low back because they use only a rope to hang the containers where the blueberry is deposited.

They also liked that this tool was adjustable for most of the workers, the manager is more pleased because they are different employees each season.

5 DISCUSSION/CONCLUSIONS

With the study of cost-benefit analysis, the feasibility of marketing this tool created for workers engaged in the harvesting of blueberries is announced.

This determined the amount of economic resources necessary for the execution of the project, and the total operating costs of the production process and the amount of income that is expected to be received in each of the useful life periods. The results of previous market, technical and organizational studies were used to determine the economic viability of the project.

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ORGANIZATIONAL ERGONOMICS: ELEMENTS THAT IMPACT THE CONDITIONS OF INFORMAL WORK IN THE COMMERCE SECTOR

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RESUMEN La investigación llevó a cabo análisis de problemas relacionados con la ergonomía, la ergonomía organizacional, el trabajo informal y las condiciones de trabajo, a fin de considerar el impacto significativo en el trabajador informal del sector comercial en el país, para demostrar que las condiciones de trabajo de este entorno se pueden optimizar. Se desarrolla de forma descriptiva y cualitativa a través de la revisión de documentos como libros, artículos y tesis como fuente teórica que forman parte de la propuesta sobre las condiciones de trabajo del trabajador. No hay evidencia tácita de los aspectos que pueden fortalecer las relaciones entre el trabajador y su trabajo, no hay una estructura organizativa y hay omisión en algunos o en la mayoría de los procesos administrativos que generan una brecha en la calidad de vida del trabajador y el trabajador. Servicio que ofrece al ofrecer un bien. La ergonomía organizacional es un pilar en el desarrollo del entorno de trabajo, permite el cumplimiento de los parámetros administrativos y de seguridad e incluye de manera importante a cada uno de sus individuos. La documentación encontrada, a través del marco teórico, presenta diferentes hallazgos de la ergonomía organizacional y cómo interactúa con el trabajo informal del sector comercial, estudiando los elementos significativos en el desarrollo del trabajo desde la informalidad, con esto se propone la inclusión de un sistema de gestión. que permite la potencialización y optimización del trabajo informal del sector comercio, mejorando la calidad de los procesos, así como; La calidad de vida del recurso humano. El análisis de la información refleja la importante intervención que debe promoverse a través del estado gubernamental para avanzar hacia la población que es una parte importante de la economía de una nación que ejerce su posición como trabajador informal.

Palabras clave: Ergonomía; Ergonomía organizacional; trabajo informal Condiciones laborales

Contribución a la ergonomía: Mayor interés y adaptación del trabajador informal a la ergonomía, haciéndolo participar en los elementos que lo conforman desde la tríada ergonómica, permitiendo así la mejora gradual de las condiciones de trabajo presentadas por el entorno de comercio informal. Al contemplar que con el desarrollo y la implementación del proyecto propuesto, surgen nuevos procesos y ramas de ergonomía para incluir al individuo que contribuye de manera indirecta e informal a la economía de un país, en condiciones de trabajo que identifican al individuo y al mismo tiempo se pueden potencializar., tal como son, su adaptabilidad al cambio y el emprendimiento que los caracteriza, así como su facilidad para reconocer al cliente generando mayor interés y atracción por ello. Además, la ergonomía estaría involucrada con un estilo de trabajador que ocupa un gran porcentaje de la economía de diferentes países de América Latina, integrándolo de manera positiva para facilitar la aceptación del trabajador informal y la mejora de sus condiciones de trabajo a partir de Desde la ergonomía organizativa.

ABSTRACT The research carried out analyzes issues related to Ergonomics, Organizational Ergonomics, informal work and working conditions, in order to consider the significant impact on the informal worker of the commerce sector in the country, to show that work conditions of this environment can be optimized. It is developed in a descriptive and qualitative way through the revision of documents such as books, articles and thesis as a theoretical source that are part of the proposal about the working conditions of the worker. There is no tacit evidence of the aspects that can strengthen the relationships between the worker and his work, there is no organizational structure and there is omission in some or most of the administrative processes generating a gap in the quality of life of the worker and the service that it offers when offering a good. Organizational ergonomics is a pillar in the development of the work environment, allows compliance with administrative and security parameters and includes in an important way each of its individuals. The documentation found, through the theoretical framework presents different findings from the organizational ergonomics and how it interacts with the informal work of the trade sector, studying the significant elements in the work development from informality, with this it is proposed the inclusion of a management system that allows the potentializing and optimization of the informal work of the commerce sector, improving the quality of the processes, as well as; the quality of life of the human resource. The analysis of the information reflects the important intervention that should be promoted through the governmental state, in making progress to the population that is an important part of the economy of a nation exercising its position as an informal worker.

Keywords: Ergonomics; Organizational Ergonomics; informal work; Labor conditions.

Contribution to Ergonomics: Greater interest and adaptation of the informal worker to ergonomics, making them participate in the elements that comprise it from the ergonomic triad, thus allowing the gradual improvement of working conditions presented by the informal commerce environment. Contemplating that with the development and implementation of the proposed project, new processes and branches of ergonomics arise to include the individual that indirectly and informally contributes to the economy of a country, under working conditions that identify the individual and in the same time can be potentialized , as they are, their adaptability to change and the entrepreneurship that characterizes them, as well as their facility to recognize the client generating greater interest and attraction in this. In addition, the Ergonomics would be involved with a worker style that occupies a large percentage of the economy of different Latin American countries, integrating it in a positive way in order to facilitate the acceptance of the informal worker and the improvement of their working conditions starting from the organizational ergonomics.

1. INTRODUCTION

Today the human factor is important for the development of a work regardless the sector in which it is formed, however, when a company is not legally constituted or lacks essential elements that ensure the quality of the work environment in which the worker performs, it is necessary to preserve the human capital as the main and differentiating agent in an environment that wants to be competitive, but at the same time procuring the working environment. This must include organizational aspects that work from the ergonomics, to motivate the worker should take into account the internal and external labour aspects, this is how the organizational ergonomics considers subjects such as, work schedules of an individual, types of hiring of personal and if it exists, or how it is suited to the objectives of their work and the economic competition that their work intends.

According to researches consulted in the elaboration of this document, the informal work of the commerce sector has significant aspects to be strengthened in the worker, environment and task relationship, however, in the documents analysed, there is no organizational structure and some administrative processes are omitted that can have an effect on the quality of life of the worker and the service or good that he offers. Involving ergonomics positively affects the employment relationship, productivity and economic income of the activity. If there is no sense of belonging of the worker towards his work, in the medium or long term he will find himself with a toxic agent that generates deficiencies in the own results and in the organization of the processes.

This can be minimized by including standards, appropriate command styles, incentives, communication, a correct hiring that provides the candidate with information validating in depth the needs, benefits that will be obtained from their work and in the opposite direction. Likewise, the ergonomic triad allows us to evaluate the modus operandi of informal work at present, in order to develop well-formulated procedures, resulting in the merchant and his company, although not (legally constituted) providing better services and visualizing greater productivity during its exercise, as well as promoting the quality of life. With this, a solution is given to risk factors that can be presented by unqualified personnel for the performance of their work, leading to inappropriate behaviours, illnesses and accidents that can be noticed; the implementation of activities from the organizational ergonomics makes the worker generate awareness and feel comfortable with their work activities.

However, there may be limitations associated with economic, social, cultural, technological, political and environmental factors, which have become a challenge for the state and for the country's economy, but there is also evidence of the opportunity for improvement that the governmental state wants to provide the informal work society, taking into account that the labour market is becoming more demanding every day and only work organizations with high competitive and innovative capacity manage to maintain management systems; but, the other large percentage of the economy, which moves suppliers, customers, resources, among others, must operate with greater support and attention, the purpose is not to extinguish informal work, but on the contrary to contribute to the working conditions of its individuals and Progressively prevent beyond correcting the negative aspects that the lack of organizational ergonomics brings.

2. OBJECTIVES

2.1 General Objetive

Analyse the impact of the different working conditions from the organizational ergonomics on informal workers of the commerce sector in the country in order to optimize their work activity.

2.2 Specific Objectives

- Identify information corresponding to organizational ergonomics to know its interaction with the ergonomic triad.
- Examine the main risks and characteristics to be potentiated in this population that involve organizational ergonomics.
- Generate an intervention proposal in order to optimize the positive factors identified and minimize risks evidenced.

3. METHODOLOGY

The type of research developed in this work is qualitative, descriptive, where the document was reviewed; for this purpose, articles, thesis papers, among others, were identified as the theoretical source for the elaboration of this research study. In order to establish the population and sample of the research work, articles with key words (Ergonomics, Organizational Ergonomics, Informal Work and Trade Sector) were searched in the databases of the Manuela Beltrán University, Scielo, Navarra of Spain, degree works and journals Cuban health and work. For the collection of the information created a matrix of the articles where the name of the article was included, the analysis of the information contained in the document was made from a descriptive analysis, in the documentary review articles were searched for between 2004 and 2018. In the search and analysis of articles, the information was treated in accordance with the following criteria:

Table 1. Population and sample

In accordance with the criteria below, the related articles on the theme of organizational ergonomics for the informal labour trade sector were classified.

Inclusion criteria	Items that are complete. Items that are free. Articles that talk about the subject researched (organizational ergonomics of the informal sector)
Exclusion criteria	Articles that do not contain keywords corresponding to the research work. Articles that contain information like the one that had already been referenced.

4. RESULTS

The information corresponding to organizational ergonomics is identified through the revised documentation to know its interaction with the ergonomic triad and how it gives a solution from organizational ergonomics to informal work. This will examine risks and characteristics in the population of the informal work commerce sector to finally develop a proposal that optimizes the positive aspects of this medium and minimizes the risks that may be reflected. Thus, informal work will be observed in a more positive and appropriate way, as a contributing part of the country's economy, evidencing that by supporting the sector, conditions relating to quality of work and work are improved, as well as quality in the physical and monetary resource. , as well as the quality of life in the human resource.

The documentation found and through the theoretical framework presents different findings from the organizational ergonomics and how it interacts with the informal work of the commerce sector, examining the significant working conditions for the exercise of informal work, which have also been subject to study and are mentioned in the analysed articles giving evidence that the informal population tends to be exposed to similar problems due to the management that has been given, which can generate effective changes with the inclusion of organizational ergonomics. However, it is also found that there is greater concern on the part of the regulatory bodies for the elimination of informal work that would hardly cease to exist in our country, so what should be considered is the adequacy of workplaces and serious control over work. informal, guaranteeing dignified conditions as declared by the regulations in its constitution, and considering that the approximate 50% of the Colombian population is in this medium of informality, which leads to significant exposure to natural risk factors, public, social and more disturbing the work environment and its worker. If a management system for informal work is established, it could positively affect not only the trade sector but also all sectors of informal work and therefore its applicability would provide opportunities for improvement to inadequate contracting in activities whose worker exposure High-risk tasks are significant, such as the informal hiring of a construction worker, where the basic requirements for the exercise of a safe task for the individual who executes it are omitted. as for the client, likewise the people who carry out surveillance activities are not part of the commerce sector either, but there is informal work related to this activity where there is no management that considers elements from the organizational ergonomics and contributes to the improvement of the conditions of work, so we see that the inclusion of ergonomics organized Informal work in the trade sector can affect or involve other economic spheres and improve a national situation.

5. DISCUSSION

Colombia is a country in the process of economic and labour growth, therefore, it is necessary to give importance to any economically active person and this includes the informal worker, since, although it is not regulated, the issue concerning safety and health in the work if it is in an advanced process of implementation compared to other Latin American countries, which allows its progress to include the informal worker, not strictly in the safety and health management system at work, but the improvement is can develop from the implementation of a management system that involves organizational ergonomics as it allows the compression of parameters that affect the environment and work processes, including aspects such as quality of life, social and family environment.

By analysing this situation from the domains of ergonomics, you can implement environments and working conditions in areas and processes, thus improving the conditions of the individual and their environment. The economic development of the country is affected by the informal sector which arises from the basic need of the individual and the difficulty of being formally employed to satisfy those needs, therefore, people are in a work environment where working conditions directly affect your quality of life.

It is important to assess the effort an informal worker is making from different factors, which is multiplied by the lack of management regarding their occupational health and safety. Just as companies need to comply with the SGSST as required by Colombian regulations, to improve the quality of life of their workers, it is also necessary to involve the informal worker in the adaptation of processes and procedures that guarantee the care of their health and control the risks to which this is exposed.

6. PROPOSAL

Through the proposal seeks to identify mainly the elements with which a worker is involved and the inclusion of tools from organizational ergonomics to optimize the quality of life of the individual and the optimization of their work environment as well as quality and service in the supply of its product, as well as the continuous improvement of the working environment at the informal level in order to guarantee the care and protection of human and economic resources, taking into account the impact generated by the inclusion of a management system in these sectors of the economy.

Then are involved issues concerning safety and health as it has been working in the country, being relevant the improvement of the working environment, so that informal workers little by little make part of the social security system ensuring that with it their nuclear family receive the benefit of being a contributor, protecting a society that is growing and is vulnerable in different aspects. In addition to this, introduce organizational ergonomics to its different elements, allowing adaptation to a system that provides more information and characterization of the informal population.

As well as the inclusion plans that the state has as it has done with the IPES. With this proposal for the informal sector aspects are worked from ergonomics, as training activities and training in different management issues that involve greater ownership of their work, self-care, organizational, physical, cognitive and other aspects, which, although they are in the environment in an intrinsic way, they can be potentiated. The ideal is to involve all informal workers in the economy, without it being persecuted, improving even the experience with the client.

Design a manual that establishes steps to follow during a year and the follow-up of these, starting with a checklist of points concerning organizational ergonomics such as:

1. Contracting
2. Schedules
3. Existence or creation of mission, vision and policies
4. Training and training
5. Motivational talks
6. Command styles, coaching, leadership
7. Vertical and horizontal communication
8. Team work
9. Processes and procedure
10. Sense of belonging
11. Work environment
12. Elements, equipment and tools

With these issues anchored to organizational ergonomics, the manual is implemented with a duration of one year, with these 12 steps to be completed per month, which concludes a year of management in the work performed by informal work. thus, from organizational ergonomics, the sector is included in a timely management system that optimizes working and worker conditions. Promoting that other spheres of the informal sector, apart from trade, participate in these activities.

With the information obtained, we propose the inclusion of a management system that allows the potentializing and optimization of the informal work of the commerce sector in our country, improving at the same time the quality of its processes such as the quality of life of the human resource, the analysis of the information gives an account of the important intervention that the state must promote in making progress to the informal worker's population.

For this it is important to carry out an analysis from the organizational ergonomics, since its absence in the work activities of the informal sector is a key point for the start and development of the SST of the members and the work environment, minimizing at least 90% of procedures inadequate, decadent styles of command, effective communication, incentives and good contracting practices, among others; Although this has been the way carried out for many years, it has also given rise to inappropriate work environments, lack of identification and sense of belonging to an organization regardless of its constitution and with it unsafe acts and conditions. Therefore, a proposal is generated that includes organizational ergonomics from an informal sector point of view, so that the work is properly structured and improves the working conditions of this sector, such as the form of organization, schedules, command and communication in their environment and with the client, improving attention to the citizen and foreigner, improving the care of the product and even increasing the business opportunity.

Organizational ergonomics is a pillar in the development of the work environment, which leads to the introduction of administrative and security parameters, including in an important way the individual, informal work in Colombia can be conditioned to this improvement, going beyond the economic contribution and the substitution of basic and daily needs for which an individual goes to work in the informal sector. However you can also find aspects of organization, although not documented and processed, if there are three elements that make up the ergonomic triad in the development of their work, is; the worker is in an environment or working environment, although their conditions in most of their occasions are not optimal or adequate as evidenced in the studies; there is also use of elements, tools, materials and others that are part of the individual's activities; however, a management system given from the organizational ergonomics allows optimization and good management of resources.

7. CONCLUSIONS

- Include organizational ergonomics for the work processes and thereby evaluate conditions and risks to which the individual is exposed that evidence the characteristics that contribute positively to the development of their work involving activities of improvement in times of work, incentives, effective communication, hiring, considering the style of command.
- Adapt informal activity to a management system, minimizing found characteristics that may cause safety and quality deficiencies in the development of tasks.
- Generate processes that contribute to the quality of life outside work and internal labour of the individual and its contractor if the latter applies, considering that some informal jobs are unipersonal or "partnerships" between different people in the same sector.
- It is suggested for future research to address the issue of ergonomic triad since it is essential for the understanding of the interaction between the worker, his work environment and the elements he uses in his processes, since his analysis

and development allows to show the positive aspects and negative, giving rise to the proposal of the optimization of processes, improvement of the economic impact of the work, quality of life of its workers, as well as, the adaptation of tools for the development of its activities and the improvement of the work environment, even if You can establish recruitment processes and assertive communication could introduce other relevant aspects such as social security that impacts apart from the basic needs of the worker, the protection of the same and even his family.

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BIOMECHANICAL DETERMINATION OF THE CENTER OF MASS, FOR WORKERS DEDICATED TO MANUAL HANDLING OF MATERIALS.

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Resumen: El conjunto multifactorial de acciones que se llevan a cabo en el manejo manual de materiales, impacta de manera negativa en la estabilidad mecánica de la columna vertebral, lo que genera las condiciones necesarias para que se presente un desorden músculo esquelético, afectando con ello la calidad de vida del operador que se desempeña en este tipo de actividades y en su contra parte, se reduce el potencial productivo de la entidad empresarial. Debido a lo anterior, es necesario encontrar un mecanismo que logre representar de manera confiable la resultante de las fuerzas biomecánicas que intervienen en el desarrollo de los movimientos realizados en este tipo tareas. Para definir una estrategia de solución a la situación problémica planteada, se presenta el siguiente objetivo de investigación: diseñar un procedimiento biomecánico confiable, validado y de elevado valor práctico, que permita a personal no experto con el mínimo de recursos y entrenamiento, determinar el centro de gravedad para trabajadores dedicados al manejo manual de materiales. Para llegar al cumplimiento del objetivo se establece un procedimiento de investigación mixta en cuya primera fase se desarrollan los instrumentos de medición y cálculo del centro de masa a partir de un conjunto de pasos de la biomecánica ocupacional, la segunda fase desarrolla el procedimiento que define propiamente el cálculo del centro de masa de los operadores dedicados al manejo manual de materiales y en la tercera se realiza su validación concurrente en función al análisis estadístico comparativo de los datos obtenidos por el procedimiento diseñado y un mecanismo teórico definido en la literatura para el mismo propósito. La aplicación del procedimiento ha logrado calcular con alta confiabilidad y sustento biomecánico los centros de masa de trabajadores dedicados al manejo manual de materiales, esta situación permite establecer un conjunto de estrategias ergonómicas que logran reducir de manera importante el impacto negativo de este tipo de tareas sobre la función anatómica y fisiológica del trabajador y en su último eslabón mejoran sustancialmente el potencial productivo de la empresa.

Palabras clave: Centro de masa, Manipulación manual de materiales.

Relevancia para la ergonomía: el trabajo de investigación establece una conformación pragmática de: estudios de movimientos, análisis biomecánico de

trabajos que contemplan el manejo manual de materiales, fisiología y anatomía de la columna vertebral, procedimiento de medición y validación estadística. Con esto, se desarrolló un procedimiento para calcular el centro de masa en seres humanos que mantenía características de confiabilidad, facilidad de uso y alto valor práctico. Esto se ve como una contribución esencial a la ciencia ergonómica.

Abstract: The multifactorial set of actions that are carried out in the manual handling of materials, impacts negatively on the mechanical stability of the spine, which generates the necessary conditions for a musculoskeletal disorder to occur, affecting with this the quality life of the operator who works in this type of activity and against it, the productive potential of the business entity is reduced. Due to the above, it is necessary to find a mechanism that can reliably represent the resultant biomechanical forces that interfere in the development of movements performed in this type of tasks. To define a strategy to solve the problematic situation, the following research objective is presented: design a reliable biomechanical procedure, validated and of high practical value, that allows non-expert personnel with the minimum of resources and training, determine the center of gravity for workers dedicated to the manual handling of materials. In order to achieve the objective, a mixed research procedure is established. In the first phase, the instruments for measuring and calculating the center of mass are developed from a set of steps in occupational biomechanics. The second phase develops the procedure that defines properly the calculation of the center of mass of operators dedicated to the manual handling of materials and in the third, its concurrent validation is carried out based on the statistical comparative analysis of the data obtained by the designed procedure and a theoretical mechanism defined in the literature for the same purpose. The application of the procedure has managed to calculate with high reliability and biomechanical sustenance the centers of mass of workers dedicated to the manual handling of materials, this situation allows to establish a set of ergonomic strategies that manage to reduce in an important way the negative impact of this type of tasks on the anatomical and physiological function of the worker and in his last link substantially improve the productive potential of the company.

Key words: Center of mass, Manual handling of materials.

Relevance to ergonomics: The research work establishes a pragmatic conformation of: studies of movements, biomechanical analysis to works that contemplate manual handling of materials, physiology and anatomy of the spine, procedure of measurement and statistical validation. With this, a procedure was developed to calculate the center of mass in human beings that maintained characteristics of reliability, usability and high practical value. This is seen as an essential contribution to ergonomic science.

1. INTRODUCTION

The center of gravity is equivalent to the center of mass in uniform gravitational fields as is the case of the action of the force of gravity of earth on human beings. The

calculation of center of gravity allows to define a representative point of the resulting forces that act on the human body.
The application of the force of gravity in the center of mass generates a zero moment, which allows to establish the negative biomechanical impact that can be generated when carrying out the manual handling of loads.
Theoretically, the center of mass is located at the intersection of the sagittal plane, the coronal plane and the transverse plane. The most representative studies in the area, frame that is between the lumbar vertebrae L4 and L5, and between the sacrum S1 and S3 depending on the characteristics of the person. Characteristics defined as: endomorphic, ectomorph and mesomorph; sex; age and some type of Skeletal Muscle Disorder (DME) developed by the subject may also influence.

The research carried out in the area of biomechanics in specific sports biomechanics, have defined several procedures for the calculation of the center of gravity, with the aim of representing the movement of the body in a single point and use the largest number of muscles for the development of the demanding action on the subject. These procedures require sophisticated equipment and are usually applied under laboratory conditions and with the greatest disposition of the subject of study.

In the case of occupational biomechanics, a procedure has not been established that allows the calculation of the center of gravity with requirements and needs of the manufacturing processes.

For these processes it's necessary that the calculation is carried out without interfering in a complex way in the manufacturing cycle. Which implies great difficulty to apply the procedures developed by sports biomechanics.

In addition to the above, the concept of application changes radically, since occupational biomechanics focuses on reducing the negative impact of work on the operator, so the center of gravity is used to analyze the forces that are generating moments when carrying out manual handling of materials and thereby determine if there is any risk that the worker will be generating a DME.

Due to the above, it is established as a research hypothesis: the development of a biomechanical procedure for the calculation of the center of gravity, allows to value the negative impact of the manual work of materials on the worker.

To fulfill the hypothesis, the following objective is presented: design a reliable biomechanical procedure, validated and of high practical value, that allows non-expert personnel with the minimum of resources and training, determine the center of gravity for workers dedicated to the manual handling of materials.

Occupational biomechanics as a factual science, is supported for its studies and analysis in several sciences, one of the main ones is anatomy, which is considered as a branch of morphology dedicated to the study of the figure and structure of the alive human body.

Occupational biomechanics details the body segments that intervene in the movements required to achieve the necessary actions in the work. These actions are defined by the laws of motion and depending on the complexity in which they develop is the degree of impact of the task in the operator. So as a starting point, occupational biomechanics takes up the way in which anatomy structures the body segments and a way to classify the position of organs, systems and tissues. Of greater transcendence for biomechanics is the way in which anatomy describes human movement and the anatomical position.

The human body as a dynamic biological system, is subjected to the force of attraction of the earth on each body segment that composes it, however, the forces of attraction are manifested on the centers of mass of the bodies that are attracted, so that the center of mass of the human body is attracted by the center of mass of the earth. The force performed by the earth on the human body, towards the center of the earth is called weight. The center of gravity is a useful concept for the analysis of human movement, since this is the point in which it can be considered that all the mass or weight of the body is concentrated. Therefore, the force of gravity acts down through this point. If a net external force acts on the body, the acceleration caused by it is the acceleration of the center of gravity. If an external force does not act on the object, the center of gravity doesn't accelerate.

From the theoretical perspective, in this work it's assumed that the weight is a vector magnitude whose point of application is the "barycenter" or "center of gravity" of the segment, that imaginary point where we can consider that the resultant of the weights of its infinite mass elements accumulates. In an analogous way, we can consider that the center of gravity of the total human body is that imaginary point where the resultant of accumulating the effect of the weights of a finite number of body segments is applied.

These elements are of the greatest importance, given that, in the conventional anatomical standing, the deviation of the line of action of body weight (external force exerted by the earth on the body) it can be an indication of a muscular imbalance, a postural defect or some pathology or secondary injury derived from the impact of the work on the worker.

The theories developed so far agree that the center of gravity or center of mass in the human body, is located at the intersection of anatomical planes.

This is a theoretical point with enormous applicability in the dynamics of movement and which is located at a certain height Z from the heels in the transverse plane, at a right or left lateral distance X from the axial axis of our body in the frontal plane and finally this point has an anterior or posterior distance Y from the axial axis of our body.

However, the conditions in which tasks are developed in the industry (production times, syndicates, space in lines of operation) does not make feasible the application of this type of methods. So the scientific analysis of the state of the art reveals the need to establish a validated biomechanical procedure, of high practical value that allows non-expert personnel with the minimum resources and training to calculate the center of gravity of workers in the industry subject of study.

2. OBJECTIVES

2.1 General objective

Design a reliable biomechanical procedure, validated and of high practical value, that allows non-expert personnel with the minimum of resources and training, to determine the center of mass for workers dedicated to the manual handling of materials.

2.2 Specific objectives

1. Elaborate the theoretical reference frame of the investigation from the scientific study of the established methods and procedures for the calculus of center of mass in human beings.
2. Develop the phases of the reliable biomechanical procedure, validated and of high practical value, which allows non-expert personnel with the minimum of resources and training, to determine the center of mass, for workers dedicated to the manual handling of materials.
3. Validate the procedure from the statistical methods of concurrent assessment of the calculation of the developed.

3. METHODOLOGY

The methodology used in this project is based on mixed research, stipulating three phases in its achievement.

In the first phase the measurement instruments required by the procedure are developed, basically there are 2, the template used for the verification of the alignment of the worker and the table for calculating the center of gravity. Another instrument required by the procedure is an anthropometer, this instrument is commercial and has a calibration certificate.

The second phase develops the biomechanical procedure for the calculation of the center of gravity, the computer mechanisms for the registration and analysis of the data, and the usability tests of the procedure.

In the third, its concurrent validation is performed through the interclass correlation coefficient, with the objective of establishing whether the results of the procedure are statistically significant compared with the results of similar procedures.

For the fulfillment of the first phase, the template to verify the alignment of the skeletal muscle system of the operator is developed. This template is composed of a set of 5 by 5 centimeters squares, aligned vertically and horizontally. The template manages to verify if there is a difference between the heights of the acromion of the operator, from the horizontal comparison of them and verifies if there are problems of lordosis, kyphosis and scoliosis in its vertical verification. The template is easy to transport and highly resistant, so it can be carried to the work area where verification is required. In figure 1, the verification template is shown.

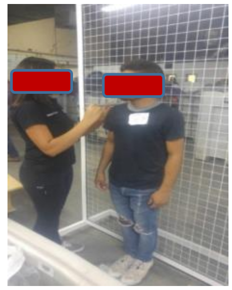

Figure 1. Verification template.

The second instrument designed is the table of calculation of the center of gravity, this table was constructed of wood for greater flexibility in the handling and transportation of the same. The capacity of the table is 200 kilograms in weight and 195 centimeters in length, with this it is possible to apply the procedure to the 99th percentile of the population dedicated to the manual handling of materials in the industry under study. A rectangular wooden platform with homogeneous density and weight WP applied at the center of gravity is structured, which, under such circumstances, agrees with the geometric center or "centroid" located at the point P equidistant from two points of support. The platform is supported at its two ends by two movable supports of wood, one of friction considered null (point A) and another supported on a scale (point B) that records the force WB that is exerted on said end. En la figura 2, se muestra el diseño esquemático del instrumento.

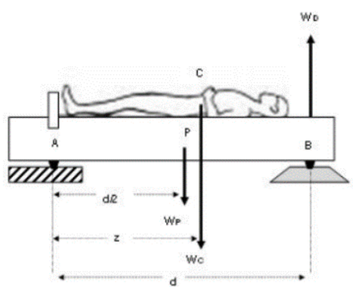

Figure 2. Schematic design of the instrument.

In figure 2, it can be seen that the three forces are perpendicular to the rectilinear segments that represent the distances. Applying the condition of static equilibrium for this system considering the torques with respect to point A we have: Z of equation 1, expresses the real value of the distance from point A, to the location of the body's center of gravity.

$$\sum \tau_A = 0$$
$$W_D \cdot d - W_P \cdot \frac{d}{2} - W_C \cdot Z = 0$$
$$W_D \cdot d - W_P \cdot \frac{d}{2} = W_C \cdot Z \qquad (1)$$
$$\left(W_D - \frac{W_P}{2}\right) \cdot d = W_C \cdot Z$$
$$Z = \frac{\left(W_D - \frac{W_P}{2}\right) \cdot d}{W_C}$$

For the design developed by the research team the movable support points are constituted, which allows high flexibility in the handling and use of the table. In addition to this the bases handle a support where security is provided for the operator that is being measured and the support area is small. In figure 3, the center of gravity calculation table is observed.

Figure 3. Table of calculation of the center of gravity.

The second proposed phase develops the calculation procedure of the center of gravity, where as a first step the vertical and horizontal alignment of the worker in the designed template is verified, with the objective mentioned before, this verification is necessary because when there are alignment problems in the vertebral column the center of gravity changes position in reference to the theoretical location of it (the intersection of the anatomical planes), so the procedure can indicate variations in reference to the calculation made.

The second step focuses on establishing the point of intersection of the three anatomical planes, where theoretically is the center of gravity, it is important to have reference that depending on the structure of the subject of study, the intersection of the three anatomical planes is going to have a variation and only in the mesomorph people the intersection is given to the height, in men at a distance from the sole of the feet equal to 58% of the total stature of the individual, and in women the center of gravity is find at a distance of 55% of his height. In the case of ectomorph people the point is below the navel and in the endomorphic the point is located above the navel. Figure 4, shows the theoretical location point of the center of gravity.

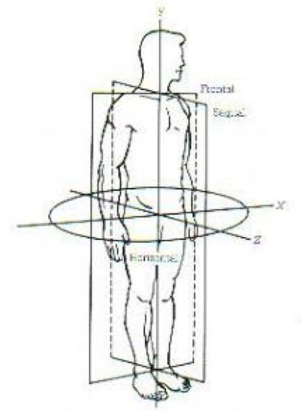

Figure 4. Theoretical center of gravity.

The third step is to calculate the center of gravity from taking the lectures of the scale placed at one end of the calculation table and perform the corresponding calculations, defined in equation 1. Figure 5 shows how this step is carried out with a worker dedicated to the manual handling of materials, in his area of work, the designed table has flexibility that allows the instruments designed for the application of the procedure enters a work.

Figure 5. Taking lecture of center of gravity in the designed table.

Once the measurement is carried out, the data is captured in a computer support system, in which the center of gravity is calculated.

Table 1 shows the computer support system and some of the measurements realized.

Table 1. Computer system to support the calculation of the center of gravity

NO	WP	WC	WD	D	Z
1	19.5	76.5	52.5	195	108.97
2	19.5	94	62.4	195	109.22
3	19.5	96.5	64.35	195	110.33

WP	Weight of table
WC	Weight of person
WD	Weight measured by the scale
D	Total distance

.

As shown in equation 1, the value of Z corresponds to the distance from the point of support to the center of gravity of the subject of study.
The last step defined in the procedure is the comparison between the center of gravity obtained by the measuring table and a procedure already defined for the same purpose. In figure 6, the designed procedure is shown schematically.

The data obtained must be validated so that the procedure is considered reliable. For this and as a last step of the methodology used, a concurrent validation study is performed through the interclass correlation coefficient.

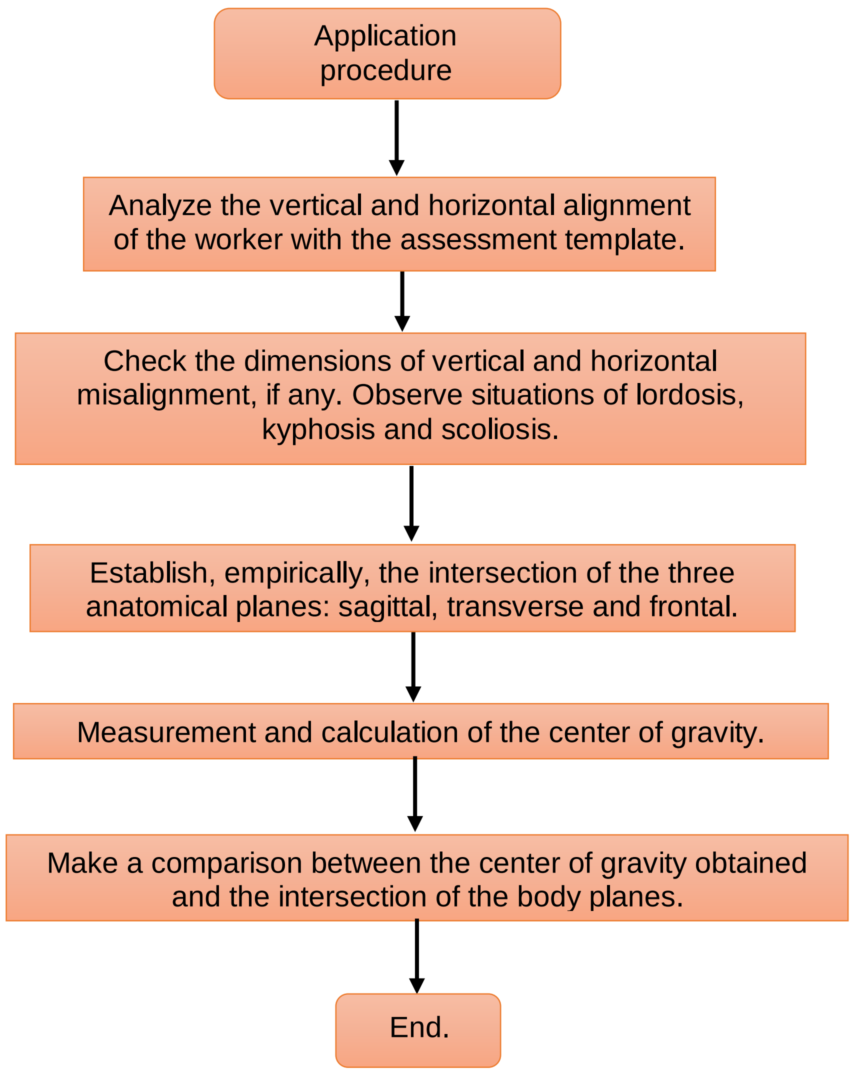

Figure 6**.** Procedure for calculating the center of gravity.

4. RESULTS

Until now, the procedure to calculate the center of gravity of workers dedicated to the manual handling of loads in the industry has been applied in 58 cases.

With the records of the 58 cases, the concurrent validation was performed through the interclass correlation index. In chart 1, the results of the measurements to be compared for the validation are shown. The chart shows the values obtained by the designed procedure and the values defined by the point of intersection of the three anatomical planes.

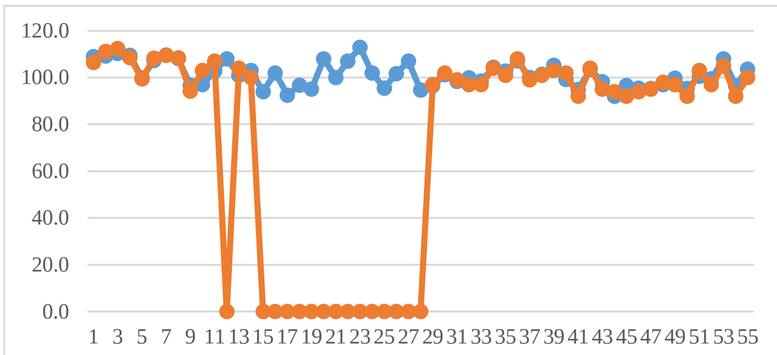

Chart 1. Comparison of the value of the center of gravity obtained by the procedure and the intersection of the anatomical planes.

Figure 1 shows a trend and similar assessment between the two results obtained from the center of gravity, however, to consider that the values are statistically significant, the statistical model of the interclass correlation coefficient is applied.

Table 2 shows the results of the coefficient obtained in the statistical package IBM SPSS Statistics version 24.

interclass correlation coefficient.

	Interclass correlation	95% of confidence interval	
		Upper limit	Lower limit
Unique measurements	.875	0.797	0.924
Average measurements	.933	0.887	0.960

Reliability statistics

Cronbach alpha	Number of elements
0.933	2

Table 2. Correlation coefficient and statistical reliability.

The values obtained in the tests of statistical significance for concurrent validation, consider that the two variables maintain a very good agreement, so that the designed procedure is validated and considered reliable in obtaining the center of gravity.

5. CONCLUSIONS

The development of the research generated a biomechanical anthropometric procedure for the calculation of the center of gravity, which presents characteristics that allow its applicability directly in productive processes that maintain activities of manual handling of materials. The main characteristics of the procedure are: reliability in the results that derive from its application; validated from a high index in the interclass correlation coefficient and of a high practical value, which allows non-expert personnel with the minimum of resources and training, to calculate the center of gravity in the activities of manual handling of materials.

Of the 58 calculations that have been executed, in 32 changes have been made in the mechanisms of manual handling of materials, considering the center of gravity as an analysis point, in such a way that the distances between the mobilized objects and the center have been reduced of severity of the worker, obtaining in this way 17% more performance in the work and a considerable decrease in the possibility that the worker develops a Skeletal Muscle Disorder.
The fundamental contribution of the research is presented, in the flexibility of the application of the designed procedure, in response to the complex conditions existing in the industry, to carry out the calculation of the center of gravity.

With the previous contribution, a new work tool is established for the ergonomists and biomechanics of production lines, for the analysis and improvement of the human - machine interaction, taking with it the possibility of improving the competitive capacity of the productive plant of the country and the improvement in the quality life of the workers.

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MANUAL MATERIAL HANDLING ORIENTED TO LOGISTICS OPERATIONS IN THE AUTOMOTIVE INDUSTRY

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Resumen. Los dolores de espalda baja, se han posicionado dentro de los factores de riesgo de incapacidad permanente dentro de los últimos 5 años en Estados Unidos (Seay, Sauer, Patel, & Roy, 2016). Por otro lado, en México, el que un operador haga una visita médica a causa del mismo síntoma, implica 3 días de incapacidad como mínimo mientas inician las investigaciones en el lugar del trabajo, una vez enviado el formato ST-09. Estudios previos, indican que la mayoría de los individuos que presentan estos síntomas, recaen al volver a sus actividades normales en alrededor de 8 semanas (Seay, Sauer, Patel, & Roy, 2016). Mientras que algunos riesgos como la exposición a movimientos repetitivos, temperaturas extremas, posturas forzadas, tensión articular y poco tiempo de recuperación, tienen también una alta relación entre el manejo manual de materiales y los desórdenes musculoesqueléticos (Heran-Le Roy, Niedhammer, Sandret, & Leclerc, 1999). Las lesiones denominadas LBP y desordenes musculoesqueléticas MSD favorecen al aumento del porcentaje de prima de riesgos que la empresa debe declarar anualmente, pues es responsabilidad de las empresas registradas en el IMSS, revisar su siniestralidad con el propósito de determinar si su prima aumentó, disminuyó o permaneció igual. (IMSS M. , 2017). En la actualidad hay aproximadamente 30,000 empleados en Hermosillo en la Industria automotriz, los cuales se enfrentan diariamente a riesgos ergonómicos de todo tipo. Las incapacidades van desde los 3 días hasta 4 semanas. El propósito de este proyecto, es realizar un diagnóstico ergonómico a una muestra de empresas automotrices del sector con el objetivo de darle a dichas compañías la visión de los niveles y factores de riesgo que en sus estaciones se presentan y de esta manera poder relacionar el riesgo más común relacionado con manejo manual de cargas.

Palabras clave: Manejo Manual de Materiales (MMM), Factores de riesgo, Lesiones en espalda baja (LPB), Trastornos musculoesqueléticos (MSD), Logística.

Relevancia para la ergonomía: El realizar el presente proyecto, ayudará a las empresas automotrices a comprender el impacto que genera el no tener un estudio ergonómico para MMM en el porcentaje de prima de riesgos pagado anualmente, derivado de las incapacidades relacionadas con dorsopatías. De ahí la ergonomía en todas las áreas, tomará un papel relevante en las compañías que revisen el artículo.

Abstract. Lower back pains have been positioned among the permanent disabling risk factors during the last 5 years in the United States (Seay, Sauer, Patel, & Roy, 2016). On the other hand, in Mexico, the fact that an operator has a medical consultation caused by this same symptom, implies at least 3 days off due to disabilities while the workplace investigation takes place once the ST-09 format has been sent. Previous studies have shown that most of the individuals that experience these symptoms, show a re-occurrence after 8 weeks of getting back to their normal activities (Seay, Sauer, Patel, & Roy, 2016), while some risks such as exposure to repetitive movements, extreme temperature, forced postures, joint strain and insufficient recovery time, are highly related to the manual material handling and musculoskeletal disorders (Heran-Le Roy, Niedhammer, Sandret, & Leclerc, 1999). The so-called LBP injuries and musculoskeletal disorders MSD favor the increase of the percentage of risk premium that the company must report annually, since it is a responsibility of all enterprises registered before IMSS, to verify their accident rate with the purpose of determining if the risk premium increased, decreased or remained the same (IMSS, 2018). Nowadays, there are approximately 30,000 employees in Hermosillo in the automotive industry, who are at an ergonomic risk of all kinds on a daily basis. The days off due to disability go from 3 days to 4 weeks. The aim of this project is to perform a diagnosis to a sample of automotive organizations with the purpose of providing these companies with the vision of the risk levels and factors present in their work stations and consequently to be able to relate the most common risk related to manual load handling.

Keywords: Manual Material Handling (MMH), risk factors, lower back pains (LBP), Musculoskeletal Disorders (MSD), Logistics.

Relevance to ergonomics: the completion of this project, will help automotive industries to understand the impact not having an MMH ergonomic study generates in the percentage of risk premium paid annually, derived from the disabilities related to dorsopathies. Hence, all the areas of ergonomics, will take a relevant role in the companies that analyze this paper.

1. INTRODUCTION

The automotive industry in Sonora, originated in 1986 when the first plant in the field was inaugurated in Hermosillo. Currently, the city has an industrial park that provides 163,000 m2 near the site, with 20 industries that employ around 30,000 employees to supply an annual production of around 20,000 vehicles (Hermosillo Stamping and

Assembly, 2017). The fact of having a great number of employees under the same automotive industry scheme, implies that they acquire new abilities and knowledge, as well as the fact of facing a variety of risk factors in their processes. Lower Back Pains (LBP) have positioned among the main causes of permanent disabilities during the last 5 years in the United States (Seay, Sauer, Patel, & Roy, 2016). On the other hand, the fact that an operator has a medical consultation to the ***Instituto Mexicano del Seguro Social (IMSS),*** caused by the same symptom implies at least 3 days of disability. LBP and MSD favor the increase of the percentage of risk premium that companies must report annually (IMSS, 2018). In the review of the scientific literature various studies carried out in countries such as United States, France, India, Ital, Korea and Germany were found where it could be observed that a special importance to the prevention and care of injuries caused by manual load handling has been taken. Nevertheless, no records were found of studies carried out in our country to date for such areas of ergonomics.

Several studies carried out in the aforementioned countries, have focused their efforts in testing hypotheses related to manual load handling, as in the case (Hill, Duncan, Oxford, Kay, & Price, 2018), where the main purpose was to investigate the effects of maintaining external loads in the posture balancing during a postural position as people age. Sixty-five healthy adults with ages between 18 to 80 years were evaluated in four conditions; (1) standing holding a load, holding a load corresponding to 5 % of their body mass con the (2) left hand, (3) right hand and (4) both hands. In which it was concluded that the task of holding a relatively light load in both hands reduced the measurement of postural control among the 2 groups of oldest age, while performing the same task with one hand causes greater fatigue and LBP in those tasks involved in the study. Another study evaluated the ergonomic indicators of the lifting task considering different positions of containers, which were divided into the following categories: a) picking up full containers from the floor, b) picking up half-full containers from the floor and c) picking up containers from the top of a shelf. All of this with the purpose of broadening the investigation of models for the ergonomic evaluation of tasks prior to the preparation of material supply. Nevertheless, it was demonstrated that OWAS and METABOLIC EXPENDITURE methods are suitable to predict the ergonomic values that are inherent to the supplying preparation tasks (Calzavara, Glock, Grosse, Persona, & Sgarbossa, 2016). That said, according to information issued by (IMSS, 2018), chronic back pain is measured by the duration, that is to say, a chronic pain is the one that persists for more than 3 months where the cause is difficult to determine as the inability continue. When lumbago is not correctly treated it can cause frequent occurrences and avoid the returning to daily activities, causing long periods of days off due to inability. These injuries are common among the working population that must seek for medical treatment in the short run due to the inability time they cause. To confirm such information, national statistics have been checked where the following summary of work/related diseases is listed updated to 2017.

On this table it can be observed (table 1.1) that, indeed dorsopathies shared the first position in 2017 along with deafness (hearing loss) of all the work-related diseases registered by ***(IMSS).***

Table 1.1 Percentage of work-related diseases by cause (IMSS, 2017).

Porcentaje de enfermedades de Trabajo según su origen					
	Casos en:		Porcentaje %		% total
Enfermedad	Hombre	Mujer	Hombre	Mujer	
Hipoacusias	1,809	64	22%	1%	23%
Dorsopatias	1,390	273	17%	6%	23%
Enfermedad del Ojo y sus anexos	982	382	12%	9%	21%
Neumoconiosis	995	22	12%	1%	12%
Intoxicaciones	554	322	7%	7%	14%
Otras Entesopatías	179	521	2%	12%	14%
Sindrome del túnel carpiano	72	564	1%	13%	14%
Dermatitis de contacto	301	279	4%	6%	10%
Lesiones del hombro	218	285	3%	7%	9%
Tenosinovitis de Estiloides Radial de (Querva	54	368	1%	9%	9%
Afecciones respiratorias debidas a la inhalación de gases, humos, vapores y sustancias químicas	268	110	3%	3%	6%
Otras Sinovitis, Tenosinovitis y Bursitis	98	251	1%	6%	7%
Enfermedades infecciosas y parasitarias	91	138	1%	3%	4%
Epicondilitis	65	119	1%	3%	4%
Trastornos mentales y del comportamiento	104	64	1%	1%	3%
Artrosis	130	20	2%	0%	2%
Enfermedad por Descompresion	107	1	1%	0%	1%
Enfermedad vascular periferica	36	40	0%	1%	1%
Cáncer ocupacional	26	9	0%	0%	1%
Asma	17	13	0%	0%	1%
Varios de frecuencia menor	805	476	10%	11%	21%
TOTALES	8,301	4,321	100%	100%	

Last November 23rd 2018, what began as a norm project was passed as a Mexican Official Norm, which was published in the Federation Official Newspaper concerning ergonomic risks at the workplace (Diario Oficial de la Federación, 2018). Where the following is quoted: *the objective is to establish the elements to identify, analyze, prevent and control the ergonomic risk factors in the work centers derived from the manual load handling for the purpose of preventing alterations to the health of workers. And its field of application applies in all national territory and in all work centers where workers exist whose activity implies performing manual load handling on a daily basis (more than once a day). this norm does not apply in manual load handling lower than 3 kg.*

2. GENERAL OBJECTIVE

To carry out a diagnosis in the automotive industry in Hermosillo, in the areas that involve manual load handling that show the number of operations that present ergonomic risk and the risk type operations are exposed to.

2.1 Specific objectives

a) Carry out an ergonomic study to the 100% of the working population that perform manual load handling in the industrial plants that are willing to cooperate.
b) Find the risk factors operators are more susceptible to suffer from in warehouses and production areas with MMH.
c) Concrete improvement proposals to each evaluated industry, in order to get a fuller view of the risk factors that happen in their work stations.
d) Reduce or maintain the trend on the reduction of days off due to inabilities caused by MMH.

3. METHODOLOGY

The first step was to take a sample of automotive companies that allowed access to conduct interventions. Once inside, the MMH were identified and the ergonomic evaluations took place considering two methods to collect data, paying close attention to the group of muscles that present more exposure and the action category provided by the result of each evaluation. The individuals that participated in the data collection process and analysis were located in work stations of diverse automotive industries of the first shift, that performed manual load handling, either directly on the production lines or in the internal logistics operations.

Once in the work station it is common to find that the operator feels observed or judged so consequently, they alter the natural way they work at, whether they start performing faster or slower, with more precision, more concentration, etc. This is why it is important to let them know in advance about the assessment and the importance of continuing their operations as normal as possible. This is why, right before the observation commenced the following was mentioned: “we will record the operations of the work you perform with the purpose of finding ergonomic improvements, on other words, we will try to check if you have unsafe conditions for your body within your work station. And if we find them, we will try to improve them, for this matter we thank you help us with the following: work at your normal pace, free of pressure, imagining we are not here, remember this is for your own benefit”. Afterwards, the recording of the video considering at least 3 operation cycles took place. It is noteworthy that, sometimes, they are not repetitive operations (specially the logistics ones), so it was not possible to record 3 consecutive series at all times.

Once the recording is finished some operators are asked the following: do you feel discomfort during or after your work? are any of the materials you manipulate too heavy? do you find this operation tiring? In the case of logistics operations, the following question is added: how often do you normally perform the same supplying operation.

In most cases, it is important to check if the material is Lincoln or Ford, since the production volume varies from 86% for Ford (1262 units) to 14% for Lincoln (200 units) during the day (data corresponding to the highest production capacity).

The methods to be used in this project will be: The MAC Tool, for lifting or lowering & transportation operations and the Liberty Mutual Tables for pushing and pulling operations when wheeled equipment is used to transport the load.

3.1 Evaluated risk factors.

The risk factors that were evaluated in this project are: load weight vs frequency, distance from hands to the lumbar region, vertical lifting distance, asymmetrical load, torsion and lateralization of the trunk, postural restrictions, hand-load coupling, surface, environmental factors, traveling distance and obstacles.

4. RESULTS

After the application of the ergonomic methods for the evaluation of risk factors in material load handling, for the lifting and lowering tasks, transportation and raising and lowering activities took place, the data was carefully analyzed with the purpose of verifying the risk situation of each company and the behavior of the results with respect to the manual handling task, in order to be able to interpret the results more objectively and provide recommendations.
The first graph (figure 1.1) indicates the sample size that was analyzed along with its respective source.

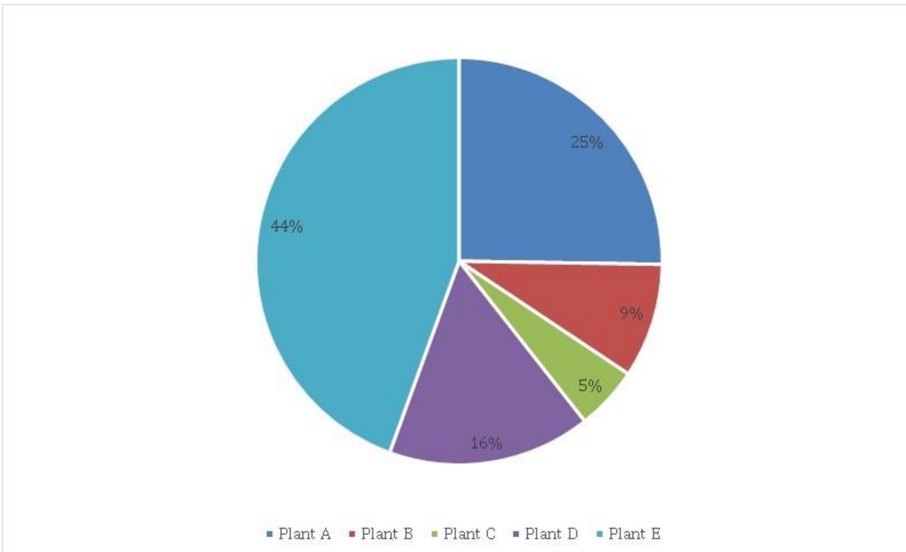

Figure 1.1 Sample size

Figure 1.2 indicates the number of logistics operations evaluated that require immediate, prompt, short run attention and the ones that do not require attention from the company.

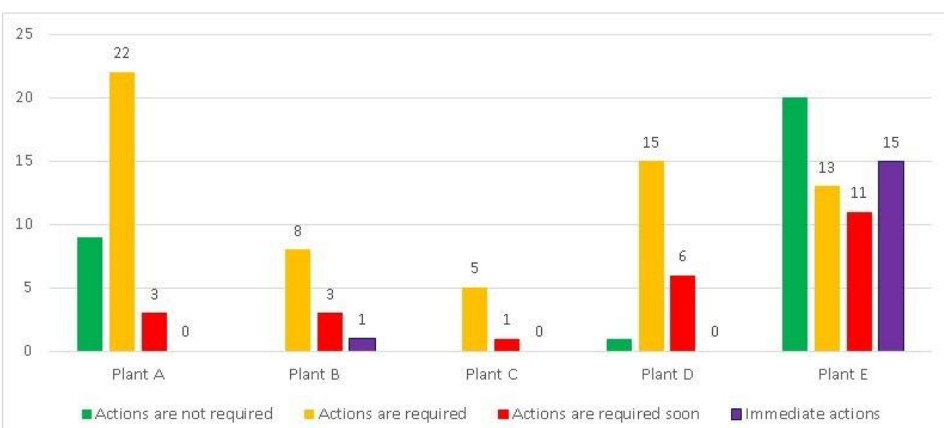

Figure 1.2 Action category

In the next graph (figure 1.3) the risk factor consolidation can be observed, including the evaluated risk factors that were more significant.

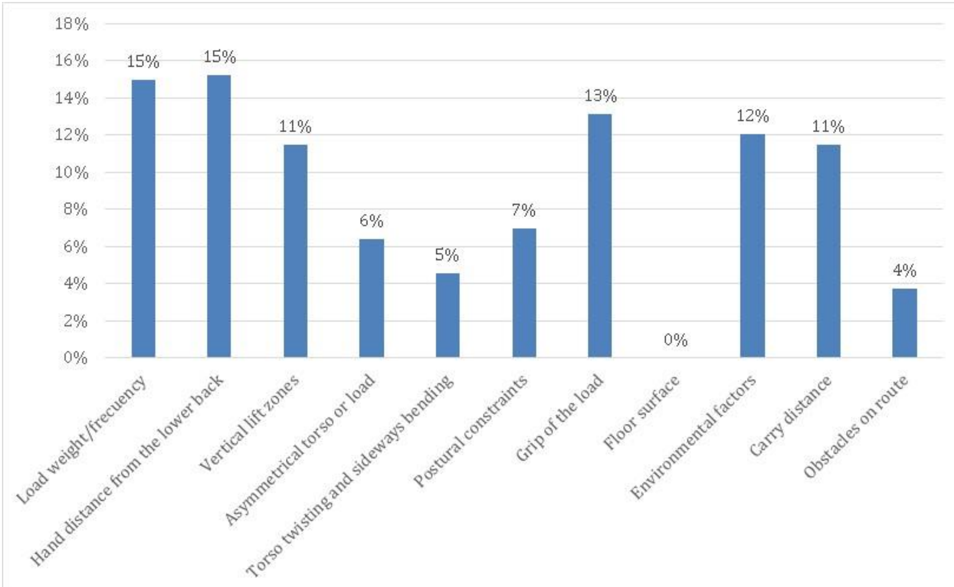

Figure 1.3 Risk factor percentage

The number of events could also be analyzed by risk factors that each industry presented in figure 1.4 as:

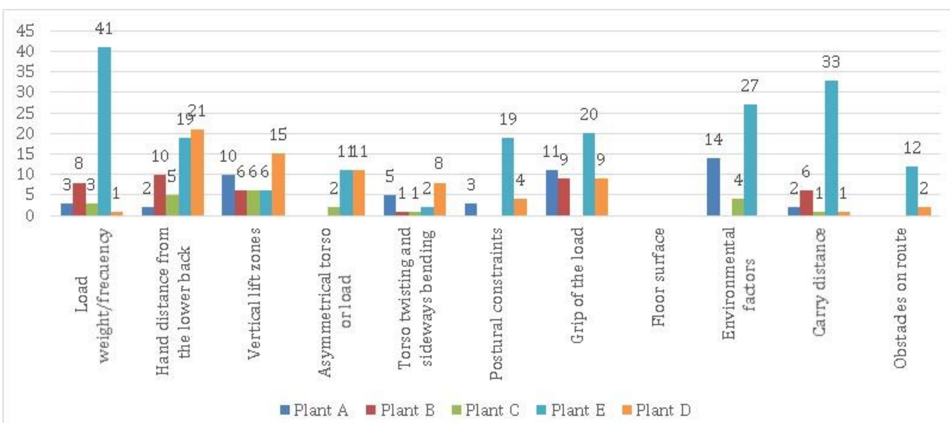

Figure 1.4 Events by risk factor

Finally, the evaluated operations were divided into three categories: lifting and lowering, transportation and pushing and pulling by industry (figure 1.5), this allowed the observation of the number of evaluated operations belonging to each task, since in each case the risk factors are different. It is worth mentioning that not all three risk categories to be evaluated were found in all industries.

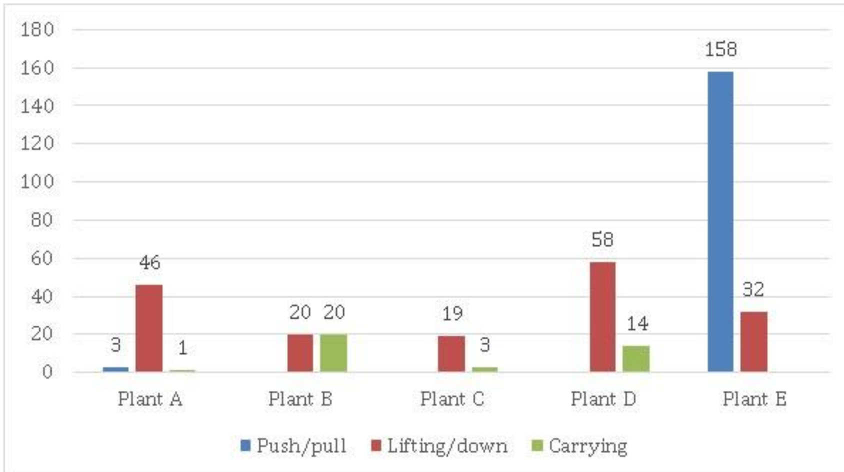

Figure 1.5 Task/oriented results by company.

5. CONCLUSIONS

The main common denominator that was present was that most organizations do not have updated ergonomic evaluations in the different production areas and the internal logistics of manual load handling, they only have records of days off due to inabilities before IMSS. Once the MAC Tool and Liberty Mutual Tables evaluation methods took place, it can be concluded that more than 50% of the operations have at least one risk factor present. 20% belong to the stations that are considered safe, shown in green, which do not require corrective action for the moment.

However, the risk factors with the highest results were the weight of the level of the load against the frequency in the first place, the transportation distance in second position, environmental factors in the third and hand/load coupling as fourth place. The remaining factors belong to bad practices that can be corrected creating a correct ergonomic culture among the workers and supervisors, the first ones is distance from the hand to the lumbar region, meaning the way the load is taken and how far it is from the body, postural restriction is the next one, and it continues with obstacles that can be basically corrected applying 5s, and the remaining ones such as torsion and lateralization or asymmetrical loads show less weight in the evaluation. Now, the pushing and pulling category is the one that shows a big risk index, especially in plant E, for this reason it is recommended to use wheeled mechanisms that ease the transportation, warehouse rearrangement to shorten distances and avoid obstacles, while in plant D, the lifting and lowering categories present the highest score and the recommendations here are to distribute the loads in different routes, schedule resting period for operators, change containers with different capacities and in all cases, create a safe culture ergonomically speaking for the employees. In this way, it can be concluded that the risk factors that were more frequently found are directly related to the inabilities caused by lower back injuries.

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EVALUATION OF ERGONOMIC RISKS FOR THE WORK OF THE PHYSIOTHERAPIST IN LOS MOCHIS, SINALOA, MEXICO

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Resumen: La fisioterapia, así como todas las ramas de la salud, debe de tener el uso de conocimientos ergonómicos, pero debido a la poca experiencia laboral o el poco conocimiento sobre el tema, en muchos de los casos, no se implementa de manera correcta y esto puede generar fatiga laboral, hasta lesiones muy graves principalmente en toda el área de la espalda, por movimientos mal hechos.

Se llevó a cabo un estudio detallado sobre cuáles son las principales causas de la fatiga y lesiones musculares en los fisioterapeutas al momento de auxiliar a pacientes y así, se propone implementar el método "Evaluación Rápida de la Extremidad Superior" (RULA) para observar y evaluar cuáles son los trastornos de tipo musculo-esqueléticos en la carga postural al momento de que los auxiliares adoptan posturas inadecuadas de forma repetida en el trabajo, generando fatiga, y a la larga generar problemas de salud. El objetivo de la presente investigación es el siguiente: Evaluar la carga postural desarrollada en fisioterapeutas en el Centro Regional de Rehabilitación Integral (CRRI) Los Mochis, durante el traslado de pacientes a camilla obteniendo 7 en el resultado final en escala de RULA, lo que quiere decir que se necesitan hacer cambios y modificaciones inmediatas en las técnicas y movimientos que usan los profesionistas.

Palabras clave: Fatiga ocupacional, método RULA, fisioterapia

Relevancia para la ergonomía: El objetivo de esta investigación es proporcionar a la ergonomía un estudio completo en el área de la fisioterapia, realizar el método RULA y observar las conclusiones para poder implementar las mejoras en su área de trabajo, con la intención de mejorar la salud del trabajador, así como Mejorar la comodidad del paciente en todas las consultas futuras.

Abstract: Physiotherapy, as well as all branches of health, should have the use of ergonomic knowledge, but due to little work experience or little knowledge on the subject, in many cases, it is not implemented correctly and this can generate work fatigue, even serious injuries, mainly in the entire area of the back, due to incorrect movements.

A detailed study was carried out on what are the main causes of fatigue and muscular injuries in physiotherapists when assisting patients and thus, it is proposed to implement the method "Rapid Assessment of the Upper Extremity" (RULA) to observe and evaluate which are the muscular-skeletal type disorders in the postural load at the moment when the auxiliaries adopt inappropriate postures repeatedly at work, generating fatigue, and in the long run generate health problems. The objective of the present investigation is the following: To evaluate the postural load developed in physiotherapists in the Regional Center of Integral Rehabilitation (CRRI) Los Mochis, during the transfer of patients to the stretcher obtaining 7 in the final result in RULA scale, which it means that changes and immediate modifications are needed in the techniques and movements used by professionals.

Key words: Occupational fatigue, RULA method, Physiotherapy.

Relevance to ergonomics: This research aims to provide ergonomics with a complete study in the area of physiotherapy, performing the RULA method and observing the conclusions to be able to implement the improvements in their area of work, with the intention of improving health of the worker, as well as improving the comfort of the patient in all future consultations.

1. INTRODUCTION

International studies establish that musculoskeletal injuries are very significant among health professionals. Physiotherapists are also exposed to different risk factors that contribute to the development of such injuries, since the nature of their work is repetitive and intensive.

Some of these risks are implicit in the direct treatment of patients as well as all health personnel, and others exclusive of the practice of physiotherapy for the variety of manual techniques used.

These studies have been carried out in different places: Canada, the United States, the United Kingdom, the Netherlands, Kuwait, Australia, Turkey, Nigeria, Israel and Sweden.

As explained by (Diego Mas, 2015) there are several methods that allow the assessment of the risk related to the postural load, these differ in the way they are applied, in how they are evaluated individually or by groups of postures.

One of the observational methods to evaluate postures is the so-called Rapid Assessment of the Upper Extremity, better known by the RULA Method, it is one of the most effective methods, since by these means the observation of the reliable information is obtained about the postural load.

The RULA method was developed at the University of Nottingham:

... in 1993 by McAtamney and Corlett, of the University of Nottingham (Institute for Occupational Ergonomics), with the objective of evaluating the exposure of workers to risk factors that cause a high postural load and that can cause disorders in the upper limbs of the body. For the evaluation of the risk, the method, the position adopted the duration and frequency of this and the forces are considered (Diego Mas, 2015).

The measurements to be made on the positions taken by the worker are in respect to angles, these measurements can be made directly on the worker by means of protractors or any device that allows the taking of angular data. It is also possible to use photographs of the worker adopting the posture studied and measure the angles on them. If photographs are used it is necessary to make a sufficient number of shots from different points of view.

The Level of Action will indicate if the position is acceptable or to what extent the changes or redesigns in the position are necessary. In short, RULA allows the evaluator to detect possible ergonomic problems derived from an excessive postural load.

1.1 Justification

The OMS (Organización Mundial de la Salud - World Health Organization) designated the period from 2001 to 2010 as the bone and joint Decade, so that discussions and revisions are carried out on topics related to work and daily activities that affect the neuron musculoskeletal system.

In the OMS International Classification of Diseases (CID-10), the ailments known as Repetitive Strain Injuries (LERT), Work Related Musculoskeletal Disorders (WRMSDs) or Work-Related Osteomuscular Dysfunctions (DORT) are not considered as such, although international studies establish that musculoskeletal injuries are very significant among health professionals.

However, physiotherapists are equally exposed to different risk factors that contribute to the development of such injuries, since the nature of their work is repetitive and intensive.

Some of these risks implicit in the direct treatment of patients as all health personnel, and others exclusive of the practice of physiotherapy for the variety of manual techniques used.

These studies have been carried out in different places: Canada, the United States, the United Kingdom, the Netherlands, Kuwait, Australia, Turkey, Nigeria, Israel and Sweden.

Therefore, a proposal for the implementation of the RULA method and improvements in an office in the physiotherapy area are created to reduce injuries and improve the occupational health of the physiotherapist.

1.2 Delimitation

This study was carried out with a physiotherapist from the Regional Center for Integral Rehabilitation (CRRI) Los Mochis, specialized in supporting patients with different abilities and in the physical rehabilitation treatment of minor and / or severe injuries.

2 OBJECTIVE

Evaluate the postural load developed in the physiotherapy, in the CRRI (Regional Center of Integral Rehabilitation, Los Mochis, during transfer of electric stretcher to chair.

2.1. Specific objectives

- Identify the causes of the physiotherapist's inadequate postures when helping patients (mostly when moving from a stretcher to a wheelchair or from a wheelchair to a stretcher).
- Analyze the patient's management of the physiotherapist in the transfer of patients from stretcher to chair with the RULA method.
- Implement the "RULA" method to the physiotherapist in the management of patients.

3. METHODOLOGY

It is a mixed research since it is "... an approach that presents several perspectives to be used. The Mixed Method is the systematic integration of quantitative and qualitative methods in a single study in order to obtain a more complete picture of the phenomenon "(Cedeño Viteri, Narcisa, 2012, page 19) since two types of research were used: quantitative and qualitative, since these investigations provided more information when evaluating the management of patients performed by physiotherapists.

Since an interview and field research were applied, at the CRRI facilities, the maneuvers performed with the patients were observed and videos were taken; In addition, quantitative indicators were obtained when applying the RULA method, "it is one of the observational methods for the evaluation of postures that is more widespread in practice" (Diego Mas, Josè Antonio, 2015) and it is because the "... approach to quantitative data is carried out" it is statistical, demonstrates with the separate aspects of its whole, to which numerical meaning is assigned and makes inferences "(Cedeño Viteri, Narcisa, 2012, page 21) and these data are obtained with the RULA method since the partial and final scores of the method to determine the existence of risks and establish the Level of Action.

2.1. Process description:

The procedure to apply the RULA method according to what it suggests (Diego Mas, Josè Antonio, 2015) can be summarized in the following steps:

1. "Determine the work cycles and observe the worker during several of these cycles. If the cycle is very long or there are no cycles, evaluations can be made at regular intervals. "

Here it was observed that depending on how serious the patient's case is, the times in which the physiotherapist assists in lifting the patient can vary.

2. "Select the positions that will be evaluated. Those that, a priori, supposes a greater postural load either because of their duration, because of their frequency or because they present a greater deviation from the neutral position will be selected. "

Here, the position was chosen at the moment when the physiotherapist folded his body slightly in order to have a greater reach of the patient and also the position taken when grasping the patient in order to apply force.

3. "Determine if the left or right side of the body will be evaluated. In case of doubt, both sides will be analyzed. "

In this step we chose the side where the greatest availability is in the office.

4. "Take the required angular data. Photographs and / or videos can be taken from the appropriate points of view to make the measurements. "

Video and photos of different angles with real size were taken so that this does not affect when taking into account the angles and postures.

5. "Determine the scores for each part of the body. Using the table corresponding to each member. "

The table of each part of the body was taken into account by groups.

6. "Obtain the partial and final scores of the method to determine the existence of risks and establish the Level of Action."

This step is essential to correctly count the score to know if the movements and postures are ergonomically appropriate.

7. "If required, determine what type of measures should be adopted. Review the scores of the different parts of the body to determine where corrections are necessary. "

Analyzing the scores thrown by the method, it is observed that the parts of the body where it causes a greater impact of load are, back, low back, legs and arms. Due to this, corrective measures and changes are taken at the moment of performing the action.

8. "Redesign the position or introduce changes to improve the position if necessary."

The change implemented is as follows:

The physiotherapist stands facing the patient with one foot closest to the chair in front of the other, the patient places his arms on the shoulders of the physiotherapist, the patient places his feet on the floor, and the physiotherapist fixes with his knee the knee of the patient. Patient must not bend it. The therapist rotates together with the patient, and once placed in front of the chair, flexes the knees as he moves down to the chair.

9. "In case of having introduced changes, reassess the position with the RULA method to check the effectiveness of the improvement."

In the study and evaluation that was carried out using the RULA method at the moment the physiotherapist helped transfer a patient from the stretcher to a chair, we observed all the movements and efforts that are made at the time of making these movements, which are the following:

The physiotherapist's knees are slightly bent to have a better low reach of the patient, the patient is taken depending on which area is the most appropriate or the one that is not damaged, force is applied to sit the patient and then help him to stop and finally help him to sit in the wheelchair or on the appropriate surface type according to the case.

4. RESULTS

The application of the RULA method was developed when assessing the risk of exposure of physiotherapists to factors that cause a high postural load, considering the position adopted the duration and frequency of this and the forces exerted when it is maintained.

For a certain RULA position, a score was obtained from which a certain Level of Action was established. The Level of Action indicates whether the position is acceptable or to what extent changes or redesigns are necessary in the position.

The transfer or movement of a patient on an electric stretcher to a chair was analyzed.

• Results: Group A. Superior members

Figure 1. *Physiotherapist lifting patient*
Source. *Own elaboration*

When measuring the angle formed by the axis of the arm and the axis of the trunk should be between 20 ° - 45 ° and abducted arm. The angle of flexion, measured as the angle formed by the axis of the forearm and the axis of the arm between 60 ° - 100 °, the arm leaves the line of the body. The flexion / extension angle measured from the neutral position is 0 ° - 15 ° which does not add value and the wrist is in the middle range of rotation. The posture is mainly static so no value is added; it has a load of> 10 kg.

Final score, group A is: **6**.

• Results: Group B. The legs, trunk and neck.

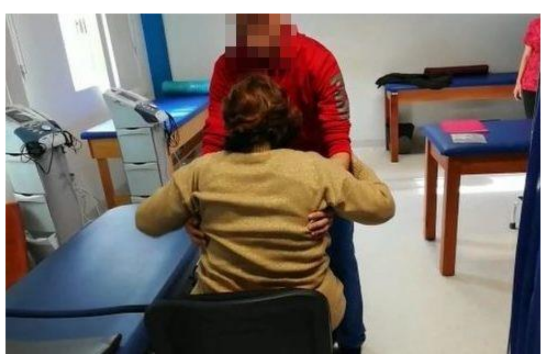

Figure 2. *Physiotherapist sitting patient*
Source. *Own elaboration*

The flexion / extension measured by the angle formed by the axis of the head and trunk axis observed in the physiotherapist is at 10 ° - 20 °, with lateral inclination. The flexion angle of the trunk measured by the angle between the axis of the trunk and the observed vertical is 20 ° - 60 °. The legs and feet are supported and balanced in movement.

Giving all these specifications the following results:

Neck: 3
Trunk: 3
Legs: 1

Final postural score B: **4**

Entering the final table, the score of group A (6) and group B (4) in the final table (Table C). We obtain a result 7 (study and modify immediately) according to the implemented method. It is observed that the parts of the body where it causes a greater load impact are: back, lower back, legs and arms. Due to this, corrective measures and changes are taken at the moment of performing the action. In short, RULA allowed the evaluator to detect possible ergonomic problems derived from an excessive postural load.

	1	**2**	**3**	**4**	**5**	**6**	**7+**
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Table 1. *Results table C.*
Source: *With data from (Diego Mas, Josè Antonio, 2015)*

Table 1 shows the final result obtained**: 7**, Study and modify immediately.

4. CONCLUSIONS

Observing the results and the final scores obtained by the applied method, it can be concluded that it is necessary to immediately modify the method that is used by the physiotherapists when performing their work, this allowed to implement improvements and ergonomic strategies by means of suggestions to avoid bad habits postures and repetitive movements in the work of the specialist, seeking to take care of the health of both the physiotherapist and the patients.

To obtain the necessary information in the workplace, observations were made of the physiotherapist at the time of attending patients, focusing mainly on the movements involved in moving a patient from a stretcher to a chair. Likewise, an interview was conducted, which was very helpful because through the answers we were given the necessary information of the fatigue and injuries that the specialist had after a certain time providing the service and thus make sure to make the decisions and implement the appropriate improvements to ensure the integrity of all involved.

Analyzing the scores thrown by the method, it was observed that the parts of the body where it causes the greatest load impact are: back, lower back, legs and arms. Due to this, corrective measures and changes are taken at the moment of performing the action.

The contribution of suggestions and information for the improvement of the work of a physiotherapist was considered of great help by means of the results obtained from the implementation of the RULA method, since fatigue decreased in the physiotherapist, his posture was improved and this helps to avoid generate injuries; whether they are severe and / or severe in the short and long term.

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EXPLORATORY STUDY OF THE AEROBIC CAPACITY FOR THE WORK OF ADULTS OVER 35 YEARS OLD, THROUGH A SIX MINUTES WALK TEST

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Resumen: El objetivo del presente trabajo es explorar, a través de la prueba de caminata de 6 minutos (6MWT), la capacidad aeróbica de los trabajadores de 35 años de edad o más, que están o estarán en la etapa intermedia de adulto (> 45 años) o en la edad adulta avanzada (> 65 años) dado que exceder los límites de capacidad aeróbica del trabajador puede causar una serie de efectos adversos, como: disminución del rendimiento en el trabajo, fatiga excesiva, incluido el potencial de lesiones y accidentes, y acompaña a un mayor riesgo de enfermedades cardiovasculares como la angina de pecho, el infarto de miocardio, el accidente cardiovascular o la diabetes, la discapacidad, el desempleo y la jubilación anticipada y, por otro lado, muestran el uso de esta prueba que es de bajo costo, no invasiva y no requiere equipo especial o alto Capacitación del personal, que busca optimizar las condiciones de trabajo o los recursos relacionados con el trabajo bajo para aumentar la posibilidad de permanencia hasta la jubilación o después, como apoyo al trabajador. y la gestión de recursos humanos de las empresas en relación con la fuerza laboral multigeneracional. Para ello, se realizó un trabajo de campo para obtener datos cuantitativos de capacidades aeróbicas (VO2 máx.) Mediante la prueba de seis minutos de caminata (6MWT) y luego se realizó el análisis estadístico comparativo de los datos recopilados comparándolos con la tabla de Mital. et al 1986, que clasifica, por edad y género, el consumo máximo de oxígeno en 5 niveles: bajo, regular, promedio, bueno y alto.

Palabras clave: capacidad aeróbica, VO2max, prueba de caminata seis minutos.

Relevancia para la ergonomía: Contribución a la ergonomía Dentro de las mejoras para apoyar al trabajador a lograr su propia satisfacción, tienen intervenciones ergonómicas prioritarias dedicadas a prevenir riesgos en el área de la salud y la capacidad funcional, en relación con las demandas del trabajo. Esta investigación busca explorar el método de evaluación de la capacidad aeróbica de 6MWT que es una prueba no invasiva que no requiere una infraestructura que normalmente es costosa y solo está disponible en los centros de investigación, es fácil de usar ya que no se requiere personal entrenado para su aplicación Y es de bajo costo.

Abstract: The aim of the present work is to explore, through the 6-minute walk test (6MWT), the aerobic capacity of workers 35 years of age or older, who are or will be in the intermediate adult stage (> 45 years)) or in advanced adulthood (> 65 years) given that exceeding the worker's aerobic capacity limits can cause a series of adverse effects, such as: decreased work performance, excessive fatigue, including the potential for injuries and accidents and it accompanies an increased risk of cardiovascular diseases such as angina pectoris, myocardial infarction, cardiovascular accident or diabetes, generating disability, unemployment and inducing early retirement and, on the other hand, showing the use of this test that is low cost , non-invasive and does not require special equipment or high training of personnel, who seek to optimize working conditions or resources related to the work low to increase the possibility of permanence until the retirement age or beyond, as a support to the worker and the management of human resources of the companies in relation to the multigenerational workforce. For this, field work was done to obtain quantitative data of aerobic capacities (VO2 max) by means of the test six minutes of walking (6MWT) and afterwards the comparative statistical analysis of the collected data was carried out comparing them with the table of Mital et al 1986 who classifies, by age and gender, the maximum consumption of oxygen in 5 levels that are: low, fair, average, good and high.

Keywords: aerobic capacity, VO_2max, walk test six minutes

Relevance for ergonomics: Within the improvements to support the worker to achieve their own satisfaction have priority ergonomic interventions dedicated to preventing risks in the area of health and functional capacity, in relation to the demands of work. This research seeks to explore the 6MWT aerobic capacity assessment method which is a non-invasive test that does not require an infrastructure that is normally expensive and only available in research centers, it is easy to use since they are not required staff trained for its application and is low cost.

1. INTRODUCTION

The capacity for work is a multifaceted and multidetermined construct not only associated with the physical health and psychological well-being of the person, but also with the professional competencies of the subjects, their values, the work environment and the work organization, as well as other factors beyond the workplace as are the overall conditions is of life. (K.H.E. Kroemer , H.B. Kroemer, 2001) wrote in his publication "To unite a person's work capacity with the requirements of a job, it is necessary to know the individual's energy capacity and how much they demand work from this capacity". In addition, he states that "the ability to perform physical work is different from person to person and depends on gender, age, body size, health, environment and motivation." I also write "For the selection of personnel where manual work or other physical demands are required, the use of physical capacity tests is an important resource ". (Balderrama, Ibarra, De La Riva, & López, 2010) points out. "Estimate el VO2 max is considered the most reliable way to determine the aerobic capacity of an individual factor it is useful in the evaluation of cardiorespiratory fitness and has been widely used in athletes, patients and workers while performing physical tasks". Meanwhile (Astrand, P. O., Rodahl, K., Dahl. H.A. & Stromme, 2003) wrote "VO2 is the fraction of oxygen that the muscle consumes while doing work and, being highly correlated with the maximum cardiac output, provides a measure of the maximum output of energy during aerobic processes and the functional capacity of the cardiovascular system " And (Vanhees et al., 2005) notes " The aerobic capacity expressed in VO2 max is one of the parameters that determine the physical condition of the subject, as well as criteria such as coordination, speed and muscle strength **"**

2. OBJECTIVE

This research was performed in order to explore, by testing 6 minute walk (6MWT), aerobic capacity workers 35 years or older, who are or soon will be in the intermediate stage of adulthood (> 45 years) or in advanced adulthood (> 65 years) given that, exceeding the limits of the worker's aerobic capacity can cause a series of adverse effects, such as: decreased work performance, excessive fatigue, including the potential for injuries and accidents and accompanies an increased risk of cardiovascular diseases such as angina pectoris, myocardial infarction , cardiovascular accident or diabetes, generating disability, unemployment and inducing early retirement and, on the other hand, showing To those who seek to optimize working conditions or resources related to work, the use of this method that is low cost, non-invasive, does not require special equipment or high staff training **.**

3. METHODOLOGY

Delimitation: The study was exploratory taking a non-probabilistic sample for convenience of 29 participants of which 14 men and 15 women, the test was applied in the fall season and in an open room at an average ambient temperature of 240 C and average humidity 48%.

Reference frame: The estimation of VO_2 max is considered the most reliable factor to determine the aerobic capacity of a person, it is useful in the assessment of cardiorespiratory fitness and has been widely used in athletes, patients and workers while performing physical tasks. There are innumerable tests that seek to measure or estimate the maximum oxygen consumption as the most valid parameter to identify and analyze the efficiency with which the cardiopulmonary system works. According to (Hartung, Blancq, Lally, & Krock, 1995)) a maximum test is defined by the plateau of VO_2 with additional increases in the workload, (Zeballos & Weisman, 1994) notes "Few are the individuals that reach a True maximum VO_2, and peak values of VO_2 are often incorrectly reported as maximum values". The units in which the maximum oxygen consumption is expressed is ml / (kg-min) and there are two large groups of tests for measuring VO2max, these are: maximum tests and submaximal tests

Maximum tests: (Vanessa Noonan, 2000) expresses "the maximum exercise tests measure or predict the maximum oxygen consumption VO2 and have been accepted as the basis for determining fitness". It also states that "although maximum exercise tests are considered the gold standard for assessing maximal aerobic capacity, these tests are limited for people whose performance may be limited by pain or fatigue in the effort and in cases where the maximum exercise test is contraindicated " (Jones et al., 2017) mention citing Greig et al., 1993 and Huggett et al., 2005, "in older adults the performance in these test protocols may not represent real-life functionality and exercise until the exhaustion is often not achieved". Within these tests are ergoexpirometry tests that use gas exchange measurement equipment, calorimetry tests that quantify the heat produced by aerobic and anaerobic metabolism by measuring the heat exchange between the body and the environment.

Submaximal tests: Vanessa (2000) says "Submaximal tests overcome many limitations of pain or fatigue in effort and in cases where the maximum exercise test is contraindicated; There are two major categories of submaximal tests that are the predictive test and the performance or performance test.

Predictors are used to assess the maximal aerobic capacity. Typically, the heart rate (HR) or oxygen consumption (VO2) 2 or more workloads measured and a value is obtained (VO2) predicted by extrapolating the relationship between HR and (VO2) to the maximum heart rate predicted by age (HRmax).

Performance tests involve measuring responses to standardized physical activities normally found in everyday life for use in clinical decision making and the implications for professional education and research. In these methods, the participant is subjected to a controlled effort such as running at a certain speed or a certain distance, walking for a certain time, going up and down steps, which entails an effort of up to 70% of the maximum pre-established heart rate for the age of the participant and, subsequently, with the obtained data and predetermined equations or tables, the VO2 max is estimated.

In order to explore the aerobic capacity of the workers, the 6-minute walk (6MWT) submaximal performance test was chosen, which is a low-cost, non-invasive test that does not require special equipment or high training personal. This test measures the distance the patient can walk as fast as possible on a flat and hard surface, they choose their own exercise intensity and are allowed to stop and rest during the test because most activities of daily living are performed at submaximal levels of effort, the 6MWD may better reflect the level of functional exercise for daily physical activities (ATS, 2002).

Validity of the 6MWT instrument: According to (Gochicoa-rangel et al., 2015) the 6-minute walk test (6MWT) assesses in an integrated way the response of the respiratory, cardiovascular, metabolic, skeletal muscle and neurosensory systems to stress imposed for the exercise. Functional integration is analyzed by the maximum distance an individual can travel during a six-minute period walking as fast as possible. The 6MWT is a reliable tool in the diagnosis, staging, prognosis and follow-up of individuals with chronic respiratory diseases, however (Burr, Bredin, Faktor, & Warburton, 2011) conducted research to characterize the aerobic demand of 6MWT in a group of adults healthy in working age; and concluded that the method is of moderate to vigorous intensity, and may be useful in the classification of aerobic fitness, which is associated with health outcomes. The inclusion of other patient characteristics significantly increases the predictive value of 6MWT to estimate VO_2 max.

Materials and methods: Procedure for a six-minute walk test.
To each of the participants who met the inclusion criteria that, according to (Arcuri et al., 2016) was not having a cardiac diagnosis, orthopedic, pulmonary, oncological or neurological condition . determined according to dimension 4 of the job skills questionnaire (WAI) from (Tuomi Kaija, IlmarinenJuhani, JankolaAntti, Katajarinne Lea, 1998) previously applied, they were asked to fill out a questionnaire of general data and life habits, in addition, according to (Wu, Sanderson, & Bittner, 2003) they took measures of height and body weight, resting heart rate, as well as SpO2 % blood oxygen saturation by ChoiceMMed digital pulse oximeter model ND300C2. Once these steps were completed, they were read the following statement:

The purpose of this test is to discover how far you can walk in 6 minutes. Start from this point (cone of traffic at the beginning of the track) and follow the path to the next cone (end of the track) and return by the same path repeating the procedure until completing the 6-minute period. Each 2 minutes will tell the remaining time and be told to stop when reach 6 minutes. If you need to stop during this time, please do so, but stay where you are until you can continue. Start test at a pace that you feel could continue for 6 minutes and try to keep that pace. After 6 minutes you will be told: stop; please do it and stay right where it is, in that place it will be taken again the pulse and oxygen saturation in blood. If during the test feel shortness of breath or feel exhausted or experience dizziness or chest pain, stop immediately, okay?

In the same way, the participant is informed that a poster with the Borg scale will be shown to him from time to time and shall indicate the number corresponding to how he feels the sensation of the test effort. (Habibi, E., Dehghan, H., Moghiseh, M., & Hasanzadeh, 2014) used this scale in her work. A charge of the apply the test you will be instructed to monitor the participant for strong cramps in the legs, diaphoresis and pale or ashen appearance. On the other hand, according to (Guyatt et al., 1984) the mood has a significant impact on the distance walked, a standardized stimulus was provided every 2 minutes, with phrases such as "good work, continue" or "You are doing it very all right".

After the test, distance walked was recorded for six minutes with this data, body weight, sex, pulse rate at rest and age of each participant, using the equation created by Burr (2011).

$$VO_2\,\max = 70.161 + 0.023 * d - 0.276 * p - 6.79 * s - 0.193 * fc - 0.191 * y \quad (1)$$

Where
VO_2 max (ml/kg-min)
d is distance walked in the 6MWT test (m)
p is body weight (kg)
s is sex male (0) female (1)
fc is resting heart rate x minute
y is age in years

Statistics of the Characteristics of the participants:

Table 1 age of the participants

gender	average	std dev..	mínimum	Q1	median	Q3	máximum
male	49.50	10.52	35.00	37.75	51.50	55.50	68.00
female	47.55	7.51	36.00	43.00	46.00	52.00	61.00

Table 2 Body weight of the participants

gender	average	std dev	minimum	Q1	median	Q3	maximum
male	94.69	15.24	81.00	84.00	91.00	101.00	137.00
female	78.55	14.10	51.00	69.00	76.00	89.00	102.00

Table 3 Body mass index of the participants

gender	average	std dev.	Mínimum	Q1	Median	Q3	Máximum
male	31.34	4.26	25.28	28.39	30.49	34.18	41.82
female	29.39	4.04	22.07	27.51	28.72	30.80	36.57

4. RESULTS

Table 4 Distance walked on the 6MWT test

gender	average	std dev.	mínimum	Q1	median	Q3	Máximu
Male	492.2	69.3	318.0	454.0	504.0	541.0	580.0
female	439.0	67.1	342.0	369.3	450.5	490.5	540.0

The analysis of data resulting aerobic capacity of the application of the equation Burr (2011) with the information obtained from the 6MWT test of workers, showed the following statistics:

Table 5 Aerobic capacity of the participants

gender	average	std dev.	mínimum	Q1	median	Q3	máximum
Male	31.45	5.97	16.00	29.44	32.76	34.84	40.59
female	26.67	5.39	18.40	23.08	26.50	30.45	37.72

According to the resulting maximum aerobic capacity, each participant was classified according to table 6 of (Mital, A. and Shell, 1986) who classifies the capacity into 5 levels: low, fair, average, good and high , by age and gender.

Table 6 Maximum aerobic capacity ranges according to gender and age

Men maximum oxygen consumption (ml / kg / min)					
age (years)	low	fair	average	goof	high
20-29	<25	25-33	34-42	43-52	53
30-39	<23	23-30	31-33	39-49	49
40-49	<20	20-26	27-35	36-44	45
50-59	<18	18-24	25-33	34-42	43
60-69	<16	16-22	23-30	31-40	41
women maximum oxygen consumption (ml / kg / min)					
20-29	<24	24-30	31-37	38-48	49
30-39	<20	20-27	28-33	34-44	45
40-49	<17	17-23	24-30	31-41	42
50-59	<15	15-20	21-27	28-37	38
60-69	<13	13-17	18-23	24-34	35

source Mital et al, (1986) Work Measurements Principles and practice

The results of the classification, by gender, are shown in graphs 1 and 2 and in graphs 3 and 4 the classification according to the table of Mital (1986) taken the average age of 49 and 47 years

5. Discussion and Conclusions

The distance traveled is within the ranges indicated by (Luna Padrón, Domínguez Flores, Rodríguez Pérez, & Gómez Hernández, 2000) for Normal walk for Mexican population. Regarding aerobic capacity calculated can be seen that the proportion of male participants on average and good level gives us a 92.3% while the woman is 72.7% so it can be concluded that there are two equal populations ($p = 0.182$).

The evaluation of the aerobic capacity of the worker is essential to build work environments more friendly to the worker and with the 6-minute walk method (6MWT) you can make a good approximation to the maximum aerobic capacity and, with the results, situations could be identified where the workers are looking for the way to perform their jobs according to the labor requirements, seeking their own personal satisfaction and implementing support to achieve it and in this way allow the worker to continue working beyond the age of retirement , in this exploration it is detected that there was no presence of participants with high oxygen consumption category that can be the effect of working with small samples .

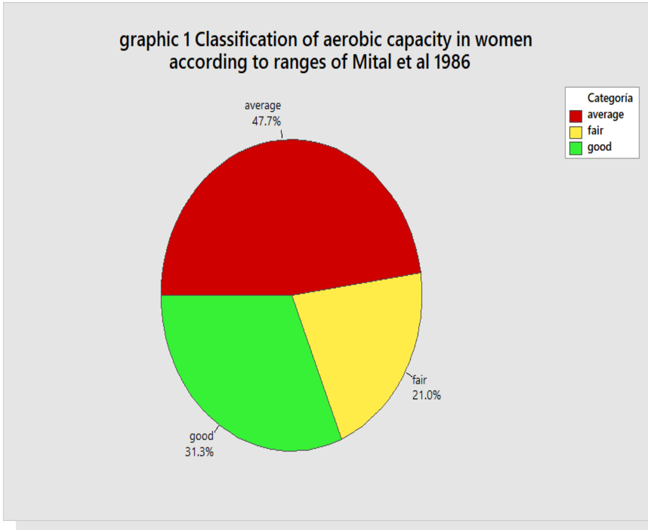

Figure 1

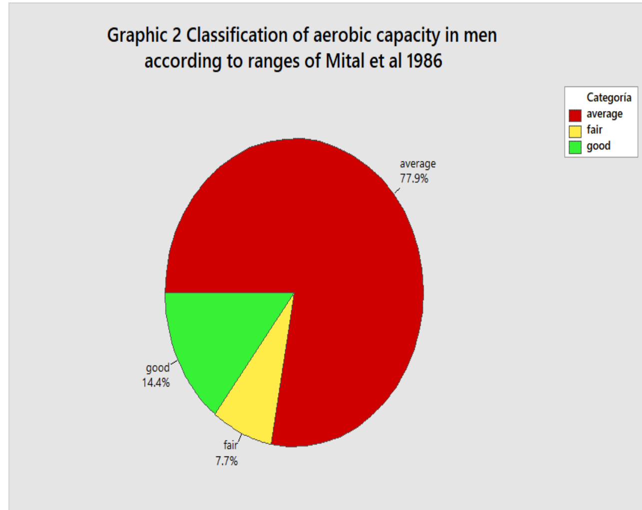

Figure 2

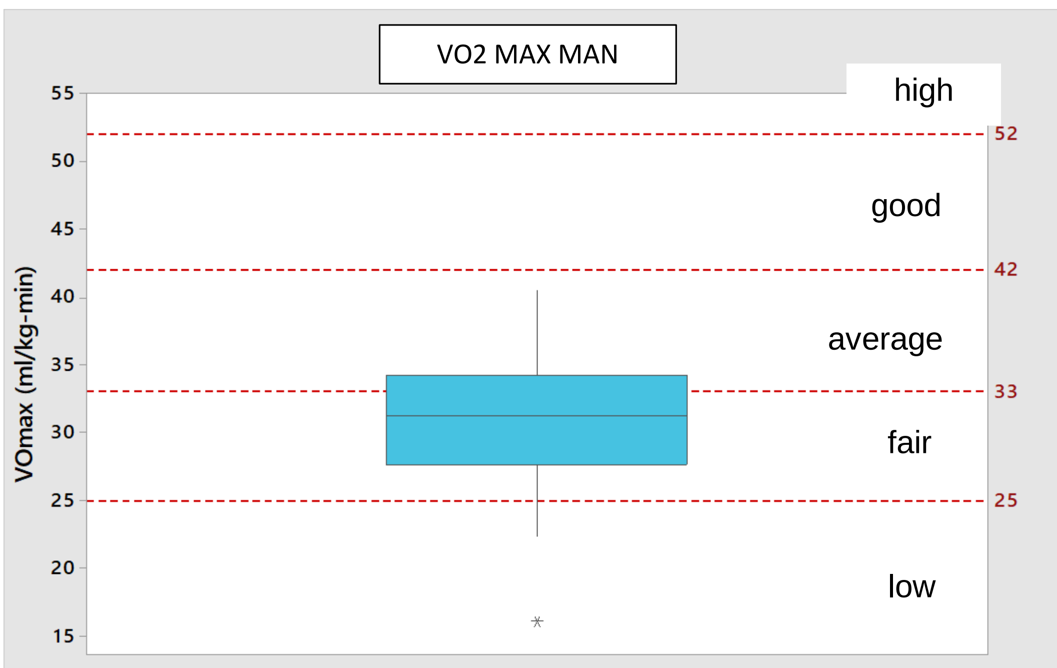

Figure 3

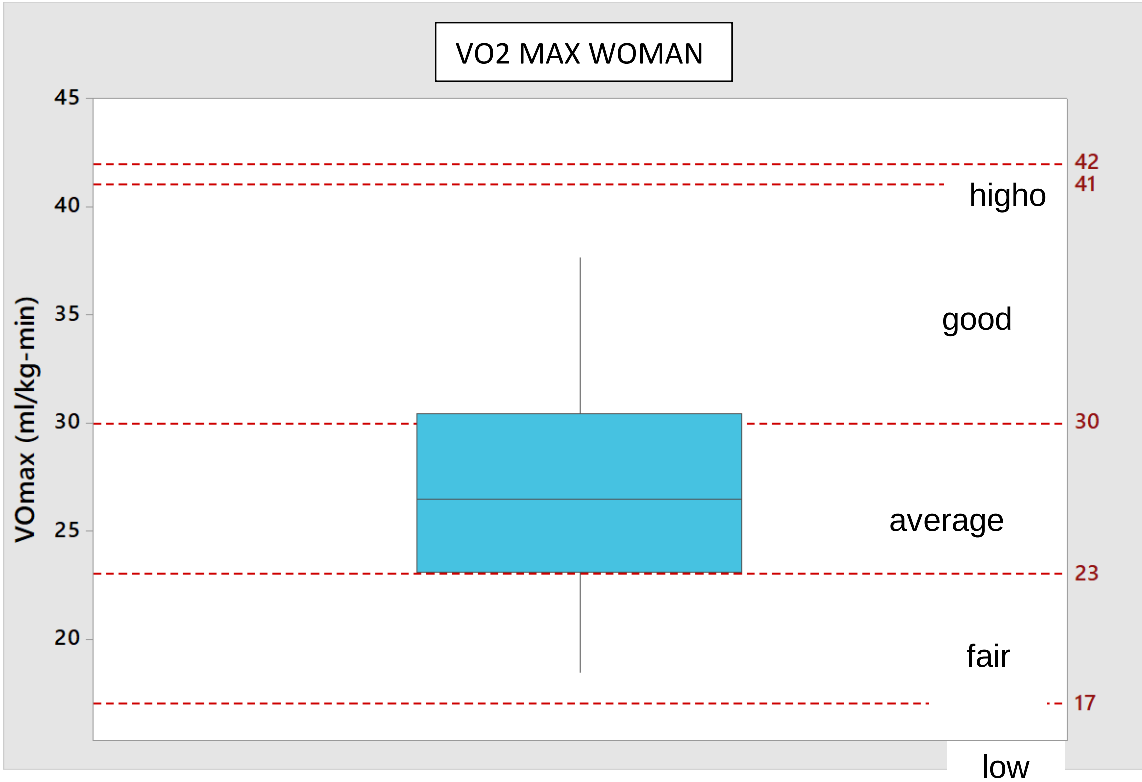

Figure 4

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POSTURAL ANALISYS IN THE DEBOING PROCESS OF CRAB

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Resumen: Dado la importancia de la ergonomía en los puestos de trabajo, se ha realizado un Proyecto de mejoras a la empresa Desarrollo Integral de Jaiba de México S.A. de C.V. Situada en la ciudad de Los Mochis, donde se ha analizado desde el punto de vista ergonómico, el proceso de deshuesado en la planta de empacado, con la finalidad de encontrar soluciones óptimas para que los trabajadores tengan un mejor desempeño al realizar sus actividades; aumentando su eficiencia, seguridad y bienestar; y remediar los problemas disergonómicos que existen en el área de producción. El análisis se realizó con base en el Método REBA en complemento con medición de fatiga y DTA's.

Palabras clave: Fatiga, DTA's, REBA, Evaluación del trabajo

Aportación a la Ergonomía: Detección e identificación de factores que ocasionan las principales lesiones, búsqueda de una mejor salud del trabajador, aumento de productividad debido a mejoras en la estación de trabajo y propuesta de diseño de mesas de trabajo que ayuden a mejorar la postura del trabajador.

Abstract: Given the importance of ergonomics in the jobs, a technical report has been made of the project of improvements to the company "Desarrollo Integral de Jaiba de México S.A. de C.V.", located in Los Mochis city; where it has been analyzed from the ergonomic point of view, the boning process in the packing plant, with the purpose of finding optimal solutions for the workers to have a better performance when carrying out their activities; Increasing their efficiency, safety and well-being; And to remedy the disergonomic problems that exist in the area of production. The analysis was performed based on the method REBA in complement with measurement of fatigue and DTA's.

Keywords: Fatigue, DTA's, REBA, Work area (according to call), Work evaluation

Contribution to Ergonomics: Detection and identification of factors that cause the main injuries, search for a better worker's health, increase in productivity due to improvements in the work station and proposal for the design of work tables that help improve the worker's position.

1. INTRODUCTION.

Currently, ergonomics is a very important issue in the workplace, since companies focus mainly on productivity, and as it is known, this science seeks an adaptation of the environment to man allowing activities to be carried out more efficiently with less effort and increase productivity.

Until a few years ago, working in ergonomics was a task reserved almost exclusively to some companies while the rest wondered if they could afford to assume the costs of applying ergonomics in their jobs and in their organization. Today the landscape has changed, and companies are beginning to consider whether they can bear the costs of not having this type of studies (according to ILO data, Musculoskeletal Disorders represent the first or second cause of work-related illness in all countries, with the social and economic costs that they cause, particularly high).

According to the WHO (World Health Organization) the goal of ergonomics is the prevention of health damage considering this in its three dimensions: physical, mental and social. The application of ergonomic principles tries to adapt and adapt the work systems to the capacities of the people who use them avoiding the appearance of alterations in health that can occur as a result of an excessively high or low workload. (Master)

Taking into account the above, an improvement project has been carried out for the company Integral Development of Jaiba de México S.A. of C.V. located in the city of Los Mochis, where the deboning process in the packing plant has been analyzed from the ergonomic point of view, in order to find optimal solutions for workers to perform better when carrying out their activities (analysis postural); increasing its efficiency, safety and well-being; and remedy ergonomics problems that exist in the production area. the analysis was made based on the REBA Method in addition with fatigue measurement and DTA's.

2. OBJECTIVES.

-Detect the risks of fatigue in workers in the production area of the boning department.

-Identify the positions that can cause possible DTA's.

-Make ergonomic evaluations with the REBA method.

-Propose improvement actions in the packing plant process.

3. METHODOLOGY.

The methodology used for the postural analysis is the REBA method (Rapid entire Body Assessment) with which it is intended to analyze the static position and repetitive actions that generate fatigue to the worker and that in the long run can cause Health problems; The method is developed by dividing the body into segments to encode them individually, with reference to the motion planes: Group A: trunk, neck, legs, group B: arms, forearms, wrists; Which is assigned a score for muscle activity due to postures, includes a gripping variable to evaluate manual handling of loads, with the final score, is known the most common risk that is exposed to the individual associated with Work. (See Figure 1).

Figure 1. Selected posture for REBA evaluation.

4. RESULTS.

The final value provided by the REBA method threw a score of 8 to 10, Level 3, high watering, actuation: As soon as possible, due to the emergence of musculoskeletal disorders by excessive postural load

With the above information, a table was designed for the deboning process in the packing / pasteurization plant in the company Integral Development of Jaiba de México SA de CV with specific measures according to the anthropometric study that was done to work 3 people on each side of the table where it measures 234 cm with a space for each person of 78 cm with a total of 6 people and a person reviewing each table in the part measuring 128 cm with a personal space of 78 cm and 50 cm Of slack for the placement of trays, also the table will have a height of 94 cm to improve the vertical distances in the workspace (See Figure 2).

The above was designed to have a better layout of the space that is needed for the realization of the tasks that are developed in the jobs.

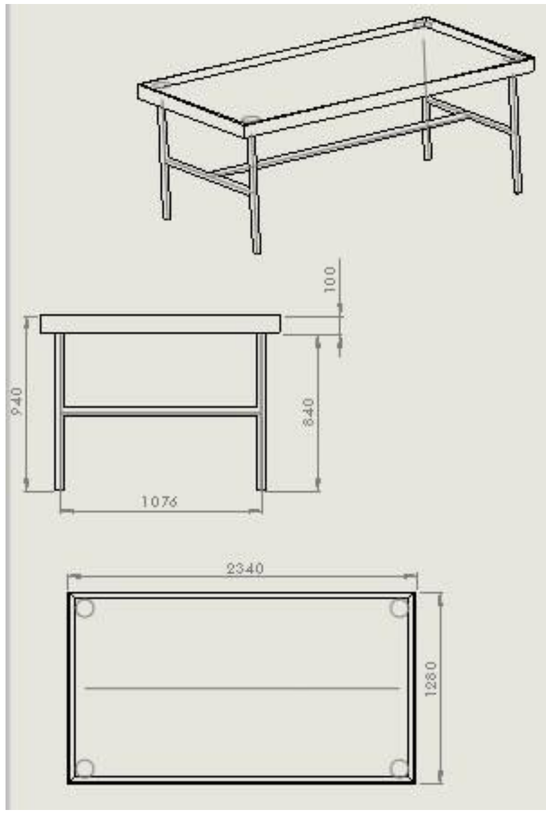

Figure 2 Proposed measurements for the jobs according to the anthropometric study.

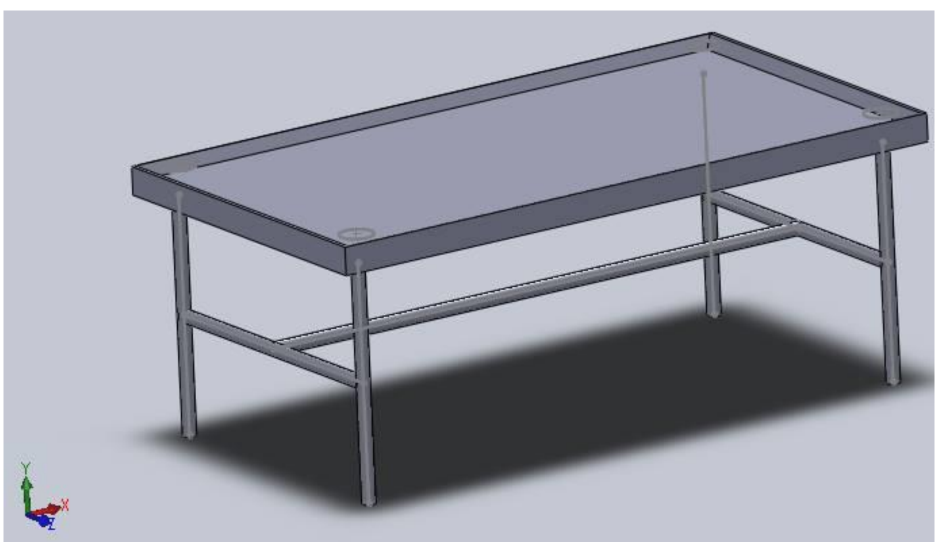

Figure 3 Table designed in Solid Works software.

In order to reduce back and leg pain, it would be appropriate to have an area where there are banks for people who find it more comforting and productive to do their activities in a sitting manner (See Figure 4).

Figure 4 Banks for jobs.

Another element that must be changed is the noise that exists in the workrooms due to the air conditioners, because this can cause:

- Temporary loss of hearing, after leaving work, can take several hours to recover, which can cause social problems, because the worker may find it difficult to hear what other people say.
- Permanent hearing loss, over time, after being exposed to excessive noise for too long, the ears are not recovered and the hearing loss becomes permanent. If a worker begins to lose his hearing, he may first notice a normal chat or other sounds. Often, workers adapt ("get used") to hearing loss caused by harmful noise in the workplace.
- Exposure to noise for a long time decreases coordination and concentration, which increases the possibility of accidents.
- Noise increases tension, which can lead to different health problems, including heart, stomach and nervous disorders. It is suspected that noise is one of the causes of heart disease and stomach ulcers.
- Workers exposed to noise may complain of nervousness, insomnia and fatigue (they feel tired all the time).
- Excessive exposure to noise can also decrease productivity and cause high percentages of absenteeism.

In case of not being able to control the noise that is caused in the halls, you must provide personal protective equipment to the workers to protect them against the risk that threatens their health and safety.

An important aspect to take is the cause of the foot pains of the workers, pain caused by the boots they use to perform their work. They must be lactic safety boots made with PVC compound, a sanitized product, inhibits the proliferation of fungi and bacteria, providing greater hygiene and health to the user. The design has an ergonometric curve that facilitates walking, extra wide and greater interior comfort, with spine that facilitates the mismatch (See Figure 5).

Figure 5. Personal protection boots

5. CONCLUSIONS.

It is undoubtedly vital that the baler be aware of the factors that are putting the health of the worker at risk, as well as being able to put into practice the measures proposed in this material. It is essential that the employee can count on dignified conditions to develop his work, thus promoting physical, mental and social well-being, and as a result it will be possible to have better capacities to develop its activities in and out of the area.

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APPLICATION OF THE RULA METHOD TO OPERATORS USING THE HANDLEBARS OF AN URBAN BICYCLE.

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Resumen: La bicicleta urbana ha sido utiliza aproximadamente desde la época de los 80's como un medio de transporte eficaz y seguro, proporcionando a las personas un fácil acceso a diferentes destinos, sin embargo en la actualidad en la ciudad de Los Mochis, Sinaloa, algunos ciclistas la utilizan grandes periodos de tiempo, por lo tanto la postura que se adopta al tomar en control el manubrio de la bicicleta, puede generar molestias o lesiones, en los codos, muñecas, manos y dedos del operador.

Por lo tanto se propone realizar un análisis de las cuestiones posturales del ciclista, para poder llegar a una conclusión sobre el agarre con el que cuenta el manubrio de la bicicleta urbana, el cual consiste en la aplicación del método RULA y su análisis, para poder identificar el nivel de riesgo presentado, para poder saber el nivel de riesgo a los que están expuestos los ciclistas y las lesiones que se pueden provocar a raíz del contacto con este tipo de manubrios.

Palabras clave: Evaluación ergonómica, Postura, Lesión

Relevancia para la ergonomía: Debido al alto uso de la bicicleta urbana en Los Mochis, Sinaloa, se busca llevar con la ergonomía la conciencia del daño que se puede generar debido a la posición adoptada con el manubrio de la bicicleta utilizado, para generar una propuesta de rediseño ergonómico que se adapte a las necesidades de las personas a las que se aplicó el estudio.

Abstract: The urban bicycle has been used approximately since the 80's as an effective and safe means of transport, providing people easy access to different destinations, however at present in the city of Los Mochis, Sinaloa, some cyclists use it for long periods of time, therefore the position taken when taking control of the handlebars of the bicycle, can cause discomfort or injury, elbows, wrists, hands and fingers of the operator.

It is therefore proposed to carry out an analysis of the cyclist's postural issues, in order to reach a conclusion on the grip of the urban bicycle handlebar, which consists of the application of the RULA method and its analysis, in order to identify the level of risk presented, in order to know the level of risk to which cyclists are exposed and the injuries that can be caused as a result of contact with this type of handlebar.

Key words: Ergonomic evaluation, Posture, Injury.

Relevance to ergonomics: Due to the high use of the urban bicycle in Los Mochis, Sinaloa, we seek to bring to ergonomics the awareness of damage that is general due to the position adopted with the handlebars used, in order to generate an ergonomic redesign proposal that suits the needs of the people to whom the study was applied.

1. INTRODUCTION

According to research conducted by Dr. Nelson Ernesto Poveda Suarez, at the National University of Chimborazo, Riobamba, Ecuador in 2016, was carried out the redesign of static bicycles for the application of sports activity in the gym through the evaluation of postural issues through the method R.U.L.A. (Rapid Upper Limb Assessment) which emphasizes the positions taken at the time of contact with the handlebars of the bicycle. As a result of the application of the above method Dr. Poveda, a result of action level 4 was produced, which indicates that changes in the design of the task and/or work station are necessary. Based on the above, this document presents the evaluation of the use of the urban bicycle handlebars by means of the R.U.L.A postural evaluation method, with the purpose of finding evidence that damage is actually generated due to the posture adopted by the cyclist and what are the damages that can be generated in the short or long term due to contact with the urban bicycle handlebars. Taking into account the results of the applied method, proposals will be made to generate the necessary changes to obtain an ergonomic handlebar that does not cause injuries to the bicycle operator.

Apply the RULA ergonomic assessment method to detect ergonomic risks and musculo-skeletal injuries suffered by the user, in order to avoid or minimize damage to the hands, wrists, elbows and fingers.

1.1 Justification

- Due to the position it is in, shorter people have to lean on their hands, causing pain in their wrists.
- After a long time of riding, it causes blisters.

According to the results obtained it can be inferred that the grip of the urban bicycle if it causes discomfort in the operators, therefore it can generate injuries

3. OBJECTIVES
4.

Apply the RULA ergonomic assessment method to detect ergonomic risks and musculo-skeletal injuries suffered by the user, in order to avoid or minimize damage to the hands, wrists, elbows and fingers.

2.1 Specific objective

- Identify which parts of the body are damaged by the grip of the urban bicycle.
- Determine the appropriate standard of measurement for the redesign of the handlebars.
- Describe the diseases that can be generated.
- Propose ergonomic handlebars redesign if necessary.
- Expose the benefits generated by the use of the ergonomic handlebar redesign of the urban bicycle.

3. DELIMITATION.

This study is specifically aimed at people who constantly use urban bicycles as a means of transport or hobby between the ages of 16 and 35, being a mestizo population in northern Sinaloa.

4. METHODOLOGY

Due to the characteristics of the research that was developed, the inductive method was applied in the search to identify irregularities in the posture that a cyclist adopts when having contact with the handlebars of the urban bicycle, focusing on its grip.

In order to carry out the analysis of these postural questions, a field investigation was carried out by means of a descriptive study; this study was applied to urban bicycle operators of indistinct sex between the ages of 16 and 35 years of age in Los Mochis, Sinaloa. In order to carry out the study, 15 randomly selected cyclists were surveyed and observed, all of whom were constantly exposed to the use of urban bicycles.

The graphs of the questions asked to the cyclists are presented below in order to gather information on the aspects available to the operators and to be able to determine whether they are suitable for research.

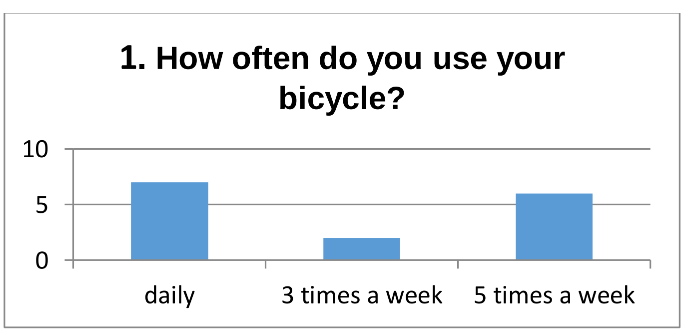

Figure. 1. Results obtained in question 1

The graph shows that of the 15 people surveyed, they are constantly manipulating the handlebars of the urban bicycle.

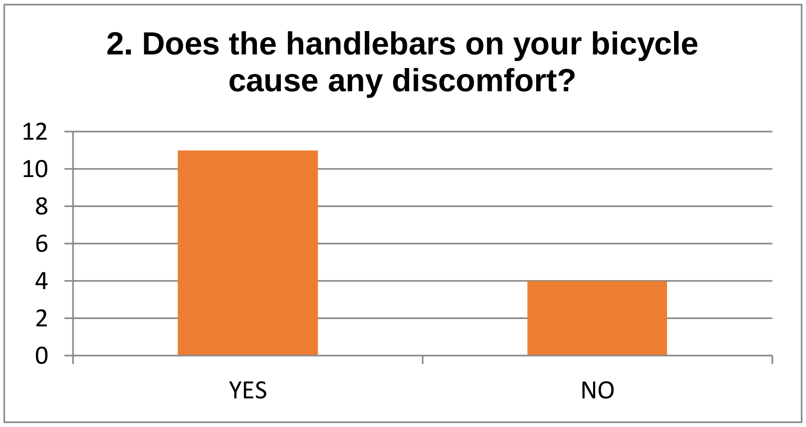

Figure 2. Results obtained in question 2

Derived from the survey applied to the sample of cyclists, it is proposed to carry out a more in-depth study on the postural issues adopted by the cyclist in the elbows, wrists and hands by means of the RULA method, in order to identify which are the aspects and parts of the handlebars that may need a change, or on the other hand to provide the operator with personal protective equipment.

To begin with the study, a field investigation was carried out to collect data by taking photographs in order to observe and document the positions taken at the time of taking control of the handlebars of the urban bicycle, as this activity may involve DTA´S (accumulated trauma disorder), due to the time and effort to which cyclists are exposed for carrying out the activity.

The objective is to study the RULA method by its acronym of Rapid Upper Limb Assessment (Rapid Upper Limb Assessment) in order to evaluate postures by means of points where repetitiveness intervenes and which is both the deviation of the natural position of the human body.

The manufacturers of an ergonomic urban bicycle handlebars must take into account the physical capacities and limits of the parts of the body that interact directly with the body's grip.

The handlebar of the urban bicycle, apart from being in charge of directing the bicycle's trajectory, is in charge of supporting part of the cyclist's weight. It has the following characteristics:

- Brake levers: These are the mobile structures that send the signal for the bicycle's brakes to act.
- Shift levers: These are the mechanism that allows the gear and chainrings of the bike to be modified.

In order to carry out this research, we went to places where this activity carried out by young people and adults is presented, such as the cycle track of the hill of memory and the Technological Institute of Los Mochis; the following activities were carried out:

1. Cyclists were observed while riding the bicycle in order to be able to define with certainty the position they adopt.
2. Capturing postures through photographs and obtaining anthropometric measurements.
3. Apply the Rula method to evaluate the risk of the postures adopted when riding the urban bicycle.

Figure 3. Angle of arm position (GROUP A)

In figure 3. We can see the angle of the position of the arms of the cyclist to take control of the handlebars of the bicycle, is placed in the score 2, but however has the shoulders raised to which is added a point, plus a point by the fact that the arms are detached from the body, gives a total of 4 points.

Fig. 4 Angle of forearm and wrist position (GROUP A)

In figure 4, we observe the position of the forearms and wrists, the forearm is assigned a score of 2, without added points, and for the position of the wrist a score of 2.

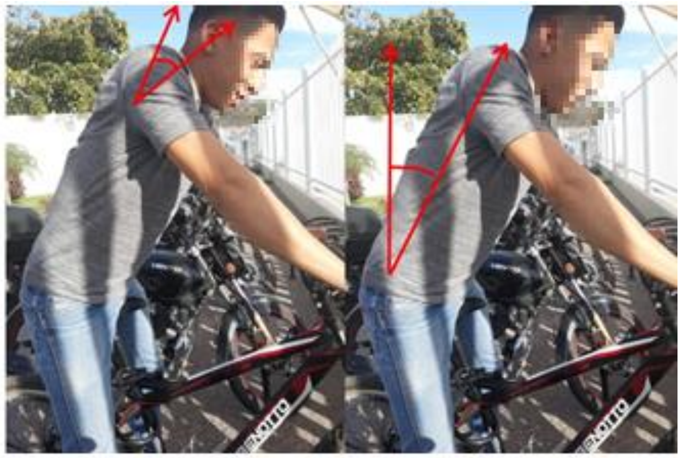

Fig. 5 positions of the neck, trunk and legs (GROUP B)

In figure 5. We can see the angles of the neck, trunk and legs, when you choose the position of the grip of the bicycle. The neck is assigned a score of 3, without any sum of points, the trunk gives us a score of 3, and finally the legs have 2 points.

Since we have the score due to the posture adopted by the operator, repetitiveness and time of exposure to the same posture should be taken into account.

- Add score for muscle utilization.
- Add strength/load score

Finally obtaining for group A a score of 5 points because it normally has a grip greater than 1 minute.

Table 1. Results of group A in the handlebar grip posture

GROUP "A"									
Arm	Forearm	WRIST							
		1		2		3		4	
		WRIST ROTATION		Wrist rotation		Wrist rotation		Wrist rotation	
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table 2 Results of group B in the handlebar grip posture

GRUPO B												
Neck	Trunk.											
	1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

To finish with the analysis of group B, 1 point is also added to this score, for the time of exposure greater than 1 minute, with a total of 6 points in this group.

Table 3. Final Handlebar Grip Posture Score

	CHART F: FINAL SCORE							
	Scoring D (neck, trunk, legs)							
Scoring C (upper limb)		1	2	3	4	5	6	7+
	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8+	5	5	6	7	7	7	7

Table 3 shows the level of risk to which urban bicycle operators are subject.

5. RESULTS

The score obtained according to the information in table 4 which indicates that research and immediate changes in the position of the handlebars of the urban bicycle are required. According to the indications, it is inferred that the posture of this handlebars must be analysed in greater depth, as well as carrying out measurements and analyses with respect to the complexion of the operators and sex, in addition to generating an ergonomic redesign of the handlebars for this type of bicycle.

Table 4. Level of action in the RULA method

Level of risk	RULA score	Action level
1	1-2	Indicates that the posture is acceptable if it is not maintained or repeated over long periods.
2	3-4	Indicates that further research and change may be required.
3	5-6	It indicates that research and change are needed in the short term.
4	7	Indicates that immediate research and change are required.

6. CONCLUSION

The RULA method is a great tool to be able to evaluate the extremities that are in contact with the hand tools, it can be concluded that thanks to this study it was possible to concretize, that as had been well assumed before, the handlebars of the urban bicycle really has to do with the annoyances and injuries that cyclists might have. The method shows that immediate changes must be made, such as a redesign of this one, since otherwise different types of injuries can be generated, such as: epitrocleitis, carpal tunnel syndrome, guyon channel syndrome, quervain tendinitis.

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RULA METHOD EVALUATION IN THE SHRIMP FREEZER

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Resumen: Habiendose extendido por todo la zona costera del estado los ultimos 30 años la labor de trabajo dentro de las congeladoras sinaloenses, este ha sido un tema con bajo nivel de atencion por las personas que trabajan dentro de estas , siendo que dentro de las congeladoras se lleva la manipulacion de distintas especies de camaraon para consumo humano, con largas horas de trabajo ininterrumpidas; no se ha encontrado un registro de estudio sobre estas actividades preguntandose si estas maniobras conllevan un riesgo asociado a su largas y pesadas cargas posturales.

Por lo tanto se propone una evaluación de la carga postural con el método RULA Método RULA (Rapid Upper Limb Assessment) con el objetivo de evaluar la exposición de los trabajadores a factores de riesgo que originan una elevada carga postural y que pueden ocasionar trastornos en los miembros superiores del cuerpo. Para la evaluación del riesgo se consideran el el método la postura adoptada, la duración y frecuencia de ésta y las fuerzas ejercidas cuando se mantiene.

Palabras clave: Evaluacion , Postura, Frecuencia , Lesión, Rula.

Relevancia para la ergonomía: El estudio de evaluación ergonómica se llevó a cabo en una estación de trabajo de una granja camaronera aplicando el método rula, por lo que el campo de estudio se ofrece a la ergonomía una investigación que permite observar la practicidad del método rula en vida real.

Abstract: Having extended by all the coast of the state in the last 30 yearsWork labor in the sinoalenses freezers, this has been a topic with low level of attention of the people working in them, being that inside the freezers the manipulation of difrent species of shrimpfor human consumption, with long hours of work unstopping ; they haven’t found a registry of these activities asking if these movements carry a risk associated with there long and heavy posture loads.

Thus it propose an evaluation of the postual load with the metod RULA (Rapid Upper Limb Assessment) with the objective to evaluate the exposition of the workers and there risk factors the originate a very elevated load and can cause upper body limb disorder. For the evaluation of risk they consider the adapted posture metod, the duration and frecuency of this an the force aplied and maintained.

Key words: Evaluation , Posture, Frecuency , Injury.

Relevance for ergonomics: The ergonomic evaluation study was carried out at a work station of a shrimp farm applying the rula method, which is why the field of study is offered to the ergonomics a research that gives to notice the practicality of the rula method in the real life.

1. INTRODUCTION.

According an article published by RONNY SOTO PARA LN, News of costa rica (www.nacion.com), “shrimp peelers are afraid of losing their job Box investigates the laboral relationship between shrimp and the operators” , 21 of January 2006 1 , ” An investigation of the payment about the dues to the box of security maintains suspended a group of women that are hired by many companies to peel the shrimp, according the portal of the INSTITUTO MEXICANO DEL SEGURO SOCIAL manifest that people dedicate to this work in the freezes don’t receive their health insurance in IMSS , the right of health insurance and medical assistance, the work of the subsistence ways and the social services needed for a weathy individual, the grant of a pension for the workers and their families live with dignity, the work inside the freezers is believed that the workers can suffer of bone disorder as a consequence of the exposition of the long work hours of the same position. Some of these pathologies are considered as professional illness. Basing of this, the present document expons the evaluation of the work with the rula metod for the headless and peeling of the shrimp (labor that causes wounds on the hand), with this they pretend to understand the capability of the damage in relation man- work.

RULA is a method developed to evaluate the exposition to the same postures, forces and muscle activity, it’s also known to contribute to the appearance of disorders and upper muscle arm (McAtamney y Corlett, 1993). In the RULA method, we observe and point out the positions of the body segments, increasing the punctuation by scales that are deviated from the normal posture. The scores are first calculated and separated by arm, upper arm and wrist (group A the trunk, neck and legs group B). These are combined to obtain the final posture.

Additional weight is added to the postures according the mas sor force manipulated and the activity of muscle static and repetitive. Later these scores are combined due actions recommended for a determined posture of RULA will obtain a score from which they will determine a level of action. The level will indicate that the posture is acceptable on which some changes are needed and some redesign of the work place. Definitely, RULA will allow the evaluator detect possible money problems from an excessive weight. (Diego-Mas, Jose Antonio).Postural evaluation maintains the RULA method. Ergonautas, University Politécnica of Valencia, 2015.

2. OBJECTIVE

Evaluate the postures of the workers in that area in the peeling and head removing applying the RULA.

2.1. Specific objectives

- Obtain an objective diagnosis.
- Offer correct postural changes.

3. DELIMITATION

This study is directed specifically to the people in the aquatic sector of the north in Sinaloa, specialized in the head removing, with an age range between 18 a 50, being a population mestizo.

4. METHODOLOGY

According to the author (Fidias G. Arias (2012)), describes: the investigation explorative as it takes place with an unknown topic or not studied , for witch the results are a estimated of that object, meaning that there is a knowledge superficial. (pg.23).
The investigation explores normaly when the object needs to be examined a topic or problema of investigation not so studied, that have many doubts (Hernández et, to 2013 p. 115).

The characteristics of study that have developed are used in the deductive metod 4 for the evaluation that runs under the metod stablished and studied has been developed in 1993 by McAtamney y Corlett, in the University of Nottingham (Institute for Occupational Ergonomics), to determine the RULA posture Will obtain a score that stablished a determined level of action. The level of action indicates the changes needed for the spot. Indeed, RULA

Allows the evaluator detect posible problems and valid for certain cases.
For the evaluation they used the investigation in the zone, taking place a study made with workers of a freezer in sea products, witch principal activity is process, storage and distribution of sea products this company is located in ejido mochis , in Ahome, Sinaloa. For the study they recorded 15 workers, ages between 18 a 50, both sex, being a educational level. Whe the film was made, all of them presented signs of tiredness, due to the activity of there respective work.

4.1 Process description.

The operator is in charge of the operations of the head removing process, this process is made by the following steps:

You need a static movement in front of a table

Take the shrimp with both hands, and with the thumb you look for the opening on the head and body, there you introduce with force your nail then throwing the head away. This process is repeated as many times as needed, Up to 124800 movements in 8 hours, and each hand . It’s an counting realized with a worker in the freezer, study threw 13500 movements in each hand per hour, making Diffrent movements (Reach, Take, Mover, Place, abduction, And let go) which are repeated every two seconds. This involves gloves that bring a better protection to the skin and hands, wich causes a part of the skin to fall causing wounds that are contaminated by the contact of the shrimp that loses acids and generates infections.

Figura 1. Vista frontal del área de trabajo y postura natural de la cabeza.

Figura 2. Medición de ángulo en inclinación

4.2 Group A evaluation

Evaluation Group A

The couting of the arm is obtained by the grade of the extention. For which the angle will be measured formed by the arm and the trunk. Figure 3 shows the different grades of flex/extention considered by the method. The score is obtained by the arm is obtained in the first table.

Evaluacion

Observaciones

Nota: no existe punto de apoyo.

Figure 3. Comparison and evaluation table of group A

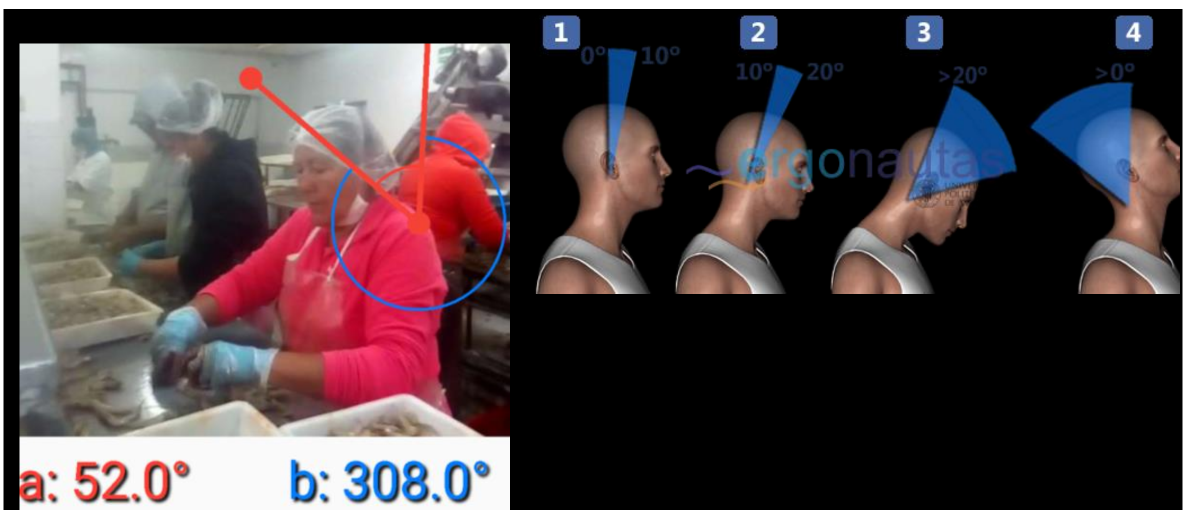
4.3 Group A: analysis of arm, lower arm and wrist.

- Arm score (1-6)
- Forearm score (1-3)
- Wrist score (1-4)
- Wrist twist score (1-2)
- Score of muscle activity type (group a) (0-1)
- Load / force score group a (0-3)

3
1
4
2
1
0

4.4 Group B: analysis of neck, trunk and legs.

The score of group B is obtained by each of the scores of the limbs that make the body.For wich, like the first step the score of the group needs to be obtained by each score



Posición	Puntuación
Cabeza rotada	+1
Cabeza con inclinación lateral	+1

Posición	Puntuación
Flexión entre 0° y 10°	1
Flexión >10° y ≤20°	2
Flexión >20°	3
Extensión en cualquier grado	4

Figure 4. Comparison and evaluation table of group B.

• Neck score (1-6)
• Trunk score (1-6)
• Leg score (1-2)
• Score of muscle activity type (group b) (0-1)
• Load / force score group b (0-3=)

3
1
1
0
0

LEVELS OF DANGER AND ACTION

FINAL SCORE RULA	5
LEVEL OF RISK	3

ACTUATION : IT'S NECESSARY TO MAKE A TEST TO CORRECT THE POSTURE AS SUNE AS POSSIBLE

Figure 5. Result table of the level of risk and action.

SCORE	LEVEL	ACTION
1 O 2	1	ACEPTABLE RISK
3 O 4	2	COULD MANAGE TO MAKE SOME CHANGES
5 O 6	3	REQUIERES SOME CHANGES
7	4	SE REQUIERS IMEDIATE CHANGES ON DUTY

Figure 6. Score table in the action level.

5. Conclusion

Based on the recording and diagramming of the process, the risk of action that the operator made during the execution of the work was more easily identified. A level of risk of 3 was identified, so it is necessary to carry out an in-depth study and correct the position as soon as possible. Based on the busy method, it is verified that the worker is exposed to a high risk of injury due to long working hours and poor postures adopted in this work environment that requires and requires it.

Figure 1 shows front view of the working area and natural posture Figure 2 Reveals the Measurement of angle of inclination of the head, Figure 3. Table of comparison and evaluation of group A. Figure 4. Table of comparison and evaluation of group B , Figure 5. Result table of the level of risk and action. Figure 6. Score table in the action level.

It can be seen that the highest level of risk in group A is the rotation of the wrist with a score of 4 being the highest score.

In group B the part of the body is the most affected since the overload of effort in the neck for the long day is a high risk.

6. Improvement proposal

A proposal is made to improve the work routine.

• It is advised to alternate this position with others that facilitate movement.
• Adapt the height of the table in the work station that is carried out.
• Change the position of the feet to distribute the weight of the body.
• Use a portable or fixed repository.
• Muscle relaxation exercises
• Wear shoes that allow you to easily move the big toes of your feet. A shoe with too narrow or flat toe causes fatigue and pain.
• Use protective gloves for the head of shrimp as a protection.

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EVALUATION OF ERGONOMIC RISKS FOR THE WORK OF THE PHYSIOTHERAPIST IN LOS MOCHIS, SINALOA, MEXICO

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Resumen: La fisioterapia, así como todas las ramas de la salud, debe de tener el uso de conocimientos ergonómicos, pero debido a la poca experiencia laboral o el poco conocimiento sobre el tema, en muchos de los casos, no se implementa de manera correcta y esto puede generar fatiga laboral, hasta lesiones muy graves principalmente en toda el área de la espalda, por movimientos mal hechos.

Se llevó a cabo un estudio detallado sobre cuáles son las principales causas de la fatiga y lesiones musculares en los fisioterapeutas al momento de auxiliar a pacientes y así, se propone implementar el método "Evaluación Rápida de la Extremidad Superior" (RULA) para observar y evaluar cuáles son los trastornos de tipo musculo-esqueléticos en la carga postural al momento de que los auxiliares adoptan posturas inadecuadas de forma repetida en el trabajo, generando fatiga, y a la larga generar problemas de salud. El objetivo de la presente investigación es el siguiente: Evaluar la carga postural desarrollada en fisioterapeutas en el Centro Regional de Rehabilitación Integral (CRRI) Los Mochis, durante el traslado de pacientes a camilla obteniendo 7 en el resultado final en escala de RULA, lo que quiere decir que se necesitan hacer cambios y modificaciones inmediatas en las técnicas y movimientos que usan los profesionistas.

Palabras clave: Fatiga ocupacional, método RULA, fisioterapia

Relevancia para la ergonomía: El objetivo de esta investigación es proporcionar a la ergonomía un estudio completo en el área de la fisioterapia, realizar el método RULA y observar las conclusiones para poder implementar las mejoras en su área de trabajo, con la intención de mejorar la salud del trabajador, así como Mejorar la comodidad del paciente en todas las consultas futuras.

Abstract: Physiotherapy, as well as all branches of health, should have the use of ergonomic knowledge, but due to little work experience or little knowledge on the subject, in many cases, it is not implemented correctly and this can generate work fatigue, even serious injuries, mainly in the entire area of the back, due to incorrect movements.

A detailed study was carried out on what are the main causes of fatigue and muscular injuries in physiotherapists when assisting patients and thus, it is proposed to implement the method "Rapid Assessment of the Upper Extremity" (RULA) to observe and evaluate which are the muscular-skeletal type disorders in the postural load at the moment when the auxiliaries adopt inappropriate postures repeatedly at work, generating fatigue, and in the long run generate health problems. The objective of the present investigation is the following: To evaluate the postural load developed in physiotherapists in the Regional Center of Integral Rehabilitation (CRRI) Los Mochis, during the transfer of patients to the stretcher obtaining 7 in the final result in RULA scale, which it means that changes and immediate modifications are needed in the techniques and movements used by professionals.

Key words: Occupational fatigue, RULA method, Physiotherapy.

Relevance to ergonomics: This research aims to provide ergonomics with a complete study in the area of physiotherapy, performing the RULA method and observing the conclusions to be able to implement the improvements in their area of work, with the intention of improving health of the worker, as well as improving the comfort of the patient in all future consultations.

1. INTRODUCTION

International studies establish that musculoskeletal injuries are very significant among health professionals. Physiotherapists are also exposed to different risk factors that contribute to the development of such injuries, since the nature of their work is repetitive and intensive.

Some of these risks are implicit in the direct treatment of patients as well as all health personnel, and others exclusive of the practice of physiotherapy for the variety of manual techniques used.

These studies have been carried out in different places: Canada, the United States, the United Kingdom, the Netherlands, Kuwait, Australia, Turkey, Nigeria, Israel and Sweden.

As explained by (Diego Mas, 2015) there are several methods that allow the assessment of the risk related to the postural load, these differ in the way they are applied, in how they are evaluated individually or by groups of postures.

One of the observational methods to evaluate postures is the so-called Rapid Assessment of the Upper Extremity, better known by the RULA Method, it is one of the most effective methods, since by these means the observation of the reliable information is obtained about the postural load.

The RULA method was developed at the University of Nottingham:

... in 1993 by McAtamney and Corlett, of the University of Nottingham (Institute for Occupational Ergonomics), with the objective of evaluating the exposure of workers to risk factors that cause a high postural load and that can cause disorders in the upper limbs of the body. For the evaluation of the risk, the method, the position adopted the duration and frequency of this and the forces are considered (Diego Mas, 2015).

The measurements to be made on the positions taken by the worker are in respect to angles, these measurements can be made directly on the worker by means of protractors or any device that allows the taking of angular data. It is also possible to use photographs of the worker adopting the posture studied and measure the angles on them. If photographs are used it is necessary to make a sufficient number of shots from different points of view.

The Level of Action will indicate if the position is acceptable or to what extent the changes or redesigns in the position are necessary. In short, RULA allows the evaluator to detect possible ergonomic problems derived from an excessive postural load.

1.1 Justification

The OMS (Organización Mundial de la Salud - World Health Organization) designated the period from 2001 to 2010 as the bone and joint Decade, so that discussions and revisions are carried out on topics related to work and daily activities that affect the neuron musculoskeletal system.

In the OMS International Classification of Diseases (CID-10), the ailments known as Repetitive Strain Injuries (LERT), Work Related Musculoskeletal Disorders (WRMSDs) or Work-Related Osteomuscular Dysfunctions (DORT) are not considered as such, although international studies establish that musculoskeletal injuries are very significant among health professionals.

However, physiotherapists are equally exposed to different risk factors that contribute to the development of such injuries, since the nature of their work is repetitive and intensive.

Some of these risks implicit in the direct treatment of patients as all health personnel, and others exclusive of the practice of physiotherapy for the variety of manual techniques used.

These studies have been carried out in different places: Canada, the United States, the United Kingdom, the Netherlands, Kuwait, Australia, Turkey, Nigeria, Israel and Sweden.

Therefore, a proposal for the implementation of the RULA method and improvements in an office in the physiotherapy area are created to reduce injuries and improve the occupational health of the physiotherapist.

1.2 Delimitation

This study was carried out with a physiotherapist from the Regional Center for Integral Rehabilitation (CRRI) Los Mochis, specialized in supporting patients with different abilities and in the physical rehabilitation treatment of minor and / or severe injuries.

2 OBJECTIVE

Evaluate the postural load developed in the physiotherapy, in the CRRI (Regional Center of Integral Rehabilitation, Los Mochis, during transfer of electric stretcher to chair.

2.1. Specific objectives

- Identify the causes of the physiotherapist's inadequate postures when helping patients (mostly when moving from a stretcher to a wheelchair or from a wheelchair to a stretcher).
- Analyze the patient's management of the physiotherapist in the transfer of patients from stretcher to chair with the RULA method.
- Implement the "RULA" method to the physiotherapist in the management of patients.

3. METHODOLOGY

It is a mixed research since it is "... an approach that presents several perspectives to be used. The Mixed Method is the systematic integration of quantitative and qualitative methods in a single study in order to obtain a more complete picture of the phenomenon "(Cedeño Viteri, Narcisa, 2012, page 19) since two types of research were used: quantitative and qualitative, since these investigations provided more information when evaluating the management of patients performed by physiotherapists.

Since an interview and field research were applied, at the CRRI facilities, the maneuvers performed with the patients were observed and videos were taken; In addition, quantitative indicators were obtained when applying the RULA method, "it is one of the observational methods for the evaluation of postures that is more widespread in practice" (Diego Mas, Josè Antonio, 2015) and it is because the "... approach to quantitative data is carried out" it is statistical, demonstrates with the separate aspects of its whole, to which numerical meaning is assigned and makes inferences "(Cedeño Viteri, Narcisa, 2012, page 21) and these data are obtained with the RULA method since the partial and final scores of the method to determine the existence of risks and establish the Level of Action.

2.1. Process description:

The procedure to apply the RULA method according to what it suggests (Diego Mas, Josè Antonio, 2015) can be summarized in the following steps:

1. "Determine the work cycles and observe the worker during several of these cycles. If the cycle is very long or there are no cycles, evaluations can be made at regular intervals. "

Here it was observed that depending on how serious the patient's case is, the times in which the physiotherapist assists in lifting the patient can vary.

2. "Select the positions that will be evaluated. Those that, a priori, supposes a greater postural load either because of their duration, because of their frequency or because they present a greater deviation from the neutral position will be selected".

Here, the position was chosen at the moment when the physiotherapist folded his body slightly in order to have a greater reach of the patient and also the position taken when grasping the patient in order to apply force.

3. "Determine if the left or right side of the body will be evaluated. In case of doubt, both sides will be analyzed. "

In this step we chose the side where the greatest availability is in the office.

4. "Take the required angular data. Photographs and / or videos can be taken from the appropriate points of view to make the measurements. "

Video and photos of different angles with real size were taken so that this does not affect when taking into account the angles and postures.

5. "Determine the scores for each part of the body. Using the table corresponding to each member. "

The table of each part of the body was taken into account by groups.

6. "Obtain the partial and final scores of the method to determine the existence of risks and establish the Level of Action."

This step is essential to correctly count the score to know if the movements and postures are ergonomically appropriate.

7. "If required, determine what type of measures should be adopted. Review the scores of the different parts of the body to determine where corrections are necessary. "

Analyzing the scores thrown by the method, it is observed that the parts of the body where it causes a greater impact of load are, back, low back, legs and arms. Due to this, corrective measures and changes are taken at the moment of performing the action.

8. "Redesign the position or introduce changes to improve the position if necessary."

The change implemented is as follows:

The physiotherapist stands facing the patient with one foot closest to the chair in front of the other, the patient places his arms on the shoulders of the physiotherapist, the patient places his feet on the floor, and the physiotherapist fixes with his knee the knee of the patient. Patient must not bend it. The therapist rotates together with the patient, and once placed in front of the chair, flexes the knees as he moves down to the chair.

9. "In case of having introduced changes, reassess the position with the RULA method to check the effectiveness of the improvement."

In the study and evaluation that was carried out using the RULA method at the moment the physiotherapist helped transfer a patient from the stretcher to a chair, we observed all the movements and efforts that are made at the time of making these movements, which are the following:

The physiotherapist's knees are slightly bent to have a better low reach of the patient, the patient is taken depending on which area is the most appropriate or the one that is not damaged, force is applied to sit the patient and then help him to stop and finally help him to sit in the wheelchair or on the appropriate surface type according to the case.

4. RESULTS

The application of the RULA method was developed when assessing the risk of exposure of physiotherapists to factors that cause a high postural load, considering the position adopted the duration and frequency of this and the forces exerted when it is maintained.

For a certain RULA position, a score was obtained from which a certain Level of Action was established. The Level of Action indicates whether the position is acceptable or to what extent changes or redesigns are necessary in the position.

The transfer or movement of a patient on an electric stretcher to a chair was analyzed.

• Results: Group A. Superior members

Figure 1. *Physiotherapist lifting patient*
Source. *Own elaboration*

When measuring the angle formed by the axis of the arm and the axis of the trunk should be between 20 ° - 45 ° and abducted arm. The angle of flexion, measured as the angle formed by the axis of the forearm and the axis of the arm between 60 ° - 100 °, the arm leaves the line of the body. The flexion / extension angle measured from the neutral position is 0 ° - 15 ° which does not add value and the wrist is in the middle range of rotation. The posture is mainly static so no value is added; it has a load of> 10 kg.

Final score, group A is: **6**.

• Results: Group B. The legs, trunk and neck.

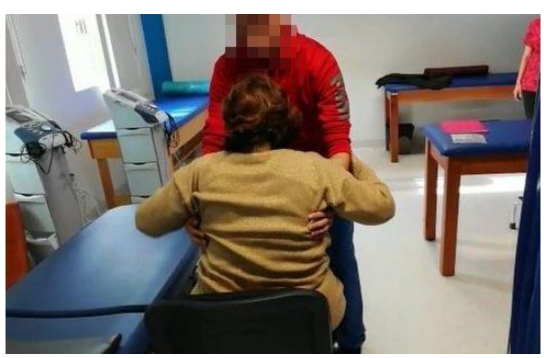

Figure 2. *Physiotherapist sitting patient*
Source. *Own elaboration*

The flexion / extension measured by the angle formed by the axis of the head and trunk axis observed in the physiotherapist is at 10 ° - 20 °, with lateral inclination. The flexion angle of the trunk measured by the angle between the axis of the trunk and the observed vertical is 20 ° - 60 °. The legs and feet are supported and balanced in movement.

Giving all these specifications the following results:

Neck: 3
Trunk: 3
Legs: 1

Final postural score B: **4**

Entering the final table, the score of group A (6) and group B (4) in the final table (Table C). We obtain a result 7 (study and modify immediately) according to the implemented method. It is observed that the parts of the body where it causes a greater load impact are: back, lower back, legs and arms. Due to this, corrective measures and changes are taken at the moment of performing the action. In short, RULA allowed the evaluator to detect possible ergonomic problems derived from an excessive postural load.

	1	**2**	**3**	**4**	**5**	**6**	**7+**
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Table 1. *Results table C.*
Source: *With data from (Diego Mas, Josè Antonio, 2015)*

Table 1 shows the final result obtained**: 7**, Study and modify immediately.

4. CONCLUSIONS

Observing the results and the final scores obtained by the applied method, it can be concluded that it is necessary to immediately modify the method that is used by the physiotherapists when performing their work, this allowed to implement improvements and ergonomic strategies by means of suggestions to avoid bad habits postures and repetitive movements in the work of the specialist, seeking to take care of the health of both the physiotherapist and the patients.

To obtain the necessary information in the workplace, observations were made of the physiotherapist at the time of attending patients, focusing mainly on the movements involved in moving a patient from a stretcher to a chair. Likewise, an interview was conducted, which was very helpful because through the answers we were given the necessary information of the fatigue and injuries that the specialist had after a certain time providing the service and thus make sure to make the decisions and implement the appropriate improvements to ensure the integrity of all involved.

Analyzing the scores thrown by the method, it was observed that the parts of the body where it causes the greatest load impact are: back, lower back, legs and arms. Due to this, corrective measures and changes are taken at the moment of performing the action.

The contribution of suggestions and information for the improvement of the work of a physiotherapist was considered of great help by means of the results obtained from the implementation of the RULA method, since fatigue decreased in the physiotherapist, his posture was improved and this helps to avoid generate injuries; whether they are severe and / or severe in the short and long term.

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THE BURNOUT SYNDROME IN INTERNAL UNDERGRADUATE DOCTORS IN THE GENERAL HOSPITAL OF LOS MOCHIS, SINALOA.

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Resumen: El Síndrome de Burnout, es un trastorno emocional de creación reciente que está vinculado con el ámbito laboral, el estrés causado por el trabajo escolar y el estilo de vida del estudiante en general, en este caso de medicina.

Es óptimo realizar estudios para identificar dichos síntomas e implementar medidas preventivas, garantizando un mejor plan de vida para estos.

Este artículo está enfocado en la determinación de su presencia en los Médicos Internos de Pregrado (MIP) del hospital general de Los Mochis, Sinaloa, los cuales realizan jornadas laborales que van desde las 12 hasta las 36 horas continuas. Esto mediante la aplicación de la encuesta Maslach Burnout Inventory (MBI).

Palabras clave: Estrés, Síndrome de Burnout (SB), Fatiga

Relevancia para la ergonomía: Conocer y desarrollar estudios de este tipo tiene grandes contribuciones en la rama de salud de la ergonomía, porque son casos existentes que se viven y se conocen, por lo que la ergonomía busca erradicar los trabajos que pueden afectar la salud del trabajador. Esta disciplina analiza las interacciones del trabajador con la actividad que desarrolla a través del medio en el que lo realiza, y si el trabajador (en este caso, el estudiante) sufre estrés y otros síntomas de SB, no puede tener una buena eficiencia ni adquirir conocimientos útiles en tu área.

Abstract: Burnout Syndrome is a newly created emotional disorder that is linked to the workplace, the stress caused by school work and the lifestyle of the student in general, in this case of medicine. It is optimal to conduct studies to identify these symptoms and implement preventive measures, ensuring a better life plan for them. This article focuses on the determination of their presence in the Internal Doctors of Undergraduate (IDU) of the General Hospital of Los Mochis, Sinaloa, which carry out working hours ranging from 12 to 36 continuous hours. This by applying the Maslach Burnout Inventory (MBI) survey.

Keywords: Stress, Burnout Syndrome (BS), fatigue.

Relevance for ergonomics: Knowing and developing studies of this type has great contributions in the health branch of ergonomics, because they are existing cases that are lived and known, so ergonomics seeks to eradicate jobs that may affect the health of the worker. This discipline analyzes the interactions of the worker with the activity he develops through the medium in which he carries it out, and if the worker (in this case student) suffers stress and other symptoms of BS, you cannot have good efficiency or gain useful knowledge in your area.

1. INTRODUCTION

Burnout Syndrome, which is the relationship with mental health problems that cause negative effects on patient care, low identification with the institution, academic failure and suicide attempts, has an impact on both psychological and labour efficiency. The study decided to carry out (survey) shows prevalences close to or higher than 50% of people who have emotional exhaustion and depersonalization, becoming already considered an epidemic.

1.1 Justification

The term burnout first appeared in 1974, in the United States, when it was used by the psychoanalyst Herbert J. Freudenberger, who observed that, a year after working, most of the volunteers suffered a progressive loss of energy, up to exhaustion, symptoms of anxiety and depression, work desmotivation and aggressiveness with patients.
(Freudenberg, 1974).

2. OBJECTIVE

Detecting Burnout Syndrome in Undergraduate Internal Doctors (MIP) by applying the Maslach Burnout Inventory (MBI) survey, to determine which of the three branches of this syndrome is most present in these.

2.1. Specific objective

- To determine the presence of burnout syndrome in PIMs in the General Hospital of Los Mochis, Sinaloa.
- Analyze the branches that make up this syndrome and its relation to the work of MIPs

2.2. Delimitation

This data collection process (surveys) is aimed at the Los Mochis IDU working at the General Hospital.

3. METHODOLOGY

The explanatory method was used for the corresponding investigation of Burnout Syndrome, mainly in the area of health, in this case it will concentrate on IDU as they are subjected to long working hours and a lot of stress. A representative sample of 30 of them was extracted from a total of 80 IDU for the study of this syndrome. The survey (MBI) was carried out to establish a standard given by this same survey and to identify the IDU suffering from this syndrome and which of its subscales is most prevalent. The results were obtained at the general hospital in the city of Los Mochis, Sinaloa, and a survey was carried out. IDU of both sexes were found between 23 and 30 years of age, with working hours of up to 36.

2.1 Process description

This test aims to measure the frequency and intensity of Burnout. Measure the 3 aspects of Burnout Syndrome:
Subscale: Ordered succession of values of the same quality
1. Subscale of exhaustion or emotional exhaustion.
2. Subscale of depersonalization.
3. Subscale of personal realization.

Table1. Cutting points of the Maslach scale

Dimention evaluated	Low grade	Medium grade	High grade
Emotional fatigue	<19	19-26	>26
Despersonalization	<6	6-9	>9
Personal realization	<34	34-39	>39

CUESTIONARIO BURNOUT
Señale el número que crea oportuno sobre la frecuencia con que siente los enunciados:
0= NUNCA.
1= POCAS VECES AL AÑO.
2= UNA VEZ AL MES O MENOS.
3= UNAS POCAS VECES AL MES.
4= UNA VEZ A LA SEMANA.
5= UNAS POCAS VECES A LA SEMANA.
6= TODOS LOS DÍAS.

1	Me siento emocionalmente agotado/a por mi trabajo.	
2	Me siento cansado al final de la jornada de trabajo.	
3	Cuando me levanto por la mañana y me enfrento a otra jornada de trabajo me siento fatigado.	
4	Tengo facilidad para comprender como se sienten mis alumnos/as.	
5	Creo que estoy tratando a algunos alumnos/as como si fueran objetos impersonales.	
6	Siento que trabajar todo el día con alumnos/as supone un gran esfuerzo y me cansa.	
7	Creo que trato con mucha eficacia los problemas de mis alumnos/as.	
8	Siento que mi trabajo me está desgastando. Me siento quemado por mi trabajo.	
9	Creo que con mi trabajo estoy influyendo positivamente en la vida de mis alumnos/as.	
10	Me he vuelto más insensible con la gente desde que ejerzo la profesión docente.	
11	Pienso que este trabajo me está endureciendo emocionalmente.	
12	Me siento con mucha energía en mi trabajo.	
13	Me siento frustrado/a en mi trabajo.	
14	Creo que trabajo demasiado.	
15	No me preocupa realmente lo que les ocurra a algunos de mis alumnos/as.	
16	Trabajar directamente con alumnos/as me produce estrés.	
17	Siento que puedo crear con facilidad un clima agradable con mis alumnos/as.	
18	Me siento motivado después de trabajar en contacto con alumnos/as.	
19	Creo que consigo muchas cosas valiosas en este trabajo.	
20	Me siento acabado en mi trabajo, al límite de mis posibilidades.	
21	En mi trabajo trato los problemas emocionalmente con mucha calma.	
22	Creo que los alumnos/as me culpan de algunos de sus problemas.	

Figure 1. Burnout Questionnaire

Table 2. Answers Interpretation

Adding the answers obtained as follows			
Evaluated aspect	**Evaluated questions**	**Obtained value**	**Burnout's indications**
Emotional fatigue	1−2−3−6−8−13−14−16−20		More than 26
Despersonalization	5−10−11−15−22		More than 9
Personal realization	4−7−9−12−17−18−19−21		Less than 34

Application of the questionnaire to IDU:

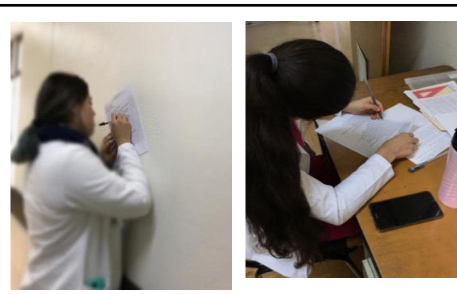

Figure 2. Questionnaire aplication

Table 2. Emotional fatigue subscale

EMOTIONAL FATIGUE		
11	30	10
30	34	25
41	22	35
48	15	13
21	32	22
37	17	38
29	44	48
49	42	41
16	28	29
37	34	25

Table 2.shows the results obtained on the basis of the questionnaire with it parameter of emotional fatigue (questions 1 2 3 6 8 13 14 16 20), if the sum of each questionnaire in such questions exceeds 26 points, (can be seen in red), this means that they present high signs of BS in the aspect of emotional fatigue. **19 IDU showing signs of emotional wear, representing 63.33%.**

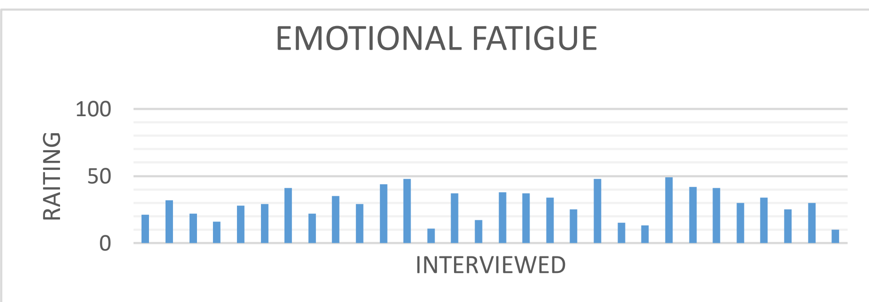

Figure 3. Variation of each interviewee's responses to emotional fatigue

Table 3 shows the results obtained on the basis of the questionnaire with it depersonalization parameter (questions 5 10 11 15 22), if the sum of each questionnaire in such questions exceeds 9 points, (can be seen in red) This means that they present high indications of BS. **18 IDU showing signs of depersonalization, representing 60%**

Table 3. Despersonalization subscale

DESPERSONALIZATION		
14	12	16
4	24	11
6	21	8
2	4	1
19	17	6
22	19	11
11	15	13
0	12	0
7	24	7
2	19	24

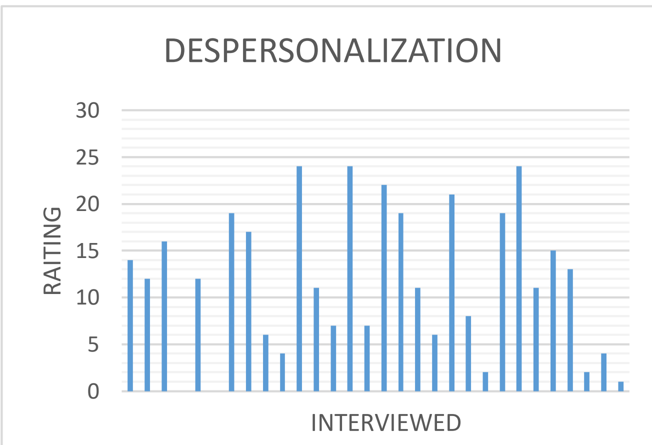

Figure 4 Variation of each interviewee's responses to Despersonalization

Table 4 shows the results obtained on the basis of the questionnaire with it personal performance parameter (questions 4 7 9 12 17 19 21), if the sum of each questionnaire in such questions is below 34 points, (can be seen in red), this means that they present high signs of BS in the aspect of personal fulfillment. **4 IDU showing evidence of low personal performance, representing 13.33%**

Table 4. Personal realization subscale

PERSONAL REALIZATION		
24	38	37
37	32	38
32	40	47
35	47	46
38	38	43
43	43	38
48	44	42
38	35	36
42	32	36
39	47	46

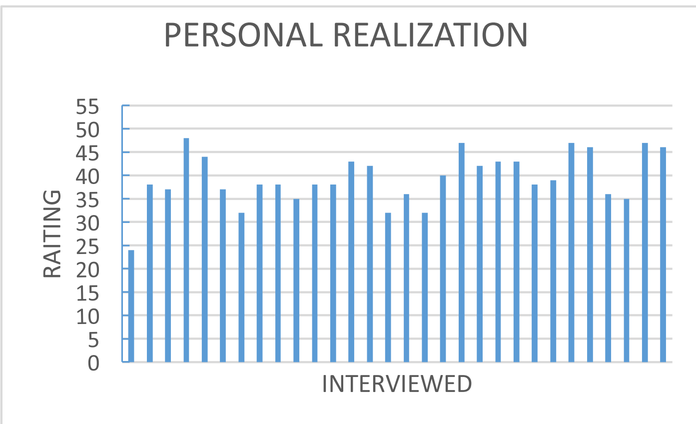

Figure 5 Variation of each interviewee's responses to Personal realization

Table 5. Total aspects

Evaluated aspects	IDU with indications	Percentage
Emotional fatigue	19	63.33%
Despersonalization	18	60%
Personal realization	4	13.33%

Interpretation of subscales:
DESPERSONALIZATION
Development of negative feelings, attitudes and feelings of cynicism towards the people targeted for work.
PERSONAL REALIZATION

A low personal Achievement is the tendency of workers to evaluate negatively and to present negative responses towards themselves and work.
EMOTIONAL FATIGUE
It is the progressive loss of energy or the exhaustion of own emotional resources, besides the presence of tiredness, weariness and fatigue.

4. RESULTS

Thanks to the percentages released from the questionnaire, we conclude that 63% of IDU suffer from emotional wear, 60% depersonalization and 13.33% have a low personal performance. Both physical and emotional wear and tear impacts on the performance of your work, treatment, and the acquisition of new knowledge and skills.

5. CONCLUSION

By obtaining the highest index in the aspect of emotional attrition, we can infer that most IDU feel exhausted and fatigued from their daily activities, in addition to developing tiredness and fatigue, even during the application of the questionnaire, comments on the diagnosis of anxiety were made in some of them as shown in Table 5.

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IMPORTANCE OF THE APPLICATION OF ERGONOMICS IN EDUCATION TO INCREASE SCHOOL PRODUCTIVITY

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Resumen: Actualmente, el trabajar en una institución pública y realizar actividades escolares como tomar clases, impartir clases y realizar actividades administrativas puede significar cansancio así como; problemas musculares, lesiones físicas o psíquicas, fatiga mental, estrés, ansiedad, debido a que muchas veces los mesa bancos, sillas o asientos no están diseñados de una manera correcta por lo cual, la investigación se lleva a cabo en el análisis de los factores que hacen que no se llegue a tener una buena productividad debido a que no se tiene las áreas de trabajo adecuadas en las instituciones públicas educativas, en este caso en UABC(Universidad Autónoma de Baja California) en FIM(Facultad de Ingeniería Campus Mexicali).

Por lo tanto se pretende analizar la distribución del área de trabajo de los usuarios de la institución de educación superior para garantizar reducción de lesiones y aumentar el número de usuarios motivados, mayor productividad y mejor calidad en las actividades diarias escolares así como, demostrar que mejorando el área de trabajo y aplicando la ergonomía, se puede mejorar el objetivo que se tiene en las instituciones públicas educativas. Para esto se realizaron encuestas a los usuarios para ver cómo se ven afectadas por los factores que involucran no tener un área de trabajo inadecuada, para posteriormente realizar un análisis cualitativo y cuantitativo de la importancia de aplicar la ergonomía en el sector público educativo para incrementar la productividad de los usuarios de UABC.

Palabras clave: Salud, Aula, Ergonomía

Relevancia para la Ergonomía: es necesario y esencial implementar la ergonomía en el aula para evitar lesiones musculares debido a la mala postura y el diseño de mesas, sillas y escritorios. Para ello, el usuario debe sentarse con su espalda recta y unida al respaldo, los pies deben alcanzar el piso y, si no se alcanza, se recomienda el uso de un reposapiés. De acuerdo con los resultados, debe tomar notas con la espalda ligeramente inclinada y con la cabeza recta. Además, la altura de las mesas y los escritorios debe estar a la altura de los codos para que los usuarios de la institución pública estén en un área de trabajo que se adapte a sus necesidades. Es importante que el artículo se publique porque es preocupante que los usuarios de instituciones educativas públicas puedan sufrir consecuencias a largo plazo debido a que no están en las condiciones ergonómicas adecuadas.

Abstract: Currently, working in a public institution and performing school activities such as taking and teaching classes while conducting administrative activities can mean fatigue, as well as, muscular problems, physical or psychic injuries, mental fatigue, stress, anxiety, because many times the desks, chairs or seats are not designed in a correct way. So, the research carried out analyses factors that may cause lousy productivity because of the lack of adequate work areas in public educational institutions, in this case of the Facultad de Ingeniería Campus Mexicali in the Universidad Autónoma de Baja California)

Therefore, it is intended to analyze the distribution of the work area for the users of a higher education institution. To ensure injury reduction and increase the number of motivated users, higher productivity and better quality in daily school activities as well as to demonstrate that improving the working area by ergonomics can finally improve objectives that in public educational institutions. For this, user surveys were conducted to see how they are affected by the factors that involve not having an adequate work area, to perform a qualitative and quantitative analysis of the importance of applying ergonomics in the public education sector to increase the productivity of students from the Universidad Autónoma de Baja California.

Keywords: Health, Classroom Ergonomics

Relevance to Ergonomics: It is necessary and essential to implement ergonomics in the classroom to avoid muscular injuries due to poor posture and tables, chairs and desks design. For this the user should sit with its back straight and attached to the backrest, the feet must reach the floor and if not reached the use of a footrest is recommended. According to the results, you must take notes with the back slightly inclined and with the head straight. Also, the height of the tables and desks must be up to the elbows so that precisely the users of the public institution are in a work area that is adapted to their needs. It is important for the article to be published because it is worrisome that users of public educational institutions may suffer long-term consequences due to not being in the appropriate ergonomic conditions.

1. INTRODUCTION

Working in a public educational institution and also doing school activities such as taking classes, can mean fatigue and muscle problems, physical or mental injuries, mental fatigue, stress, anxiety. Because many times the table benches, chairs or seats are not designed in the correct way, that is, manufactured ergonomically, which is a factor that prevents progress to its maximum potential and not having an excellent productivity, as a result of not having quality in the activities carried out by the teacher, administrative or students. Therefore, this arouses interest in investigating this problem as it is seen the need to work on this issue to check in some way that improving the different areas of work of users can be a more ergonomic area and thus have higher performance.

The incidence of accidents due to not having a proper distribution of the work area is worrisome due to be working with a distribution that is not adequate to what our body deserves to avoid the different problems already mentioned.

It is worrisome that students of the UABC (Universidad Autónoma de Baja California) in FIM (Facultad de Ingeniería Mexicali) do not have a table or benches for people who are left-handed since; In the long term this causes problems for this type of people who do not adapt quickly to work in these.

Within the background, we have that musculoskeletal disorders that originate in the workplace, are the first cause of low in workers (Gardea, Savilla, & Garcia, 2015). Currently the muscle problems in the school cause many students to leave the classroom are with neck problems, back pain, so in this case, study is made known to the reader, the factors that make that there is no proper distribution of the work area and which consequence brings these in the long term.

Organizations are increasingly appreciating ergonomics for the benefits associated with the application of programs focused on the design of places and jobs (Haines & Wilson, 1998), which is why it is of utmost importance that ergonomics begin at use in FIM.

2. OBJECTIVES

1. Analyze the distribution of the work area for the users of the institution of higher education to guarantee reduction of injuries and increase the number of motivated users, boost productivity and better quality in the daily activities school.

2. Analyze the quantitative and qualitative characteristics, as well as factors of not having an ergonomic area.

3. Demonstrate that improving the work area and applying ergonomics, you can improve the goal you have in public educational institutions.

3. METHODOLOGY

The case of study is limited to UABC in FIM where this research was conducted during a 6 months period, in which it is inquired about the factors that prevent a good distribution of the work area and therefore lousy productivity. The lack of good balances of work areas, poorly designed chairs or tables as well as non-existence for left-handed people, the reduced height of desks, poorly designed monitors, bad posture of the users of the institution of higher education.

To investigate the case of study, it was necessary to determine how many variables were to be measured. By the quantitative approach of the research, the determination of how many chairs, computers, table-benches are in ergonomic conditions so that the user is adequate; since according to the standards ISO 11228-1: 2003, ISO 11228-2: 2007, ISO 11228-3: 2007 (ergonomic principles must be used for the design of the work area.) Then the type of sampling is defined in this case is intentional, since you cannot have access to all the chairs, table-benches of the entire public educational institution.

Subsequently, in the qualitative approach of the research, it is determined that the units of analysis together for the realization of interviews are the students of the UABC. As well as teaching and administrative personnel, who live the largest part of the day in the university, for which they show qualities or characteristics of our variables to be measured.

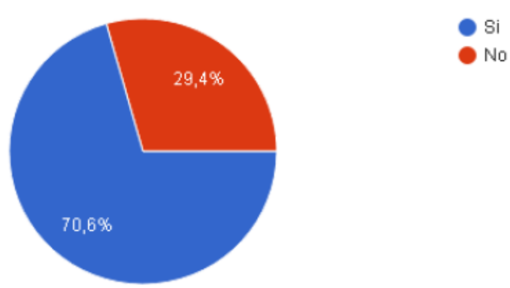
It was determined that the population for this research is around 4300 people; this is all students, as well as the teachers and administrators of the FIM.

It is considered a sample of 46 people: 40 students, men and women, of an age range of 18-30 years, 3 teachers involved in the area of industrial engineering of about 30-40 years and 3 administrative women of about 40 years.

Finally, interviews are carried out as a data collection technique, to know from a personal perspective what users think about the distribution of the work area and if they considered that ergonomics was implicit within the institution and not only in the classroom. If not, that also in the library and laboratories where they ask what they experience day to day when they are in contact with chairs, table benches, computers and tables.

4. RESULTS

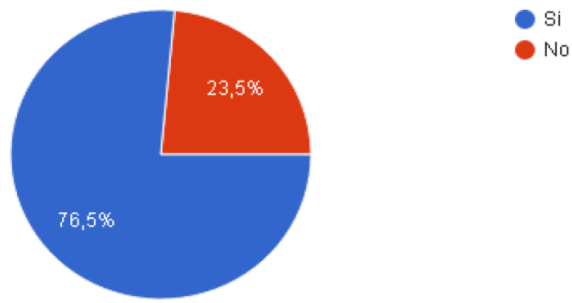
In the case of study, it is determined that it is of the utmost importance that we all understand what ergonomics can provide, since 29.4% of respondents, men and women, do not know ergonomics as shown in figure 1.



Graph 1. People who know Ergonomics, as well as those who don't.

As can be seen in Figure 1, the majority (70.8%) of respondents know about ergonomics, this seems to indicate that the term is no longer unknown but in the public domain, even if it is not applied effectively.

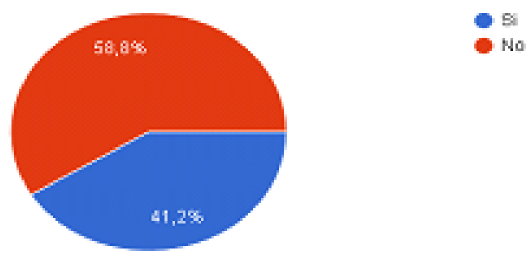
Likewise, 76.5% had muscle pain after a class session as seen in figure 2.



Graph 2. People who have had muscle pain.

Graph 2, shows that within the student population most of the students have suffered discomfort when taking classes; this could be caused by not having chairs or ergonomic benches or clear ideas on how to apply the concept of occupational health.

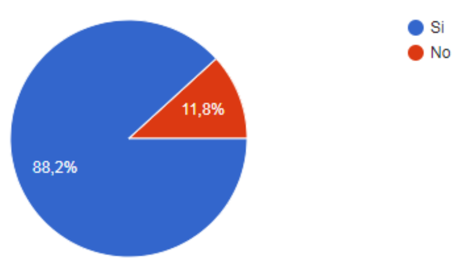
According to the results, 58.8% of the sample speculates that they are not adapted in the correct way to the work area as shown in figure 3.



Graph 3. Percentage of people who consider that they are in an ergonomic area.

As can be seen in graph 3, (41.2%) of respondents consider that they are adapted to their work area, this seems to indicate that each person adapts to their workplace depending on several factors such as height, posture , capabilities and the design of the bank table since; not all the table banks of the respondents have the same design.

And likewise 88.2% consider that there should be a bank or desk table for left-handed people due to the difficulty to write and carry out school activities such as shows in figure 4.



Graph 4. Percentage of people who consider that desks should exist for left-handed people.

Graph 4, shows that within the student population it seems that due to the difficulty to write and carry out school activities, left-handed people have been forced, from a young age, to operate benches designed for right-handed people.

Likewise, 100% of the surveyed sample speculates that there must be training for students, teachers and administrative staff of the public institution as shown in figure 5, on the risks that may be caused by poor user attitudes, as well as the bad design of chairs and table benches.

Graph 5. Percentage of people who consider there should be training.

Figure 5, shows that within the sample surveyed there is no person who thinks that training on user positions is not necessary, which is why it is very important to implement the habit of creating training for users to avoid complications a long term.

Of the risk factors that cause table benches, chairs, desks that are not ergonomic, the one with the greatest impact in the classroom is stress with 41.2%, consecutively back pain with 35.3%, afterwards the neck pain with 11.8% and anxiety with 11.7% as shown in table 1.

Table 1. Risk Factors caused by the lack of ergonomic benches, chairs and desks.

Factor	Percentage
1.- Stress	**41.2%**
2.- Back pain	**35.3%**
3.- Neck pain	**11.8%**
4.- Anxiety	**11.7%**
Total	**100%**

As shown in Table 1, most of the respondents are affected by not having a good posture and design of a good bank table to take classes in the case of students, as well as a good chair to perform teaching and administrative activities.

As quantitative characteristics average grade from student is used as an indicator of productivity finding that the majority of the respondents who are most affected by not having an ergonomic area are students who have an average of less than 80%, so; ergonomics could affect the fact that they are not in an adequate area to carry out academic activities in the public institution.

5. CONCLUSIONS

According to what resulted from the analysis of the case study, the variables to be measured in the research must be that ergonomics applied to the classroom must be attached to occupational health, that is, to provide in some way the safety of the users of the institution of higher education so that there are no long-term repercussions such as illnesses, muscular problems, physical or mental injuries, mental fatigue, stress, anxiety and especially back problems due to the fact that users do not adopt a correct position when carrying out school and administrative activities. Likewise, according to the analysis of results, training should be carried out for all users of the UABC about the work area and the design of chairs, table benches, as well as training for FIM users about the repercussions that can be had in the future if ergonomic principles are not followed to help adapt the work area more comfortably since; that is the function of ergonomics.

According to the analysis of the case study, it was concluded that it is very important that this investigation be expanded; since it is of great interest to measure the qualitative characteristics of the users of the FIM, as well as, the quantitative characteristics to measure the productivity of the users to achieve higher academic performance.

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STUDY AND ANALYSIS OF DISORDERS MUSCULOSKELETAL IN THE SONORA INDUSTRY IN THE PERIOD 2014-2016

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Resumen: En este trabajo se realiza un estudio correspondiente a los costos generados durante el periodo 2014-2016 por los trastornos musculoesqueléticos que ocurren dentro de la industria sonorense, con la finalidad de obtener información relevante por parte del Instituto Mexicano del Seguro Social (IMSS) respecto a los trastornos reportados por las empresas debido a que algunos de éstos son atendidos por el personal médico que labora para la industria donde ocurre el trastorno. El estudio sirve como base para entender que sector industrial genera la mayor cantidad de trastornos, así como los más comunes, y validar si hay una reducción de dichos trastornos en el periodo estudiado. Es bien sabido que estos trastornos afectan la productividad y el desempeño económico de la empresa, el conocer esta información para la empresa ayuda a mejorar el tiempo de acción y reacción, así mismo, a la reducción de los costos y de capital humano.

Palabras clave: Trastornos musculoesqueléticos, enfermedad laboral, riesgo, incapacidad

Relevancia para la ergonomía: En el presente trabajo se desarrolla un análisis estadístico para posteriormente desarrollar una metodología para evaluar los costos ocasionados por los trastornos musculoesqueléticos en la industria sonorense tomando como base los datos que se le aportan al IMSS.

Abstract: In This work is carried out a study corresponding to the costs generated during the period 2014-2016 for the musculoskeletal disorders that occur within the Sonora´s industry, with the purpose of obtaining relevant information by the Institute Mexican Social Security (IMSS) regarding the disorders reported by the companies because some of these are cared for by medical staff working for the industry where the disorder occurs. The study serves as a basis for understanding that the industrial sector generates the greatest number of disorders, as well as the most common, and to validate if there is a reduction of these disorders in the period studied. It Is Well known that these disorders affect the productivity and the economic performance of the company, knowing this information for the company helps to improve the time of action and reaction, likewise, to the reduction of the costs and of human capital.

Keys Words: Musculoskeletal Disorders, occupational disease, risk, disability

Relevance to Ergonomics: This paper develops a statistical analysis to develop a methodology to evaluate the costs caused by musculoskeletal disorders in the Sonora´s industry based on the data provided to the IMSS.

1. INTRODUCTION

This paper focuses on conducting a study and analysis of occupational diseases in the Sonora´s industry in the period from 2014 to 2016, to determine a cost generated by the risk situation that is present under certain conditions within the industry. The approach of this Research is because the problem of absenteeism of the personnel in the industry is of great importance, because they are those that carry out the activities in the work place to meet the objectives and goals in an effective way, to satisfy The needs of both internal and external customers complying with the quality and specifications proposed by them.

There Are several reasons why workers are absent in the industry, one of the main ones is the muscular-skeletal injuries or dislocations that occurred during the work activities, this is mainly due to the bad facilities, to the spaces Work, to the equipment or tools in which they are in bad condition, to the bad postures that they adopt in their area of work for long periods of time, to mention some.

Ergonomics is a multidisciplinary activity that strives to gather information about people's capacities and use that information in the design of jobs, products, workplaces and equipment (The Eastman Kodak Company, 2004). Ergonomics is compulsory in the organizational culture, as it is the most efficient way to incorporate the best ergonomic decisions in all Hierarchical levels of the organization. The main objective of improving ergonomic intervention is continuous improvement, the only factor that drives success and competitiveness in the market (BOATCA & Cirjaliu, 2015).

Safety at work is the set of actions to locate and assess risks, and to establish measures to prevent accidents at work. Safety at work is shared responsibility of both the authorities and employers and workers. (Galindo Barajas, 2003). During the chapter, we collected information about the benefits of ergonomics and human factors, occupational safety and health such as occupational risk factors, musculoskeletal disorders, repetitive work design, Individual risk, costs and utility due to musculoskeletal disorders. In Addition to the legal framework of safety and health.

Health is defined by the World Health Organization (WHO) as "a state of complete physical, mental and social well-being and not simply the absence of disease or ailment" (WHO, 1998). This definition is part of the WHO Constitution since its creation in 1948. The Constitution of the United Mexican States also recognizes that health is one of the fundamental rights of human beings and that achieving the highest level of well-being depends on the cooperation of individuals and nations for the provision of measures Health and Social. Occupational injuries and/or illnesses are always considered to be major problems for workers, especially in the least developed countries. The International Labour Organization (ILO) estimated that around 2.3 million people are killed by occupational accidents and illnesses, 317 million suffer serious non-fatal employment injuries and 160 million suffer from diseases Professionals and most of them belong to rural areas in less developed countries (International Labour Organization (ILO), 2011). The workforce in less developed countries has always been at great risk for occupational injuries and/or illnesses due to poor working conditions and lack of social protection (Abbas, 2015).

In underdeveloped countries, occupational injuries and/or illnesses carry a high cost of the national social security system due to poor health-safety infrastructure. Occupational injuries are the main reasons for economic decline, as the economic costs of occupational injuries and/or illnesses, calculated by the ILO, represent an average of 4% of national GDP. Adequate social insurance schemes are not consolidated in less developed countries, especially in rural areas, and constraints such as low-quality information are a reality there; Therefore, a typical data analysis would be useful for estimating the country's occupational health safety performance. Labour-related injuries and deaths are more common in less developed countries, where workers are involved in hazardous work activities (Abbas, 2015).

In his article (Abbas, 2015) seeks to analyses the trends in the value of the Injured Workers index (IEP) covered in the labour force surveys of Pakistan from 2001-02 to 2012-2013, through years-based indices and Reference groups, which were used to analyses IEP trends in terms of different criteria such as gender, area, labor situation, industry types, occupational groups, types of injuries, injured body parts, and treatment. Received. The analysis of Pearson's correlation coefficient was also carried out to investigate the interrelation of different occupational variables. The results obtained from this study were the IEP values that increased at the end of the year studied in the different divisions of the industry, such as agriculture, forestry, hunting and fishing, followed by the manufacturing industry and the Construction. People associated with major occupations (such as skilled agricultural and fishing workers) and elementary (unskilled) occupations Were found to be at increased risk of occupational injuries/illnesses with a trend Increased IEP. His conclusion was the increasing trend in IEP% of the total number of people employed due to agricultural activities shows that there is a need to improve health care configurations in rural areas of Pakistan.

Working conditions and organization are factors that contribute to occupational accidents. Therefore, safety at work requires that working conditions do not cause a significant risk to workers, thus preventing them from becoming incapable of doing their job. On the other hand, the industry must create the conditions, capacities and habits that allow the worker and his organization to carry out their work efficiently and in a manner that avoids events that may cause them harm. Studies on health and safety at work, aimed at preventing injuries, have traditionally focused on physical aspects, dealing with ergonomic factors and musculoskeletal disorders or hygiene conditions such as Temperature and noise (García-Herrero, Mariscal, García-Rodríguez, & Ritzel, 2012).

Another health problem that has been highlighted in several researches conducted in recent decades, is the problem of musculoskeletal disorders or physical symptoms. These include disorders of the muscles, tendons, nerves, or joints that can occur in any part of the body, but most commonly affect the neck, back, and upper extremities. Although they may be due to non-workplace factors and may even have personal causes, for this reason, working conditions are directly related to musculoskeletal disorders. The prevention of such disorders is directly related to the correct design of the work (e.g. allocated space or provision of adequate lighting), and physical demands (e.g., moving heavy loads and performing repetitive tasks) (García-Herrero, Mariscal, García-Rodríguez, & Ritzel, 2012).

In Addition to be a problem for the health of the workers, these disorders constitute an important financial burden for the society. Most financial losses associated with occupational injuries and illnesses include musculoskeletal disorders; These disorders are the main cause of time-wasting injuries in developed countries (García-Herrero, Mariscal, García-Rodríguez, & Ritzel, 2012). (Pinto, A., Nunes, I., Ribeiro, R., 2011) mentions that occupational injuries and illnesses affect not only safety and health, but also the economy, due to the high costs associated with occupational injuries. It Was noted that safety in industries has gained attention because workers ' compensation insurance premiums are increasing resulting from increased costs in medical services for work-related accidents or disabilities.

Companies are increasingly employing proactive and participatory programs to detect, evaluate and control the risks present in workplaces that are prone to cause accidents and illnesses that could lead to absenteeism, treatment and the replacement of injured employees. These programs seek to minimize risks by understanding the impact on the business and reducing the costs involved (Rodriguez Fernandez, Berretta Hurtado, & Concepción Batiz, 2015).

Every 15 seconds, a worker dies from an accident of work or illness, 153 workers had an occupational accident (International Labour Organization (ILO), 1996-2017). On the other hand, 6,300 people die each day from work accidents or work-related illnesses, which results in more than 2.3 million deaths a year (International Labour Organization (ILO), 1996-2017).

The difference in accident rates between developed and developing countries is notable, which is because some industries in developed countries have implemented the zero-accident policy for their goal in building Infrastructure and industrialization. Meanwhile, industries in developing countries are not able to effectively identify their risks and reduce subsequent accidents, because industries are recently established and not all apply zero-accident policy (Afifah Y., RASDI, Zainal Abidin, Abd Rahman, & Ismail, 2016).

2. OBJECTIVES

Based on the information collected, a study is made of the cost required for the disability and/or compensation for an occupational disease in the industry, in addition to the cost generated by the absence of the worker in his area of work. The above, in order to control the human resource within the industry, improving the working conditions and strengthening the link between them. Guaranteeing an excellent quality product and/or service that meets the customer's needs and reduces the costs for the industry.

- Identify The most frequently occurring industrial illnesses within the industry.
- Collect The necessary information for the elaboration of a database focused on the different industrial sectors of interest for this work.
- Carry out an analysis to determine which are the most common occupational diseases that occur in the industry and the costs that are generated to determine the relationship between them.

3. METHODOLOGY

The data were obtained from the Mexican Institute of Social Security (IMSS) regarding occupational diseases in the State of Sonora in the period 2014 – 2016, in the industry to determine the costs generated by the absence of work and/or disability generated Depending on the severity of the situation presented. It Is necessary to have the necessary knowledge and adequate to identify the work disease and severity of the same one to provide timely and useful help for both parties (employee-industry), since the importance that presents this type of situations is very high Because of the costs that are generated.

The analysis carried out is quantitative, because the information is based on the registered cases and days of disability and thus determine the frequencies and costs in the period mentioned. Subsequently, it proceeds to classify the data obtained by selecting the type of risk 3, which corresponds to the illnesses of work, it is worth mentioning that in this investigation, it is also based on the codes and terms of the IMSS to complement and Working with the data, because there is information codified by the IMSS, on the other hand, it should be noted that the information obtained was in accordance with the restrictions of the IMSS because several points are confidential. In the analysis of the information we only focus on the illnesses of work corresponding to the musculoskeletal disorders of most frequency in incidence, as well as the days of disability generated per year, in addition, it is determined the area of the body that most It affects the industry in the State of Sonora. Therefore, an analysis is performed by specific areas of the body, with a division of upper extremity, lower extremity and back.

4. RESULTS

In The year 2014 a total of 17.395 cases and 608.410 days of disability were recorded, of which those corresponding to the type of risk 1 of accidents of work were reported 13.393 cases registered and 460.470 days of disability, the preceding corresponds to 76.99% of the cases and the 75.68% of days of disability. For the Type 2 risk that corresponds to accidents caused by way of work were 3.499 cases registered and 105.034 days of disability, corresponding to 20.11% of the cases and 17.26% of the days of disability. While for the type of risk 3 corresponding to work diseases for the same year were 503 cases registered and 42.906 days of disability, corresponding to 2.89% of the cases and 7.05% of the days of disability.

During the year 2015 the cases registered in the IMSS were 17.684 cases and 643.333 days of disability, of which, those of the type of risk 1 of accidents of work were 13.580 cases registered and 478.347 days of disability, corresponding to the 76.79% of the cases and the 74.35% of the days of disability. For the type of risk 2 of accidents per trip were 3.411 cases registered and 112.816 days of disability, corresponding to 19.29% of the cases and 17.54% of the days of disability. The type of risk 3 of occupational diseases for the same year were 693 cases registered and 52.172 days of disability, corresponding to 3.92% of the cases and 8.11% of the days of disability.

In The year 2016 cases were recorded in total were 17.139 cases and 598.176 days of disability, of which those corresponding to the type of risk 1 of work accidents were 12.981 cases registered and 437.326 days of disability, corresponding to 75.74% of the cases and 73.11% of the days of disability. For the type of risk 2 of accidents per trip were 3.542 cases registered and 112.764 days of disability, corresponding to 20.67% of the cases and 18.85% of the days of disability. The type of risk 3 of occupational diseases for the same year were 616 cases registered and 48.086 days of disability, corresponding to 3.59% of cases presented and 8.04% in days of disability.

As mentioned above, in this study we will focus on the risk type three, of the was proceeded to the identification of the areas of the body affected by the diseases of work registered in the mentioned period. The body parts specific to this study depending on the medical diagnosis were upper extremity, lower extremity, back, trunk.

In Order To identify and select the correct data by sector or economic turn of the company, it was carried out by means of the catalogues of files and glossary with which IMSS has. However, other fields that required research were medical diagnoses and keys corresponding to the initial and final International Statistical Classification of Diseases and Problems Related to Health (ICD-10), thus emphasizing Only Type 3 risk.

Table 1. Data collected from the IMSS corresponding to the period 2014-2016 of the different types of risk

Risks	Cases 2014	Days of disability 2014	Cases 2015	Days of disability 2015	Cases 2016	Days of disability 2016
Type 1	13, 393	460, 470	13, 580	478, 347	12, 981	437, 326
Type 2	3, 499	105, 034	3, 411	112, 816	3, 542	112, 764
Type 3	504	42, 906	693	52, 172	616	48, 086

5. DISCUSSION/CONCLUSIONS

In the year 2014, 503 cases were registered with 42.906 days of disability. According to the classification performed, working diseases in the upper extremity represent 68.19% with 343 cases reported and 75.75% with 32.503 days of disability, at the lower extremity represents 1.79% with 9 cases registered and 0.91% With 389 days of disability, in the back represents 13.92% with 70 cases registered and 18.82% with 8.076 days of disability, in the trunk with a 1.19% with 6 cases registered and 0.17% with 73 days of disability.

On the other hand, in the year 2015, 693 cases were registered with 52.172 days of disability. According to the classification performed, working diseases in the upper extremity represent 51.66% with 358 cases reported and 66.56% with 34.724 days of disability, at the lower extremity represents 2.74% with 19 cases registered and 1.58% With 826 days of disability, in the back represents 18.33% with 127 cases registered and 24.79% with 12.936 days of disability, in the trunk with a 2.45% with 17 cases registered and 2% with 1.041 days of disability.

In the year 2016, 616 cases were registered with 48.086 days of disability. According to the classification performed, working diseases in the upper extremity represent 52.44% with 323 cases reported and 65.60% with 31.546 days of disability, at the lower extremity represents 3.25% with 20 cases registered and 4.96% With 2.387 days of disability, in the back represents 20.13% with 124 cases registered and 22.17% with 10.660 days of disability, in the trunk with a 2.92% with 18 cases registered and 1.45% with 695 days of disability.

Musculoskeletal disorders recorded in the upper extremity were classified in hand and fingers, wrist, elbow and shoulder. For the year 2014 the area of the hands and fingers represents 2.15% with 7 cases registered and 1.52% with 483 days of disability, the wrist area represents 38.34% with 125 registered cases and 36.65% with 11.649 days of disability; The elbow zone represents 2.76% with 9 cases registered and 1.47% with 468 days of disability and the shoulder area represents 56.75% with 185 cases reported and 60.36% with 19.184 days of disability.

For the year 2015 the area of the hands and fingers represents 0.60% with 2 cases registered and 0.53% with 180 days of disability, the wrist area represents 42.90% with 142 registered cases and 35.91% with 12.303 days of disability; The elbow zone represents 5.14% with 17 cases registered and 3.59% with 1.230 days of disability and the shoulder area represents 51.36% with 170 cases reported and 59.97% with 20.546 days of disability. While for the year 2016 the area of the hands and fingers represents 0.66% with 2 cases registered and 0.58% with 179 days of disability, the wrist area represents 38.21% with 115 cases registered and 34.90% with 10.741 days of disability; The elbow zone represents 7.31% with 22 registered cases and 6.40% with 1.970 days of disability and the shoulder area represents 53.82% with 162 registered cases and 58.12% with 17.889 days of disability.

Table 2. Classification of working diseases by body parts specific to registered cases and disability days in the period 2014-2016

Zone	Cases 2014	Days of disability 2014	Cases 2015	Days of disability 2015	Cases 2016	Days of disability 2016
Upper Extremity	343	35, 503	358	34, 724	323	31, 546
Lower Extremity	9	389	19	826	20	2, 387
Back	70	8, 076	127	12, 936	124	10, 660
Trunk	6	73	17	1, 041	18	695

Musculoskeletal disorders recorded in the lower extremity were classified in the foot and knee. For the years 2014 and 2015 in the area of the feet there are 0 cases reported, while for the knee area for both the 2014 and 2015 there are 3 cases recorded each year, with 228 and 588 days of disability respectively. In the year 2016, for the foot area there are 2 cases registered, with 216 day of disability, and in the area of the knee 12 cases were presented, with 1, 873 days of disability, as can be seen there was an increase in foot and knee injuries this year.

The disorders recorded in the back were classified into cervical, lumbar and sacral vertebrae. For the year 2014 in the area of the cervical vertebrae were presented 7 cases registered with 832 days of disability, in the area of the lumbar vertebrae were detected 55 cases registered with 6, 446 days of disability; Whereas in the area of the sacral vertebrae only 1 case with 365 days of disability was reported. In the year 2015 the area of the cervical vertebrae was presented 11 cases with 1, 289 days of disability, while in the area of the lumbar vertebrae there are 99 cases registered with 11, 124 days of disability; Finally, in the area of the sacral vertebrae only 5 cases were presented with 152 days of disability. For the year 2016 the area of the cervical vertebrae presented 11 cases with 2,126 days of disability, in the area of the lumbar vertebrae were presented 96 cases with 7, 636 days of disability; While in the area of the sacral vertebrae there was only 1 case recorded with 16 days of disability.

In the year 2014 the musculoskeletal injuries presented in the upper extremity for the area of the hands and fingers the most frequent disease was the Trigger Finger with 6 cases registered and 454 days of disability, Synovitis of the Trapezium Metacarpal with 1 case registered and 29 days of disability. For the wrist area The most common diseases were carpal Tunnel Syndrome with 53 cases reported and 7.921 days of disability, Tendinitis with 54 cases reported and 3.020 days of disability, Tenosynovitis of Styloid Radial [Quervain] with 9 Cases reported and 488 days of disability, Synovial Cyst with 7 registered cases and 168 days of disability, and Tenosynovitis of Wrist with 2 registered cases and 52 days of disability.

Table 3. Classification of musculoskeletal injuries in areas of upper extremity, lower extremity and back in the period 2014 to 2016

	Cases 2014	**Days of disability 2014**	**Cases 2015**	**Days of disability 2015**	**Cases 2016**	**Days of disability 2016**
Upper Extremity						
Hand and fingers	7	483	2	180	2	179
wrist	125	11, 649	142	12, 303	115	10, 741
Elbow	9	468	17	1, 230	22	1, 970
Shoulder	185	19, 184	170	20, 546	162	17, 889
Lower Extremity						
Foot	0	0	0	0	2	216
Knee	3	228	3	588	14	2, 089
Back						
Cervical	7	832	11	1, 289	11	2, 126
Lumbar	55	6, 446	99	11, 124	96	7, 636
Sacral	1	365	5	152	1	16

In the period studied, the musculoskeletal injuries presented in the upper extremity for the area of the hands and fingers the most frequent diseases were the Trigger Finger, Synovitis of the Trapezium Metacarpal. For the wrist area most commonly diseases were carpal Tunnel Syndrome, Tendonitis, Radial Styloid [Quervain] Tenosynovitis, Synovial Cyst and Wrist Tenosynovitis. For the elbow zone most frequently diseases were Epicondylitis, Ulnar Nerve Injury and Bursitis. While for the shoulder area, Painful Shoulder abduction Syndrome, Rotator Cuff Impingement syndrome and Shoulder Tendonitis were presented. The musculoskeletal injuries presented at the lower extremity in the knee area were Medial Meniscus and Patellar Tendonitis. In the area of the back in the region of the cervical vertebrae were Cervical Stenosis, Cervicobrachialgia and Cervical Radiculitis. For the region of the lumbar vertebrae were low back Pain, Herniated Lumbar Disc, Lumbar Stenosis, Spondylolisthesis and Spondylarthrosis, while for the region of the sacral vertebrae was Coccidioidomycosis.

According to the results, the economic turns with musculoskeletal disorders were: Construction, reconstruction and assembly of transport equipment and its parts with 93 cases registered and 8.762 days of disability; Manufacture and/or assembly of machinery, equipment, appliances, accessories and electrical, electronic items and their parts with 60 cases registered and 6.202 days of disability; Food Processing with 47 cases registered and 4.044 days of disability; Manufacture of clothing and other articles based on textiles and miscellaneous materials; Except footwear with 21 registered cases and 2.937 days of disability. For The Sale of food, beverages and tobacco products with 21 registered cases and 2.984 days of disability; Construction of buildings and civil engineering works with 20 registered cases and 1.626 days of disability; Trading in self-service stores and specialized departments by line of goods with 20 registered cases and 1.107 days of disability; Sales of raw materials, material and auxiliaries with 14 registered cases and 1.552 days of disability; Manufacture, assembly and/or repair of machinery, equipment and parts thereof; Except electrics with 13 registered cases and 1.770 days of disability; No reason with 11 registered cases and 1.105 days of disability; and Other Manufacturing industries with 9 registered cases and 1.088 days of disability.

During The development of this study, it was determined that the worker receives medical attention by the IMSS for any discomfort, pain or illness. The IMSS follows a process for evaluating a possible work disease under the standards of the institute based on the Medical Benefits Regulations of the Mexican Institute of Social Security and the Social Security Act, when the successor complies with the requirements are credited with all the benefits in kind and economic.

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ERGONOMICS AND ITS RELEVANCE FOR QUALITY LICENSING IN THE INTERNATIONALIZATION OF SMES

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Resumen La presente investigación trata del Estudio del Trabajo desde el enfoque interdisciplinario del Factor Humano, para el incremento de la productividad sin menoscabar, la salud, emocional ni física de los trabajadores, en el contexto de una empresa maquiladora de productos para una marca internacional. El objetivo principal fue obtener la certificación y Licenciamiento que ha establecido el Programa de Estándares Laborales Internacionales (el “Programa de ILS”) para ayudar a fomentar lugares de trabajo seguros, que favorezcan la inclusión y el respeto en todos los lugares donde se fabriquen productos con su marca y Proveedores. La empresa Delta donde se realizó el estudio, es una PYME de polímeros, a la cual le fue suspendido su contrato de exportación de producto, hasta no obtener el licenciamiento. Se llevó a cabo un análisis para la identificación de riesgos y se utilizó como instrumento de medición la lista de chequeo del Instituto Nacional de Seguridad e Higiene en el Trabajo de España INSTH, análisis de condiciones ambientales con referencia a las Normas Oficiales Mexicanas correspondientes a cada Factor de riesgo y evaluación de riesgos ergonómicos a través del método REBA. Los resultados mostraron factores de riesgo altos por posiciones incomodas, niveles de ruido que exceden los límites permisibles por la norma, riesgo en factores psicosociales generando un alto índice de incapacidades, inadecuada manipulación de cargas, entre otros. Se realizaron propuestas de mejora, las cuales fueron implementadas dando como resultado en una segunda evaluación disminución en los índices de riesgo. Todo el proceso fue documentado y se elaboraron planes de seguimiento y mejora. La información generada fue adecuada para los auditores y la empresa Delta logro su Certificación y licenciamiento. Con base en lo anterior se han generado acuerdos de trabajo colaborativo Escuela-Industria para mantener la licencia obtenida.

Palabras clave: Riesgo, estación de trabajo, licenciamiento.

Relevancia para la ergonomía: El estudio contribuye a la difusión del conocimiento y concientización de la importancia de la Ergonomía en el diseño de estaciones de trabajo y los procesos productivos, destacando lo más importante que es la salud y la vida de los operarios sin descuidar la parte productiva y funcional de la empresa contemplada desde una perspectiva legal y normativa para el incremento de exportaciones.

Abstract (Spanish/English, this order): The present investigation deals with the Work Study from the interdisciplinary approach of the Human Factor, for the increase of the productivity without diminishing, the health, emotional or physical of the workers, in the context of a maquiladora company of products for an international brand. The main objective was to obtain the certification and licensing established by the International Labor Standards Program (the "ILS Program") to help promote safe workplaces that favor inclusion and respect in all places where products are manufactured. with your brand and Suppliers. The Delta company where the study was conducted, is an SME of polymers, which was suspended its product export contract, until obtaining the license. An analysis was carried out for the identification of risks and the checklist of the National Institute of Safety and Hygiene in the Work of Spain INSTH was used as a measuring instrument, analysis of environmental conditions with reference to the Official Mexican Standards corresponding to each Risk factor and evaluation of ergonomic risks through the REBA method. The results showed high risk factors for uncomfortable positions, noise levels that exceed the limits allowed by the norm, risk in psychosocial factors generating a high disability index, inadequate handling of loads, among others. Improvement proposals were made, which were implemented resulting in a second evaluation reduction in the risk indexes. The entire process was documented and follow-up and improvement plans were prepared. The information generated was adequate for the auditors and the company Delta achieved its Certification and licensing. Based on the above, collaborative work agreements have been generated School-Industry to maintain the license obtained.

Key words: Risk, work station, licensing.

Relevance to Ergonomics: The study contributes to the dissemination of knowledge and awareness of the importance of Ergonomics in the design of work stations and production processes, highlighting the most important thing is the health and life of operators without neglecting the productive and functional part of the company contemplated from a legal and normative perspective for the increase of exports.

1. INTRODUCTION

The world economy has been affected by phenomena of various kinds, and Mexico is not the exception; due to this, employing them in large companies has been increasingly difficult, which is why the entrepreneurship mentality has been fostered in educational institutions for the creation of small and medium enterprises (SMEs), which in turn generate new sources of employment. Once established, the new companies face another challenge when they do not find sites for the sale of new products in domestic domestic markets.

Based on the previous ones, some SMEs have opted for the search of new markets to export their products; this confronts them with new challenges and with great economic, cultural, technological, normative and legal restrictions among others. Such is the case of the company considered in the development of this research, a micro company (Mypime) called Delta, located in the state of Mexico, Mexico, which produces products in PVC (polyvinyl chloride) for ornaments and children's parties . DELTA started 15 years ago and in that period it has increased its local, regional and international markets by approximately 50%, due to its great variety of products that characterizes it, generating the expansion of productive capacity and infrastructure. Allowing in this way that DELTA is one of the leading leading companies in the country in the manufacture of PVC adornment products.

Since its inception, the company has placed at its disposal in the national and international market a range of products, always backed by the guarantee provided by its facilities with state-of-the-art cutting-edge laboratory equipment and equipment and a great human resource assistance. ensure the quality of the product, always based on compliance with the specifications established in the standards. The executives of this company have a vision of broad expansion and took their products to the Disney company to apply for licensing to be suppliers. In response to their request they were given the opportunity, as long as they complied with the legal, regulatory and licensing requirements.

Licenses are the right granted by the owner of an industrial property (such as brands that cover products or services or an intellectual property right to a third party) to use them commercially without infringing or violating their rights. Through a contract, the licensee is responsible for manufacturing and selling the product that bears the brand or provides the service under the brand and the licensor obtains a direct benefit such as obtaining royalties based on the sale of the product. or the provision of services.

Some transnational companies are a good example in many of the cases in the granting of licenses, since they exploit them without having a physical presence in certain countries through demarcation licenses. This has been one of the practices increasingly used by the various productive sectors to establish solid foundations of business association. The company was given the task of fulfilling all the requirements, among which is the International Labor Standards Program (the "ILS Program"), with the general requirements for Licensees and Suppliers. (Disney, 2013).

The ILS Program applies to the production of all products, product components and materials that contain, incorporate or apply intellectual property owned or controlled by The Walt Disney Company and its affiliates ("Disney") produced for any purpose in any place in the world ("products with the Disney brand"), to help promote safe workplaces that favor inclusion and respect in all places where products are manufactured with their brand, all Licensees and Suppliers will be required deliver audit reports prior to production and on an ongoing basis as described in the ILS Program Manual. (Disney, 2013). The action corresponds to what is known as technology transfer.

1.1 International Labor Standards Program

The ILS Program applies to the production of all products, product components and materials that contain, incorporate or apply intellectual property owned or controlled by The Walt Disney Company and its affiliates ("Disney") produced for any purpose in any place in the world ("products with the Disney brand"), to help promote safe workplaces that favor inclusion and respect in all places where products are manufactured with their brand, all Licensees and Suppliers will be required deliver audit reports prior to production and on an ongoing basis as described in the ILS Program Manual.

The program is prepared in compliance with Standards, Laws and Regulations where the production or sale of the brand is carried out and subject to the recommendations of the repertoire of practical recommendations on technology transfer of the International Labor Organization (ILO). (Disney, 2013).

The transfer of technology has always been an essential factor for economic development and the improvement of social conditions and, at present, machinery, products and procedures are part of an incessant transfer that takes place from the industrialized countries to the developing countries This is not limited to knowledge of how the machinery, products or procedures work or are used. On the contrary, it is about expanding that knowledge with respect to the effects that the transferred technology can have on the safety, health and working conditions of those who use it.

In relation to the above-mentioned interest, the International Labor Organization has initiated various activities on the transfer of technology and safety, health and working conditions discussed and finally adopted the repertoire of practical recommendations on the subject; text that provides practical guidance on policies and regulations on occupational safety and health, intended to be used by governments, employers and workers in order to promote safety and health at the national level and at the enterprise level, deals with aspects of the safety and hygiene inherent to technology transfer and is aimed at: technology planners, technology exporters, technology importers, licensors of technology licenses, competent authorities on safety and health and working conditions in relation to imported technology, contractors and subcontractors involved in the installation of technology, users of technology and are designed for use by all those who, in the public or private sector, have the responsibility to prevent risks that the transfer of technology could originate for safety and health.

It should be noted, however, that this repertoire is not intended to replace national legislative or regulatory provisions or existing regulations. The publication of this repertoire was approved by the ILO Governing Body at its 235th Session (February-March 1987) and has had adjustments in each meeting up to the last of March 2018 (ILO, 2018). To obtain the license, the company requested the services of two Consultancies and the the support of the Polytechnic University of the Valley of Mexico, specifically the University Chapter of Ergonomics, Directorate of Industrial Engineering, who conducted risk identification studies and forced postures in jobs and determining contributions for licensing, shown below.

2. OBJECTIVES

1.1 Identify ergonomic risk factors of jobs.
2.1 Carry out an ergonomic evaluation adapted to the needs of each job.
3.1 Propose Plan of corrective and preventive measures that reduce the level of ergonomic risk.
4.1 Highlight the relevance of applying ethical and responsible conduct in all operations of a productive company providing a safe and healthy workplace in compliance with all applicable laws and regulations.

3. METHODOLOGY

Delta has several lines of continuous production and sometimes intermittent, depending on the customer's requirement. The most representative activities by area of the production process in the manufacture of decorative figures is as follows:

Table 1 process in the manufacture

Step	Procedure and work area	Activity Oper	Oper.
1	Raw material	Transport of raw material from warehouse to platforms • • PVC resin supply	3 men
2	Weighing of additives	• Mixing of components • Organization of raw material Addition of additives	2 Women 1 men
3	Injection machines	• Delivery of raw material and resins Molding •	2 Women 3 man
4	Detailing and storage for sale	Classification of reprocessing. • Pulverized	5 Women 2 man

Due to the fact that it is a small company, the 10 workers in this area were considered for the sample: 9 women with ages ranging from 19 to 38 years old and 9 men between 18 and 48 years old. For the identification of risks, the checklist of the National Institute for Safety and Hygiene in the Workplace of Spain INSTH was used as a measuring instrument, which has been designed as an initial risk detection tool and in case of identifying any in its results is decisive for the selection of the method of evaluation of ergonomic risks. (Cañas, 2011)

In the application of the method (INSTH NTP 601), the body of the worker was divided into two groups: (INSTH, 2003).

- Group A (trunk, neck and legs)
- Group B (arm, forearm and wrists)

Materials:

- Goniometer
- Measuring tape
- Photo and video camera
- REBA method tables

Factors considered:

- Thermal conditions
- Noise
- Illumination
- Drawing of the work station
- Working with display screens
- Manipulation of load
- Uncomfortable postures and repetitiveness
- Forces
- Mental load
- Psychosocial factors The Application Procedure also indicates that it is necessary to collect data on the handling of loads:
- Actual weight of the load handled by the worker
- Duration of the task
- Positions of the load with respect to the body: height and separation of the load of the body. Vertical displacement of the load or height to which the load is lifted
- trunk rotation
- Type of load grip. Duration of handling
- Frequency of manipulation. Load transport distance.

4. RESULTS

With the results obtained, it was possible to determine that for this study in the second step the evaluation of the postural load by the method REBA (Rapid, Estire Body Assement) proposed by Sue Hignett and Linn Mc.Atamney published in the specialized journal Aplied Ergonomic in the year 2000. (Smolander & Louhevaara, 2001). In order to assess the degree of worker exposure to risk by adopting inappropriate postures, dividing the body into segments to be individually coded: Upper limbs, trunk, neck and legs. The result determines the level of risk of injury by establishing the level of action required and the urgency of the intervention. (INSTH, NTP 601). The results of the evaluation classify the surveys in surveys with tolerable risk and with a non-tolerable risk. Before applying the survey, a conversation was held with each worker and some said they had suffered recent physical ailments, which sometimes caused them medical disabilities as can be seen in the graph.

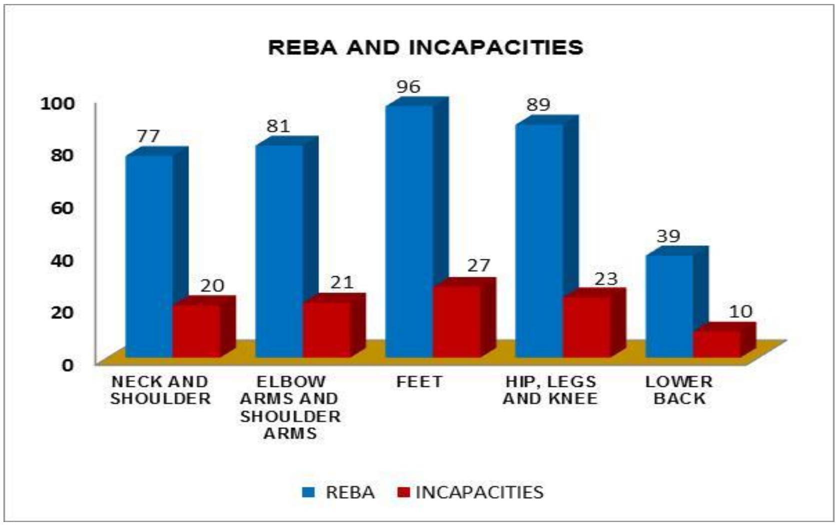
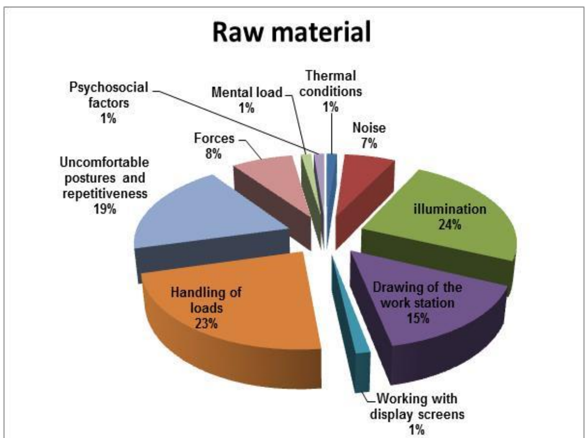
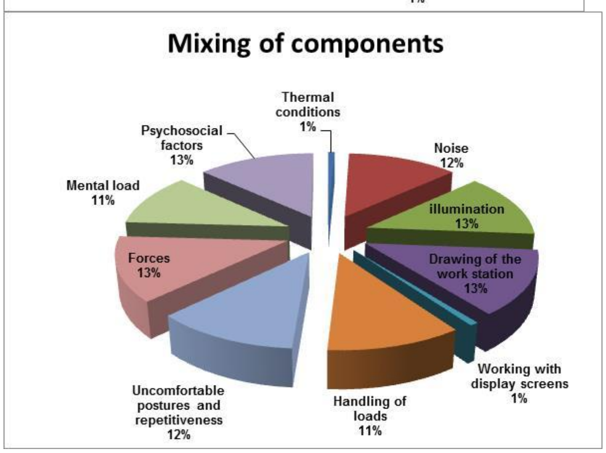


Figure 1. Summary of the results of REBA and incapacities before the proposed changes

The results of the evaluation classify the surveys in surveys with tolerable risk and with a non-tolerable risk. Summary of the results obtained by area in the identification of potential risks through the INSTH List in Figure 2.





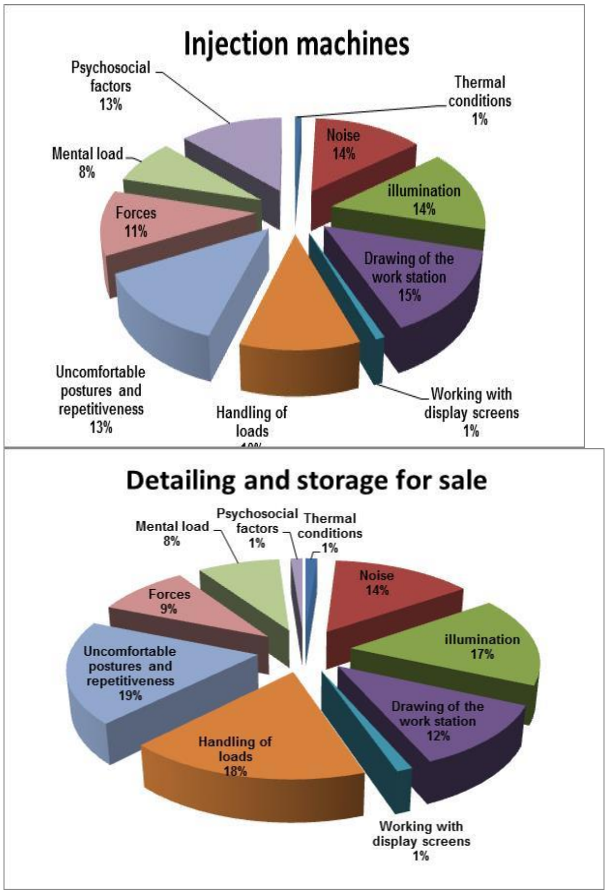


Figure 2. Summary of the results the INSTH List

Table 2 shows the results of the REBA method, including the score of the degree of risk identified by area and its impact on performance for the implementation of changes and their temporality. (Grandjean, 2013).

Table 2. Result of method (INSTH NTP 601),

Evaluatión REBA	**Raw material**	**Mixing of components**	**Injection machines**	**Detailing and storage for sale**
Stance	5a	2b	c	2d
Level of action	2	3	3	2
Level of risk	**medium**	**high**	**high**	**medium**
Performance	action half	immediate action	immediate action	action half

Table 3. Result of method (INSTH NTP 601)

Factors	**Raw material**	**Mixing of components**	**Injection machines**	**Detailing and storage for sale**
Temperature				

	Regulated temperature	Regulated temperature	Regulated temperature	Regulated temperature
Noise Decibels	79 Db	80 Db	70 Db	83 Db
Iluminatión Luxes	50 de 100	450 de 750	300 de 750	500 de1000
Drawing of the work station	It requires stretching and uncomfortable positions	Tables high with respect to the anthropometry of workers, stretching, insufficient space.	Movement of materials and heavy vehicles	Movement of materials and heavy vehicles Working with display screens
Working with display screens	Not applicable	Not applicable	Not applicable	Not applicable
Handling of loads	Loads> 6 Kg, above the man or below the knees, trunk turned, load with position of straight legs and inclined trunk.	Loads> 3 Kg, above the man or below the knees, trunk turned, load with position of straight legs and inclined trunk. Loads with straight leg position and inclined trunk.	Loads with straight leg position and inclined trunk.	Loads> 6 Kg, above the man or below the knees, trunk turned, load with position of straight legs and inclined trunk.
Uncomfortable postures and repetitiveness	Forced postures of trunk, neck and legs, as well as arm, forearm and wrists	Forced positions of trunk, neck and legs, as well as arm, forearm and wrists Repetitive movements of arms, hands and wrists. Prolonged standing posture	Forced positions of trunk, neck and legs, as well as arm, forearm and wrists Prolonged standing posture with knee flexion	Prolonged standing posture
Forces	Loads> 6 Kg,	3 Kg, weight	Drag loads with straight leg position and inclined trunk	Drag loads with high positions..
Mental load	Not applicable	Not applicable	Not applicable	Not applicable
Psychosocial factors	Rotation of turns	Rotation of turns	Rotation of turns	Rotation of turns

Based on the results obtained, the following actions were made and implemented:

1. The biggest accidents and disabilities occurred in the third shift in addition to low productivity, which resulted in high costs for social insurance and especially in the health of workers, so it was decided to eliminate the night shift.

2. The weighing area was reassigned to expand the spaces and recondition with furniture according to the anthropometric measurements of the workers, in this way uncomfortable postures and dangerous displacements were avoided, in addition to a greater cleanliness and order in the corridors. It was proposed to purchase platforms for the displacement and lifting of heavy loads in small areas.
3. Generation of a preventive maintenance plan in addition to noise reduction adapters in the injectors and mills, due to the high level they generate, in addition to the use of protective equipment such as earmuffs and earplugs. (STPS, 2014).
4. Isolate with panels, machinery and noisy areas, especially the mill area. Training to all personnel on the importance of implementing a culture in ergonomics for personal care and as a working group. (OIT, 2013)
7. Train personnel performing activities in lifting loads on the correct positions (posture, grip, turns, application of forces.
8. Modify container design and adapt better grip systems.

The Table 4 shows the results of the REBA method, after carrying out these actions.

Table 4. Result of method REBA studies were repeated.

Evaluatión REBA	Raw material	Mixing of components	Injection machines	Detailing and storage for sale
Stance	1a	1a	3a	1a
Level of action	1	2	2	1
Level of risk	**low**	**medium**	**medium**	**low**
Performance	action without	action half	action half	action without

Figure 3 shows the results of the second application of the REBA method after the new implementations, where the decrease in medical disabilities is appreciated.

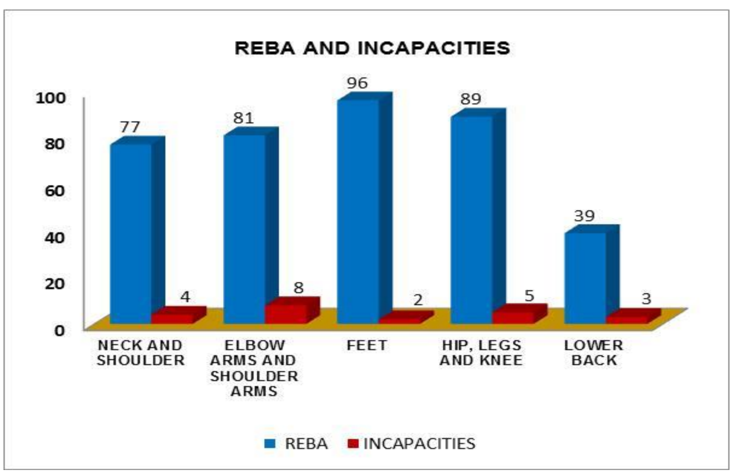


Figure 3. Summary of the results of REBA and incapacities after the proposed changes

5. CONCLUSIONS

The 18 workers who participated in the study have reported that the conditions to which they are exposed by the nature of the work they perform, implies knowledge and permanent plans in the control and elimination of elements that generate risk factors in factors such as: prolonged standing, repetitive movements, and forced postures, in addition to lifting loads improperly. With the study carried out through the INSTH list, it was obtained as a highly relevant data such as forced postures and repetitiveness in the control of mixtures; in machining and finishing excessive noise and psychosocial factors in relation to work shifts. Regarding the jobs, the forced postures were very evident and the handling of loads. (STPS, 2014)

Regarding the licensing Disney, the company was very satisfied with the work done, which did not generate the contracted consultants for which in the first two audits were rejected for not having documented work conditions with studies and ergonomic methods.

In the third and last revision, the businessmen showed the auditors the ergonomic studies carried out, as well as the data obtained in an initial condition and after the implementation of changes and improvements with the information documented with evidences and the elaboration of the various maintenance plans, training, follow-up and continuity of the same. The information was correct and adequate for the Delta company to have obtained the ILS Certification and Licensing. This highlights the impact and relevance of ergonomics in compliance with UN and ILO regulations for the preservation of workers' health. The results have been decisive in the development of new procedures, restructuring jobs and training courses to prevent further damage to the operators and to introduce the company's awareness of the importance of health care and this way also meet the requirements, in addition to the organization shall maintain its premises in a state of order, cleanliness and safety, in order to reduce occupational hazards, without discrediting industrial productivity

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LATIN AMERICAN COMPLEXITY AND CONSTRUCTIVISM METHODOLOGICAL CONTRIBUTIONS TO PARTICIPATORY ERGONOMICS

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Resumen La presente investigación tiene como objetivo presentar los estudios de ergonomía participativa y analizar su aplicación en países latinoamericanos. Se exponen métodos vanguardistas de la ergonomía participativa que permiten analizar su campo epistemológico y de método. Finalmente, se visualizará la pertinencia en países latinoamericanos para generar una propuesta de aplicabilidad desde la complejidad y el constructivismo.

Palabras clave: Ergonomía participativa, diseño participativo, complejidad, constructivismo.

Relevancia para la ergonomía: Se presenta un diseño participativo de vanguardia para aplicarse en ergonomía participativa en América Latina. Se propone la pertinencia de una metodología de ergonomía participativa latinoamericana.

Abstract: The research aims to present participatory ergonomics studies for analyzing its application in Latin American countries. The participative ergonomics is exposed so as to allow the analysis of its epistemological field and method, as well as the relevance in Latin American countries. Finally, a constructivist research and complex methodology of Latin American participatory ergonomics is looked into taking into consideration some characteristics and problems.

Keywords: Participatory ergonomics, participatory design, complexity, constructivism.

Relevance to Ergonomics: The first state-of-the-art items in Latin American participatory design and ergonomic design is presented. A methodology of Latin American participatory ergonomics is investigated by considering some characteristics and problems.

1. INTRODUCTION

The research presents the experiences of participatory design and complexity theories that have been successfully applied in Latin-American architectural and urban studies. The research presents a new participatory ergonomics methodology founded in Latin American participatory design experiences.

2. OBJETIVES

To generate a state-of-the-art of the main contributions of participatory design theorists in Latin America.
To identify constructivist proposals and theories of Latin American complexity to be applied in participatory ergonomics.
To propose a complex methodology of participatory Latin American ergonomics.

3. METHODOLOGY

1. State-of-the-art. Documentary research: In this phase the Latin American literature is contrasted with the most relevant Anglo-Saxon one on the subject.
2**.** Latin-American contributions to participatory design. This phase justifies the need to include Latin American experiences for a new methodological proposal of participatory ergonomics. The case study is a complex thinking (Edgar Morin) and a constructivist research method (Rolando García).
3. Conclusions and recommendations

4. RESULTS

4.1 Participatory ergonomic: State-of-the-art

Modern participatory ergonomics is said to have begun in 1980 with the discursive base of involving workers to identify risks and propose solutions in labor processes (García, *et al.*, 2009). In the first decades of the 20th century the proposal had little evidence and supporting theories (Haines, *et al*., 2002), this panorama changed at the beginning of the 21st century, as studies have been increasing. Between 1985 and 2004 there were 442 papers identified for their quantitative studies about participatory ergonomics (Cole, 2005).

Burgess - Limerick (2018) states that these studies include a greater participation of workers in a consultative or representative way to reduce occupational risks, proposing managerial decision-making, improve working environments in the "macro-sphere" when redesigning jobs and in the organization of work in the "micro-sphere" that affects the redesign of working teams.

Despite the increase in studies of participatory ergonomics, this scenario does not occur in studies in Spanish. On the European Ergopar page, 21 materials are cited in Spanish, which detail the experiences of the use of participatory ergonomics methodologies in articles, employment experiences and videos (Ergopar, 2019). Of these materials, four are experiences on vulnerable conditions: Participatory ergonomics in attention to disability; participatory experiences in centers for the disabled and experiences of participatory ergonomics in four centers for the disabled (Ergopar, 2019). In Latin America, information is still lower. Therefore, it is necessary to propose strategies of participatory ergonomics to be applied in disadvantaged societies.

Due to the few studies of participatory ergonomics in Latin America, the epistemological field and the method are marked by external experiences in these countries. The field of action of participatory ergonomics is located in an epistemology of economic rationality and its method in strategic planning. Its epistemological base seeks the maximization of resources to achieve productive ends. For García, *et al*. (2009) participatory ergonomics has as a strategy the planning of work to achieve a specific goal. Wilson (1995) explains that the strategy is to include workers so that they influence their own work processes and obtain desirable goals.

Accordingly, Table 1 is presented, in which the proposal of participatory ergonomics is summarized.

Table 1. Participatory ergonomic methodologies

Burgess – Limerick (2018)	García, A. Gadea, R. Sevilla, M. Genís, S. y Ronda, E. (2009)	Camelo (2013)	Summary
1 Location of the power to make decisions.	1 Forecast of problems with foreseeable obstacles for the development of the program.	1 Planning and delimitation of the project of the company.	1 Approach to the problem situation.
2 Representative participation of workers and identification of problems to be dealt with.	2 Participation of workers who make proposals and solutions.	2 Review of experiences and methodologies	2 Research design
3 The specialist is a facilitator who can be consulted by workers during the results process.	3 Participation of workers in the evaluation and effectiveness of solutions.	3 Development of the design and accessibility project.	3 Research and analysis
4 Approach directed to the level of design with respect to the tasks undertaken.	4 Commitment of management to establish the scope of resources.	4 Proposal linked to participation to implement design ideas.	4 Writing the report and socializing results.
5 Intervention at the level of the work team or department for the entire organization.	5 The specialist supports the development of the program, management and supported the necessary tasks.	5 Proposal linked to participation to implement design ideas.	5 Diagnoses.
6 Permanence of the intervention to solve the proposed program.	6 Adjustment in each phase with a broad focus on health as in the work environment.	6 Proposal linked to participation to implement design ideas.	6 Generation of the program.
7 Possible permanence of the intervention to solve problems.	7 Cost evaluation - benefits to anticipate expected results.	7 Proposal linked to participation to implement design ideas.	7 Evaluation and execution.

Source: Own elaboration based on Burgess – Limerick (2018), García, A. Gadea, R. Sevilla, M. Genís, S. y Ronda, E. (2009) and Camelo (2013).

Participatory ergonomics with its rational approach seeks to register improvements in the productive process from the workers themselves, this vision can be validated in societies with a high average level of social equality and strong labor rights. However, in developing countries, as in the case of Mexico or Colombia (García, Camelo, y Rodríguez, 2017), they have the difficulty of wide margins of social and labor inequality produced by global development. That authors like Saravi (2009) and Bayón (2012) frame it as an accumulation of social disadvantages, and they become evident in an urbanity with high percentages of popular settlements that are consolidated in decades (Suárez, 2017) , and with a high rate of informal work. Therefore, it is necessary to make adjustments both at an epistemological level and as a method to achieve its applicability in Latin America.

4.2 Latin-American contributions to participatory design

The first difference is to consider participation as a process. A process is a change or a series of changes that constitute the course of action of relationships that are designated as "causal" between events (natural or produced by human intervention) (García, 2000, p. 70). This is how morphological or object analysis is not what only matters, but also the process that brings with it the ergonomic design of the action to be analyzed.

Unlike some Anglo-Saxon proposals that define participatory ergonomics as “The involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals” (Wilson, 1991) Gustavo Romero y Rosendo Mesías (2004) points out an important difference between planning and participatory design. For Romero (2004), planning is aimed at organizing generally complex processes and directing them to specific objectives, in terms of their activities, uses, possible resources and the construction of consensus and decisions to achieve the objectives. For its part, the design aims to prefigure solutions and morphological and spatial responses appropriate to the demands that may or may not be part of a planned process (Romero, 2004). This difference has made it possible to differentiate proposals that only serve the organization and those that prefigure design responses.

Based on Romero's (Oliveras, 2008) proposal, a methodology of participatory ergonomics that includes planning and design can allow: fostering democratic culture in decision making, a proposal to generate strategies in less favored groups of society and a tool for ergonomics experts are incorporated into these processes.

Now, the tool that allows us to approach this type of process has been the complexity approach. The complexity has been addressed through two perspectives: The complex thinking of Edgar Morin and the genetic constructivism of Rolando García.

4.2.1 Morin´s epistemic influence on participatory design

The derivation of this perspective has opened new possibilities of teaching with new approaches based on complex thinking. This proposal, developed by Edgar Morin, is a reorganization of the relationships between science, philosophy and art through an interdisciplinary and trans-disciplinary articulation of knowledge focused on anthropologic problems (Morin, 2007). From educational, anthropologic, political and ethical theories, complex thinking has influenced syllabi from different educational institutions; in Brazil, the Institute of Complexity Studies (Instituto de Estudios de Complejidad) of Río de Janeiro and the Universidad del Río Grande del Norte; in Perú, the Universidad de Lambayeque or the Universidad Ricardo Palma de Lima; in Uruguay, the Latin American Center for Human Economy (Centro Latinoamericano de Economía Humana); in Colombia, the Colombian Association for Complex Thought (Asociación Colombiana para el Pensamiento Complejo); in Argentina, the Community of Complex Thought (Comunidad de Pensamiento Complejo) and in México, the Real Edgar Morin World Multiversity (Multiversidad Mundo Real Edgar Morin) in Hermosillo Sonora.

The complex thinking approaches in Latin America have allowed questioning the so-called “blind intelligence”, this is, that knowledge which is incapable of reflecting on itself and that is manipulated by anonymous powers and that go further away from everyday human problems. This has given way to a debate on how many a times specialization has led to a fragmentation of the problems of reality (Martin Juez, 2002). Similarly, it has proposed the use of a poetic function and the metaphor on the generation of algorithms and models. Its influence opened the possibility of acquiring knowledge that, not being of a scientific nature, may be legitimized by the transition from a symbolic order to a real one with an ethical commitment.

4.2.2 Garcia´s influence on participatory design

In the face of the crisis of apriorism and empiricism related to the general problem of knowledge, Rolando García developed the genetic constructivist epistemology. It is an epistemology because it refers to the conception of knowledge; it is constructivist as it considers that reality is not given, but constructed by the researcher, and genetic since its objective is to study the genesis of knowledge. Parting from Piaget’s ideas, Rolando García developed the complex systems interdisciplinary research methodology. Said proposal generated novel design research approaches in Latin America as this was founded on a process that constitute one of the basic mechanisms of cognitive development: the differentiation process from a given reality and the integration or reintegration of a conceptually more enriched totality.

To Rolando García (1988), the complex systems interdisciplinary research methodology sees the light when there is a need of creating new questions to solve “old problems” with the integration of different types of knowledge. The complex system or piece of reality a researcher wishes to study would only be possible to face if there is a common conceptual framework shared by all researchers involved (García, 1994). The methodology proposed by García is of an operational character and was configured as an option of the positivist proposal where the specialist work is not undervalued, but rather it is integrated at different stages of a research project.

By means of this methodology, large-scale systems in Latin America cities design (López Rangel, 2018), and problems related to vulnerable societies have been studied as complex systems (Osnaya, et al 2017). Similarly, there have been contributions to interdisciplinary research on natural disasters and attention to vulnerable societies based on his approach.

RECOMMENDATIONS

Recommendations for the application of participatory ergonomics in Latin America should take into account the context of social, labor and cultural diversity. Consequently, participatory ergonomics and complexity will be called, this last category arises from the epistemology of complex thought and genetic constructivism.

The distinction between participatory ergonomics and complexity with participative ergonomics focuses on the fact that participation, being a constantly changing process, tends to reorganize labor actions with respect to means - ends of subjects in correlation with objects (García, 2000). But such maximization is not considered in itself with a rational economic primacy, but the means - ends of the participatory planning depend on adequate conditions of use of the design (Romero, 2004), and this adaptation part of the social meanings that allow appropriation and appropriation in a specific social context (Castañeda, 2012). This vision considers transdisciplinary articulations (Morin, 2007), in the process of planning and designing labor systems.

Hence, the following epistemological bases are indicated: 1) It is necessary to correlate participatory ergonomics with complexity so that the interrelation between labor objects and processes is visualized together with the subjects with their social meanings that make possible the actions of social and material objects. 2) Participative ergonomics will aim not at designing the work system but at redesigning the system according to social regions. 3) The productive process itself is irreducible to the economic model but it will be open to other social functions accompanied by symbolic representations (Godelier, 1989), which are multiple and constructed realities (Castañeda, 2012). 4) The study of regional realities are interpretable (Geertz, 2003), and will have to adapt to the conditions of the region.

The method of participatory ergonomics and complexity incorporates an approach that points to alternative labor processes from participatory action research (Ander - Egg, 1990): I) Approach to the problem situation through the formation of a team between specialists and applicants. Include in the decision-making productive models: cooperatives, small local businesses, financing, technical assistance times, among others. And linkage to existing regulations or potential to modify the existing rules. II) Research design that correlates social meanings, production, work and possible scenarios of transfer of social and technical technologies that are appropriate and appropriable to regional realities to generate self-managing processes. III) Research and analysis of data from qualitative and quantitative methods. IV) Drafting of the report and socialization of results that keeps open the possibility of enriching the diagnosis by making them available to the interested community. V) Diagnosis of the problem situation with SWOT analysis. VI)

Generation of the program with possible solution scenarios. VII) Evaluation and execution of the program.

CONCLUSIONS

The research provides a state-of-the-art of the main contributions of participatory design theorists in Latin America and proposes a Latin American methodology of participatory ergonomics. Although, mainly, in the Anglo-Saxon countries there are several participatory ergonomics studies, in Latin America there is small information on the subject. However, the above, the experience of participatory design based on constructivist approaches and complexity have been used successfully in Latin America and the methodology is a useful in participatory ergonomics

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DIAGNOSIS OF THE PSYCHOSOCIAL RISK FACTORS IN A MANUFACTURING INDUSTRY

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Resumen: De acuerdo a información de la OIT (1984), el estrés relacionado con el trabajo y sus consecuencias sobre la salud de los trabajadores ha surgido como una cuestión de gran preocupación, el acoso, la violencia psicológica y otras formas de violencia no física se presentan con cierta recurrencia.

La industria automotriz es de gran importancia para el país, México es el séptimo productor de automóviles en todo el mundo. Como resultado de la actividad económica industrial, el número de casos diagnosticados como enfermedades mentales ha aumentado gradualmente.
Es importante mencionar que en México, la autoridad federal de salud ocupacional hace obligatorio identificar la exposición del trabajador a Factores de Riesgos Psicosociales (FRPS)

Esta investigación busca analizar las posibles causas que puedan ocasionar FRPS en las empresas y pretende proponer acciones para mitigar sus consecuencias. El cuestionario que se aplicará es el sugerido por la Secretaría del Trabajo y Previsión Social (STPS) el cual permite establecer inferencias sobre el ambiente de trabajo en la empresa.

Palabras clave: Estrés, Riesgos Psicosociales, Normas oficiales.

Abstract: According to information from the ILO (1984), work-related stress and its consequences on workers' health have emerged as a matter of great concern, harassment, psychological violence and other forms of non-physical violence; they present themselves with some recurrence.

The automotive industry is of great importance to the country, Mexico is the seventh producer of automobiles in the world. As a result of industrial economic activity, the number of cases diagnosed as mental illnesses has gradually increased.

It is important to mention that in Mexico, the federal occupational health authority makes it mandatory to identify the worker's exposure to Psychosocial Risk Factors (FRPS).

This research seeks to analyze the possible causes that may cause FRPS in companies and intends to propose actions to mitigate its consequences. The questionnaire that will be applied is the one suggested by the Ministry of Labor and Social Security (STPS), which allows establishing inferences about the work environment in the company.

Keywords: Stress, Psychosocial Risk Factors, Normative.

Relevance for ergonomics: when establishing the STPS the obligation of the companies to develop strategies for the reduction or elimination of the FRPS and the generation of a favorable organizational environment this study allows the companies to develop strategies to maintain the organizational health, likewise it pretends be a reference for studies related to the subject.

1. INTRODUCTION

The psychosocial risk factors (FRPS) and their negative effects related to work have been abundantly studied. In several countries there are regulations, decrees and regulations aimed at reducing exposure to risks and their consequences on workers' health.

The FRPS have been associated in the industries governed by continuous flow production systems, organized by the concepts of the system just in time and that require great flexibility in their structures of work organization to maintain a competitive level according to the demands of the globalized markets.

The International Labor Organization (ILO) has recognized psychosocial factors as a fundamental part of development in organizations considering them a positive component that promotes conservation and, sometimes, the improvement of health. However, the negative component has been associated -with some relative importance- with the appearance of diseases that can arise in practically the whole environment where people interact, particularly in the work environment, in certain aspects of the organization, in the systems and physical aspects of work and human relations, impacting on the social climate of the company and the physical and mental health of workers (ILO, 1984).

The above effects can have a decisive impact on companies if it is considered that the specific characteristics of each of the workers develop various results in the face of exposure to adverse psychosocial factors. The needs, expectations, tolerance to the various levels of stress exposure and frustration at work, can influence the adaptation of the employee to their work environment and strongly determine the intensity and nature of the behavior that presents itself to the problems of the organization.

For the company it is essential to generate strategies for detecting psychosocial factors and risks that may arise in the daily work, not necessarily generated by the same organization as the worker is exposed to a number of situations that can reduce their ability to resistance in such a way that, a situation that for others is not important, can trigger a crisis in another worker.

The aim of this paper is to address the issue of psychosocial risk factors since the coincidence in Mexico of the boom in the Automotive Industry and changes in the federal regulations on occupational safety and health, effective as of October of 2018, which includes psychosocial risk factors. According to data from the Mexican Association of the Automotive Industry, (AMIA, 2016) the country has 668,456 jobs related to the automotive industry.

1.1 BACKGROUND

The evolution of humanity from the technological changes of the nineteenth century has had a great impact on society, specifically in relation to work.

Thousands of people exchanged work in the field for work in the factories, today, already into the 21st century; a large amount of labor is used in the production of consumer goods. Mexico has grown continuously in the attraction of manufacturing industry, much of it for export. According to data from INEGI (2016) in September, more than 3.5 million people were employed in this economic activity. In the state of Sonora, more than 160 thousand people are employed in this industry, which represents 28%. The manufacturing industry is taken as a reference because it is a structured activity and with very similar work schemes, inputs are usually received for production, processed and sent to customers. Generally, time is a fundamental factor and exerts a certain type of pressure.

The generation of jobs is important and is a constant concern of governments at any level, however, there is a residual in the process that without not having enough attention can result in a bigger problem; occupational health which analyzes four major components; safety at work, hygiene for the prevention of diseases, ergonomics and psychosocial factors.

The psychosocial risk factors have been included in the Federal Regulation of Safety and Health at Work (RFSST) published in November 2014 and which has come into force this year. To make effective what is proposed by the RFSST, Normatively is required and the Official Mexican Standard NOM-035-STPS-2018, "Psychosocial Risk Factors-Identification and Prevention", has recently been published in the Official Gazette of the Federation.

This is a breakthrough in occupational health, but what are psychosocial risk factors?

When referring to psychosocial factors, the International Labor Organization (1984) defines them as interactions on the one hand, between work, environment, satisfaction and conditions of the organization, and on the other hand, the worker's capacities, their needs, culture and the personal situation that prevails outside of work, considering for this the perceptions and experiences expressed by the worker in the company. In Mexico, the Ministry of Labor and Social Welfare defines psychosocial factors as those risks capable of generating anxiety disorders, not organic sleep-wake cycle and severe stress and adaptation, arising from the nature of the functions of the workplace, type of working day and the exposure of the worker to severe traumatic events or acts of labor violence due to the work carried out (NOM-035-2018).

Although it is difficult to determine which are the main psychosocial risk, the studies (ILO, 2014, Moreno and Báez, 2010) make it possible to identify some of the most important: stress, burnout and work shifts.

Legislation in Mexico

On November 13, 2014 the Federal Regulation of Occupational Health and Safety (RFSST) was published in the Federal Official Gazette, according to the provisions of the first of the transitory articles, there is a period of three months for the entry into force of this regulation, that is, from February 13, 2015.

Article 43 states that "employers must":

I. Identify and analyze jobs with psychosocial risk by the nature of their functions or the type of workday;

II. Identify workers who were subjected to severe traumatic events or acts of Labor Violence, and evaluate them clinically;

III. Adopt the pertinent preventive measures to mitigate the Psychosocial Risk Factors;

IV. Practice examinations or clinical evaluations to the Occupationally Exposed Person to Psychosocial Risk Factors, as required;

V. Inform workers about possible alterations to health due to exposure to Psychosocial Risk Factors, and

VI. Keep records about the preventive measures taken and the results of the examinations or clinical evaluations.

Understanding also, the need to have a safety and health at work program to avoid risks in the workplace. The process of identifying psychosocial risks should start with a diagnosis of safety and health at work and, consequently, establish the set of actions aimed at prevention and correction.

Psychosocial Risk Prevention Strategies

Identifying the negative psychosocial factors that impact the worker implies an in-depth evaluation and analysis by the organization to generate a map of risks inherent in the company. The difficulty lies in the perception factor that prevails in the worker's behavior. The attitude, knowledge, experiences, social and family environment that are part of the context in which the worker develops can affect their work performance and what for a worker is a normal situation without any particularity that disturbs, for other people can be an emotional trigger that impacts your work and group work.

In this context, the manufacturing industry, particularly the automotive industry (IA), is fundamental for the development of the global economy, according to the data of the International Organization of Automobile Manufacturers (OICA, 2015), production worldwide of cars, family vehicles and light vehicles in 2014 reached the figure of 89, 747,430 units. In the same source it is mentioned that the AI represents the incorporation of more than twelve million workers for the manufacture of the total of automobiles, more considering approximately 5 additional jobs for each direct employment, the total is close to 60 million jobs related to the automotive industry.

2. THEORETICAL FRAMEWORK

As previously mentioned, the International Labor Organization (1984) defines Psychosocial Factors as interactions on the one hand, between work, environment, satisfaction and conditions of the organization and on the other hand, the worker's capacities, their needs, culture and the personal situation that prevails outside of work, considering for this the perceptions and experiences expressed by the worker in the company.

Other studies of psychosocial risks (Cox et al, 2003, Velázquez, 2010) include the content, pace and program of work, control, environment and equipment, the culture of the organization, interpersonal relationships at work, role in the company, development professional and interrelation between the organization and the worker's house. Although it is difficult to determine which the main psychosocial risks are, the studies (ILO, 2014, Moreno and Báez, 2010) allow identifying some of the most important:

Stress.

Stress is caused in part by the imbalance between the demands and pressures faced by the worker in the position and by the other, the skills and knowledge that it has (Stravoula et al., 2004). When the needs of the environment exceed the capabilities of the worker can trigger adverse effects on physical and mental health such as exhaustion, depression to the detriment of their quality of life and productivity, even leading to the termination of the contract.

The characteristics of the position, volume, rhythm and work schedules as well as the participation and control exercised by the company are triggers of stressors in the company, mismanaged administration, poorly designed processes and demanding work shifts are red hot spots that must be considered when establishing improvement strategies within the organization and that are aimed at developing the skills and competencies of the worker in a work environment that promotes creativity, motivation and productivity.

Burnout

Widely related to stress, the burnout term was used in the 70s after analyzing the behavior of some police officers of that time, according to data from the portal of work stress, were the psychologists S. Jackson and C. Maslasch those who in 1981 identified burnout as a "syndrome of emotional fatigue, depersonalization and less personal fulfillment, which usually occurs more frequently in jobs that merit attention to third parties, by physically and mentally debilitating the employee. Efficiently develop your work and increasing stress levels that can ultimately affect your behavior. "

The work shifts

The agitated dynamics of organizations in industrialized countries has led to the need to incorporate a shift system that covers 24 hours to meet the demands of the market, considering the fragmentation of schedules in shifts that include Sundays and holidays causing These work rhythms generate physical and mental imbalances in the worker.

According to the Foundation for the Prevention of Occupational Risks, sleeping during the day does not allow the organism to adapt easily, as when sleeping at night, sleep provides a state of uniform rest of the organism characterized by low levels of physiological activity which includes Two phases; one of slow sleep allowing the physical recovery of the organism and the other of rapid sleep that helps the psychic recovery. It is necessary to sleep at night around 7 hours to be able to travel through all phases of sleep and obtain physical and mental recovery.

3. METHODOLOGY

Due to its characteristics, this study observes situations that already prevail in the day-to-day activities of companies and there are no external controls on the variables, which is why it can be defined as a non-experimental investigation (Hernández, Fernández and Baptista, 2014), since it is located in a unique moment of time, can be defined as transactional or transversal.

A first approach towards the determination of the FRPS that prevails in the companies of the automotive sector was made through the instrument of information collection suggested by the STPS in the NOM-035-2018, applying it to 50 workers of the company.

The results obtained from the applied surveys were processed using the statistically.

4. RESULTS

As can be seen in table 2, the global average obtained by the company according to the parameters established by NOM-035, table2, is low with a 72.72

Table 1. Parameters for the global results (NOM 035 STPS 2018)

Resultados del cuestionario	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Calificación final del cuestionario C_{final}	$C_{final}<50$	$50\leq C_{final}<75$	$75\leq C_{final}<99$	$99\leq C_{final}<140$	$C_{final}\geq 140$

Table 2. Global average**.**

Nulo	Bajo	Medio	Alto	Muy alto	Promedio global
51.32	15	6.4	0	0	**72.72**

Table 3 shows the parameters established in the standard for each category, table 4 presents the data obtained from the average of the sum of the scores of the items by category according to the evaluation of the qualification ranges of the same, indicating that the categories of factors specific to the activity and organization of working time represent a medium level of risk.

Tabla 3. Parameters by category (NOM 035 STPS 2018)

Calificación de la categoría	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Ambiente de trabajo	$C_{cat}<5$	$5\leq C_{cat}<9$	$9\leq C_{cat}<11$	$11\leq C_{cat}<14$	$C_{cat}\geq 14$
Factores propios de la actividad	$C_{cat}<15$	$15\leq C_{cat}<30$	$30\leq C_{cat}<45$	$45\leq C_{cat}<60$	$C_{cat}\geq 60$
Organización del tiempo de trabajo	$C_{cat}<5$	$5\leq C_{cat}<7$	$7\leq C_{cat}<10$	$10\leq C_{cat}<13$	$C_{cat}\geq 13$
Liderazgo y relaciones en el trabajo	$C_{cat}<14$	$14\leq C_{cat}<29$	$29\leq C_{cat}<42$	$42\leq C_{cat}<58$	$C_{cat}\geq 58$
Entorno organizacional	$C_{cat}<10$	$10\leq C_{cat}<14$	$14\leq C_{cat}<18$	$18\leq C_{cat}<23$	$C_{cat}\geq 23$

Tabla 3. Parameters by category (NOM 035 STPS 2018

Table 4. Results by category. Own data

Categoría	Nulo	Bajo	Medio	Alto	Muy alto	Promedio
Ambiente de trabajo	1.24	1.64	0	0.44	0	3.32
Factores propios de la actividad	0	3.28	23.28	7.72	5.24	**39.52**
Organización del tiempo de trabajo	0.28	1.24	2.44	2.6	0.68	**7.24**
Liderazgo y relaciones en el trabajo	4.04	6.56	1.56	2.28	0	14.44
Entorno organizacional	3.12	1.72	2.32	0	1.04	8.2
Total						**72.72**

As can be observed in the tables, the overall results indicate a level of zero risk, so according to the table specified in NOM-035 no additional high-impact measures are required, but nevertheless, the classification by category and by domain they indicated an average level of risk, where the main categories that represented this level of risk are the factors of the activity and the organization of time and, on the other hand, the domain that affects these categories mentioned above is the burden of work and work day.

The above suggests an increase in the degree of personal interest that the organization shows for the workers. It is necessary that within the organization the functions and / or attributions of each person are well defined, in order to guarantee the optimal adaptation between the jobs and the people who occupy them.

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ANALYSIS AND IMPROVEMENTS OF POSTS IN THE AREA OF SHIPMENTS IN WIRING INDUSTRY AND CIRCUITS

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Resumen: El balance o balanceo de línea es una de las herramientas más importantes para el control de la producción, dado que de una línea de fabricación equilibrada depende la optimización de ciertas variables que afectan la productividad de un proceso, variables tales como los son los inventarios de producto en proceso, los tiempos de fabricación y las estrategias parciales de producción. La Distribución de plantas según Sortino, (6 de junio, 2001), implica un ordenamiento físico de los elementos considerados este ordenamiento requiere espacio para movimientos de materiales, almacenamientos y procesos, además de las actividades de servicio relacionadas. Realizar un análisis sobre errores cometidos en la distribución de gran cantidad de empresas de nuestro país (y de muchos otros) sería sumamente extenso. Lo importante no es efectuar una excelente descripción de los errores cometidos, sino aprender de ellos, sus causas y buscar posibilidades para corregirlos. Se destaca la importancia de un buen Layout. Se debe de incluir esta expresión en el vocabulario de uso técnico diario, como generalidad para todo lo que es distribución, ordenamiento de un sector, máquinas y equipos.

El siguiente trabajo se hablará de las cargas de trabajo, que son determinantes para el balanceo, cuyo objetivo principal fue balancear la carga de los operadores del área de embarques en ambos turnos con el fin de que ambos turnos trabajen lo mismo, para de esta manera hacerle más fácil su jornada y evitar alguna lesión así como también que este logre un mayor rendimiento laboral.

Palabras Clave: Balanceo, análisis de puesto, mejora.

Relevancia para la ergonomía: Mediante una adecuada carga de trabajo de los operadores, preservar la salud de los mismos, y realizar una distribución equitativa de los trabajos a desarrollar de forma que evite tener accidentes o lesiones propias de la actividad laboral.

Abstract: The balance or balance of line is one of the most important tools for the control of production, since a line of balanced production depends on the optimization of certain variables that affect the productivity of a process, variables such as the inventories of product in process, manufacturing times and partial production strategies. The Distribution of plants according to Sortino, (June 6, 2001), implies a physical ordering of the elements considered this ordering requires space for movements of materials, storage and processes, in addition to the related service activities. Carrying out an analysis of mistakes made in the distribution of a large number of companies in our country (and many others) would be extremely extensive. The important thing is not to make an excellent description of the mistakes made, but to learn from them, their causes and look for possibilities to correct them. The importance of a good Layout is highlighted. This expression must be included in the vocabulary of daily technical use, as a generality for all that is distribution, ordering of a sector, machines and equipment.

The following work will talk about the workloads, which are decisive for the balancing, whose main objective was to balance the load of the operators of the area of shipments in both shifts in order that both shifts work the same, in this way Make your day easier and avoid any injury as well as that this achieves a higher work performance.

Keywords: Balance, work analysis, improvement

Relevance to ergonomics: Through an adequate workload of the operator's activities, preserve the health of the same, and make an equitable distribution of the work to be developed in a way that avoids accidents or injuries of the work activity.

1. INTRODUCTION

Studies of workloads constitute an instrument for the strategic management of human talent as they allow to plan and organize personnel plants and support other decision-making processes. These studies have normative feasibility for their execution and the information they provide is useful for the management of human talent in different processes such as human talent planning, integration to the institution, occupational health, compensation, organization and development

2.OBJECTIVES

Balance workloads in the Departures area of the materials department in Wiring and Electrical Circuits. To have balanced loads of work and a better use of time in both shifts

2.1 Specific objectives:

- Balance of workloads.
- Establish the current workload within the area studied.
- Making the most of the staff.
- Decrease of dead times.
- Use of technological equipment and resources.

- Establish an optimal procedure.
- Redistribute specific jobs for each technician

2. DELIMITATION

The recent investigation was carried out in Materials Department of the departures department in industrial circuits and wiring, in the city of Mochis Sinaloa.

3. METHODOLOGY:

The idea is to be able to detect which is the reason why there are workers that work more than one, several possible causes have been found through the observation of their activities among which we can mention: they do not follow the correct methodology imposed by the company, workers with downtime and others without moments to rest.

Our first point is to make aware of the established processes so that they are met in the correct way, these were defined to avoid losses to the company, to avoid errors or customs problems.

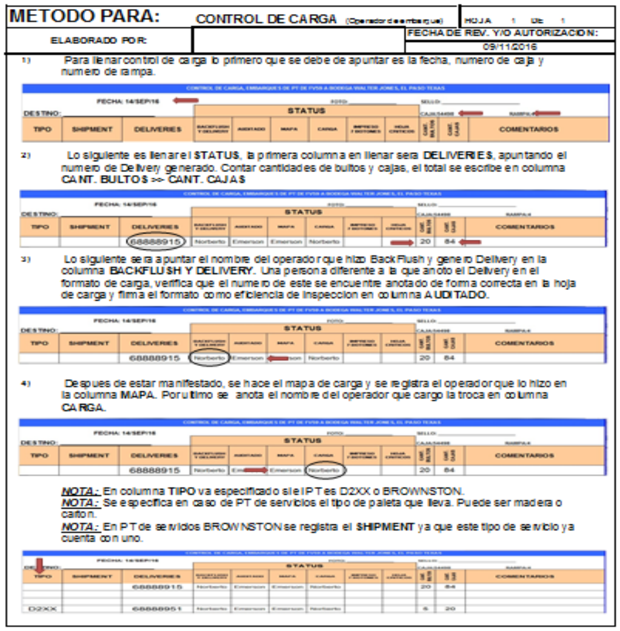
As in any process, we have to comply with the times indicated in order to maintain a healthy customer service, so that when we fail to comply with a delivery, we must identify the factors and attack them.

The main causes in this analysis are: discharges that were not made in time, damages in the cash register, search of materials out of time or a null knowledge of the work methodology.

The conclusion is corroborated that the root of the causes that alter the outputs lies in the knowledge and correct realization of the methodology, in addition to an update and improvements of already proposed methods. An example of a previous method is presented.

With the aforementioned, it was necessary to carry out the modifications immediately to reduce the losses that were being generated, among the improvements that were made, the placement of visual aids was first found, it is very important that operators see graphically the place where to place the product. to avoid any error that may arise. The use of downtime is another factor that could be improved, the equipment used are electric forklifts, therefore at the time of the change of battery were times without any activity, with this it was sought that the operator will perform his activities to place orders at that time.

And finally, we considered the application of a macro in Excel, this is so that when the finished product is registered in the area, the macro is recorded who brought it, what line, the name of the operator, this is only registering the skid serial number, and the worker number. In a certain way it helps a lot, it is essential that you continue with that step and not skip it. Always in constant communication with the operators.


METODO PARA: CONTROL DE CARGA (Operador de embarque) HOJA 1 DE 1
ELABORADO POR:
FECHA DE REV. Y/O AUTORIZACION: 09/11/2016

1) Para llenar control de carga lo primero que se debe de apuntar es la fecha, numero de caja y numero de rampa.

TIPO	SHIPMENT	DELIVERIES	STATUS								COMENTARIOS

2) Lo siguiente es llenar el STATUS, la primera columna en llenar sera DELIVERIES, apuntando el numero de Delivery generado. Contar cantidades de bultos y cajas, el total se escribe en columna CANT. BULTOS >> CANT. CAJAS

TIPO	SHIPMENT	DELIVERIES	STATUS								COMENTARIOS
		68888915	Norberto	Emerson	Emerson	Norberto			20	84	

3) Lo siguiente sera apuntar el nombre del operador que hizo BackFlush y genero Delivery en la columna BACKFLUSH Y DELIVERY. Una persona diferente a la que anoto el Delivery en el formato de carga, verifica que el numero de este se encuentre anotado de forma correcta en la hoja de carga y firma el formato como eficiencia de inspeccion en columna AUDITADO.

TIPO	SHIPMENT	DELIVERIES	STATUS								COMENTARIOS
		68888915	Norberto	Emerson	Emerson	Norberto			20	84	

4) Despues de estar manifestado, se hace el mapa de carga y se registra el operador que lo hizo en la columna MAPA. Por ultimo se anota el nombre del operador que cargo la troca en columna CARGA.

TIPO	SHIPMENT	DELIVERIES	STATUS								COMENTARIOS
		68888915	Norberto	Emerson	Emerson	Norberto			20	84	

NOTA: En columna TIPO va especificado si el PT es D2XX o BROWNSTON.
NOTA: Se especifica en caso de PT de servicios el tipo de paleta que lleva. Puede ser madera o carton.
NOTA: En PT de servicios BROWNSTON se registra el SHIPMENT ya que este tipo de servicio ya cuenta con uno.

TIPO	SHIPMENT	DELIVERIES	STATUS								COMENTARIOS
		68888915	Norberto	Emerson	Emerson	Norberto			20	84	
D2XX		68888951	Norberto	Emerson	Emerson	Norberto			6	20	

Figure 1 Control de Carga

5.RESULTS

For the development of the project, each step of the process was known, developed and applied, in order to improve the worker's experience.Thanks to the visual aids, the time to find the finished product will improve, because both operators and technicians know the location or location of the product.The results were largely included A greater use of equipment and time, and a computer of the computers.The times between the two shifts will be analyzed and changes will be considered for the part of the two shifts in the same direction, as well as the same number of boxes for shifts, changing the hours as well as the arrival and departure times.In the same way, a decrease in the dead times in the load of the forklift battery. Since this can load the operators do not perform any activity, and in the loading time is where they are assigned activities such as special orders, critics and bodys. (It is known as such to the products and special orders required by customers) At the end of the shift and the beginning of the next one, a piece of plastic was agreed between technicians and operators, a kind of meeting in which the information about what is done in turn A is clarified and left, as well as clarifying what happened in turn B the previous day. Communication is always a very important factor for the area.

6. CONCLUSION

This project addresses the problems of human resources planning in organizations and the utility of an operations model or procedure for performance as a substantial improvement in planning. They emphasize the basic principles in an organization in the path of excellence, managed under a quality system, as a basis for the design of a procedure developed in the present project. The various procedures presented in this project turn out to be simple and practical for all people in general in the best way, so that you can understand what you want to convey, and thus continue to apply the fundamentals of continuous improvement for maximum optimization of the areas evaluated.

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COGNITIVE ANALYSIS IN THE TASK OF PASSENGERS BOARDING IN PUBLIC TRANSPORT IN CIUDAD JUAREZ, MEXICO

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Resumen: En la conducción de autobuses de transporte público la seguridad es un elemento muy importante, en el cual el factor humano es primordial en la prevención de accidentes, el objetivo de este artículo fue analizar la tarea de los conductores al subir pasajeros a los autobuses e identificar factores de riesgo, se aplicó el método de carga mental NASA-TLX a cinco conductores de una línea de autobuses de transporte público en Ciudad Juárez, México, se les hizo una entrevista y se realizó una observación de la tarea analizada, con el fin de hacer un análisis jerárquico de tareas y una evaluación con el método de error humano SHERPA. Como conclusión del estudio se obtuvo que la tarea examinada tiene una importante carga de estrés en los conductores, en el análisis jerárquico de tareas y el método de error humano SHERPA se detectaron cuatro errores que pueden poner en riesgo la seguridad de los pasajeros o provocar un accidente vial, y finalmente con la evaluación del método de carga de trabajo NASA-TLX se obtuvo que todos los conductores tenían un nivel de carga mental alto al realizar la tarea de subir pasajeros al autobús.

Palabras clave: Análisis jerárquico de tareas, carga mental, conducción, transporte público urbano.

Relevancia para la ergonomía: Es importante un análisis de la carga de trabajo de los conductores de transporte público por la responsabilidad que este trabajo implica, y para conocer los factores de riesgo que se presentan durante el ascenso de los pasajeros a los autobuses.

Abstract: Safety is very important when driving public transport buses, the human factor is essential for the prevention of accidents. The objective of this article was to analyze the task of bus drivers when boarding passengers to identify risk factors, the NASA-TLX mental load method was applied to five drivers of a bus line in Ciudad Juarez, Mexico, an interview was conducted and an observation of the analyzed task, in order to make an Hierarchical task analysis and an evaluation with the SHERPA human error method. As conclusion of the study it was obtained that the analyzed task has a significant load of stress on drivers, with the hierarchical task analysis and the SHERPA human error method, four errors were detected that could put at risk the passengers safety or cause a road accident, and finally with the evaluation of the workload method NASA-TLX it was obtained that all drivers had a high level of mental load when boarding passengers to the bus.

Keywords: Hierarchical task analysis, mental load, driving, urban public transport.

Relevance to Ergonomics: An analysis of the workload of public transport drivers is important for the responsibility that this work implies, and to know the risk factors that are present during passengers boarding to buses.

1. INTRODUCTION

Urban public transport driving requires an important responsibility since it implies the safety of the passengers and other drivers, according to the Highway Traffic Safety Administration (NHTSA), the human factor would be involved between 71% to 93% of traffic accidents; route factors, between 12% and 34%; and those of the vehicle, between 4.5% and 13% (Aguirre, 2017). The number of traffic accidents is on the rise, according to Aguilar (2010) if the observed trends persist, by 2020 the number of people dead or disabled each day on the roads and streets of the world will have grown more than 60%.

The mental demand that driving cars requires, according to Chaparro and Guerrero (2001) leads to experiencing fatigue, that can result in drowsiness, sleepiness, irritability, difficulty in concentration, back pain, leg pain and eye pain. As a consequence, in the long term, chronic fatigue can occur, the result of an inappropriate rest-work relationship and an inadequate recovery derived from work demands that often involve long working hours.

The issue of mobility has had an increasing importance in recent years, in this sense, public transport is a topic of interest in today's society for different reasons (Anguita, Duarte & Flores, 2014). Public transport is a fundamental tool to solve urban transport problems and achieve an efficient and equitable city, since it is more efficient tan private motorized in terms of passengers transported per unit of space, energy consumption and environmental impacts (Pardo, 2009).

Driving public transport vehicles is a very stressful job, drivers have intense work days, facing hazards due to time, distance, road conditions, passengers accommodation and mechanical attention of the unit, all this, lacking occupational safety and professional qualification (Salazar & Pereda, 2010), as mention Chaparro and Guerrero (2001) urban public transport drivers work is characterized by a high frequency and a simultaneous execution of tasks, and exposed to noise and vibration; high density of traffic and continuous stops. On average, more than 200 tasks per hour are carried out during driving, its execution requires particular attention in relation to those performed with the parked vehicle.

It is difficult to consider any occupation or profession that does not involve stress, given the speed and demands in which people are immersed (Lima & Juárez, 2008), but "Drivers are subject to a high level of work stress, rather than workers from other occupations. Urban public transport driving is one of the most stressful trades. Stress and vehicle driving are intimately linked: stress modulates to a large extent the driving style of people and can be the cause of a considerable number of accidents and can also cause negative effects on the driver as generation of higher levels of hostility and competitive behaviors; greater tendency to impatience, risky decision-making and reckless driving; decrease in concentration; and the negative effect of the uncontrolled use of drugs, alcohol or other substances that can be used to reduce stress" (Aguirre, 2017).

2. OBJECTIVES

In Ciudad Juarez the issue of public transport has been of interest since decades ago, mainly due to the deficiencies that this presents, "it is provided with old buses, these are from companies of the private initiative; usually the buses are in very bad physical and mechanical conditions" (Bayardo, Medina, & Aranda, 2013), in addition to this problem, in infrastructure, as in the case of the city downtown, the urban layout has narrow streets, that at certain times of the day, show a traffic chaos, the problem is aggravated by the continuous circulation of public transport, with a tendency to make stops in improper places (Gallegos & Lopez, 2004), this study focuses on the drivers, on analyzing the tasks they perform when boarding passengers to the units and identifying the risk factors that arise, according to Aguirre (2017) "it was not until the middle of the 20th century that research began on occupational health of urban transport drivers, in this sense the works published by Morris and colleagues (1953, cited in Aguirre, 2017) established the potential harmful nature of driving. Among the variables that most affect the driving work, we can name the environment and the health status of the drivers ".

It becomes important to evaluate the mental load on this group of workers, such as the time pressure of the task (time available, time needed), the amount of processing resources that the task demands and aspects of an emotional nature such as fatigue and frustration (Olivares, Jélvez, Mena & Lavarello, 2013).

3. METHODOLOGY

Stage 1: To carry out this study, the issue of public transport in the city was chosen, then a review of literature was made, with many studies on the subject found, an exploration of this service in the city was made, it was decided to do the study with a specific task performed by bus drivers: board passengers to the bus, and a single line of buses were selected, so the drivers were under similar working conditions. It was selected the 5A bus line in the city downtown, which is an important point of buses arrival.

The evaluation of the mental load method NASA-TLX was applied to five drivers, previously the six dimensions that the method addresses were explained to them: mental demands, physical demands, temporal demands, performance, effort and level of frustration, and based on these, they had to mark in a table the aspect of the presented pair that contributed more load in the task of boarding passengers to the bus.

M – F	**F – T**	**T – E**
M – T	**F – R**	**T – Fr**
M – R	**F – E**	**R – E**
M – E	**F – Fr**	**R – Fr**
M – Fr	**T – R**	**E – Fr**

Figure 1. Selection of aspects that contribute most to mental load, NASA-TLX

In the evaluation, a scale with 20 spaces is also managed, in which the evaluated person fills the part that considers as representative of the load in each of the six dimensions.

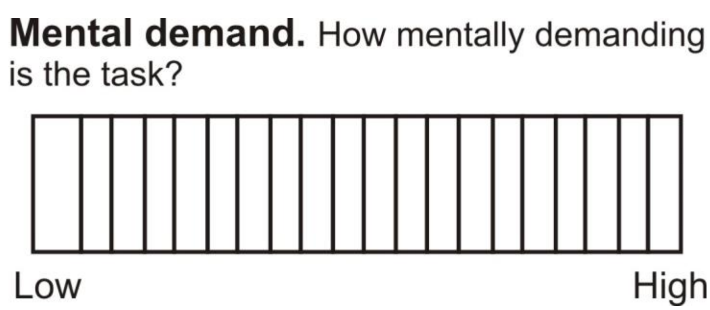

Figure 2. Scale with mental demand dimension, NASA-TLX

After the evaluation, a small interview was made to each one of them to obtain more data, among the information provided, they mentioned that boarding passengers to the bus was a stressful task since they have to comply with established times and this task can delay them, most of them mention that at the end of the day the stress is greater than at the beginning of the day, another fact they mentioned was that sometimes it is difficult to deal with the passengers because they were in a bad mood, also, traffic was an important stress factor.

Stage 2: On the selected bus line, a unit was board to take a tour and observe the tasks performed by the driver when boarding passengers, in order to subsequently perform a hierarchical task analysis and an evaluation with the SHERPA human error method.

Stage 3: During the observation, notes were taken, the task was analyzed from the moment of driving, when a person requested to board the bus by a hand signal, boarding the bus, the driver receiving the money and giving change, and the bus returning to traffic, with this information a hierarchical task analysis was done.

Stage 4: The evaluation of the mental work load carried out with the NASA-TLX method was done boarding the transport units that arrived after a route, when drivers had a free time before leaving again; they were explained about the evaluation purpose.

Stage 5: To carry out the SHERPA human error method, the hierarchical task analysis mentioned above was used, with which the task was categorized, there were errors, consequences and repair strategies identified.

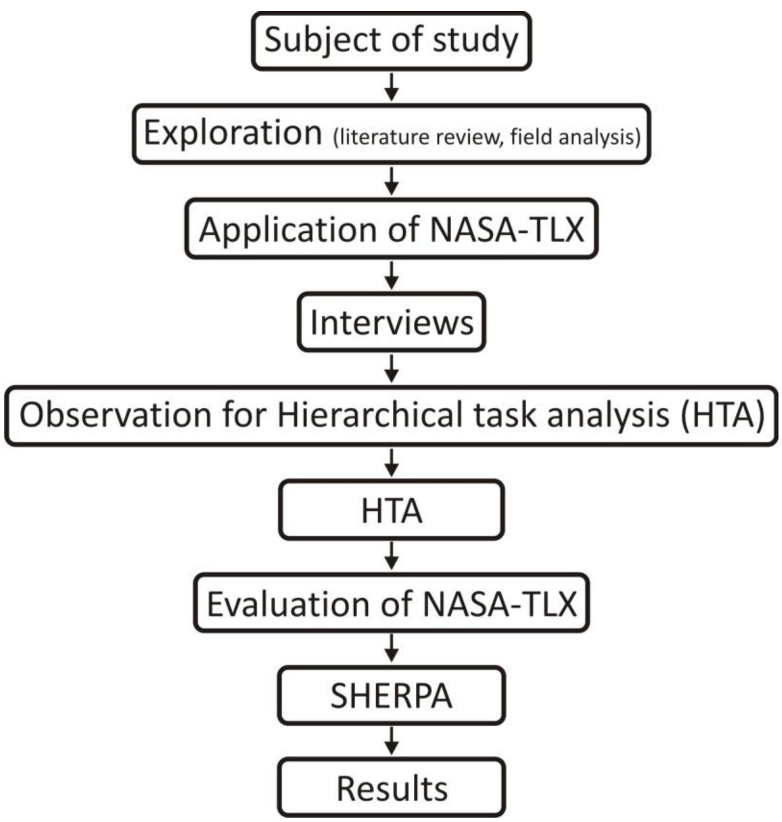

Figure 3. Methodology

4. RESULTS

Stage 1 results: From the information provided by public transport drivers, the result was that the task of stopping to board passengers had a significant stress load, mainly due to the time they have to complete the route, the traffic and passengers' mood.

Stage 2 results: In the bus that was boarded to observe the tasks performed by the driver, some risk situations were observed that will be detailed below.

Stage 3 results: In the hierarchical task analysis, based on the observations, four errors were identified that were detailed in the SHERPA human error method.

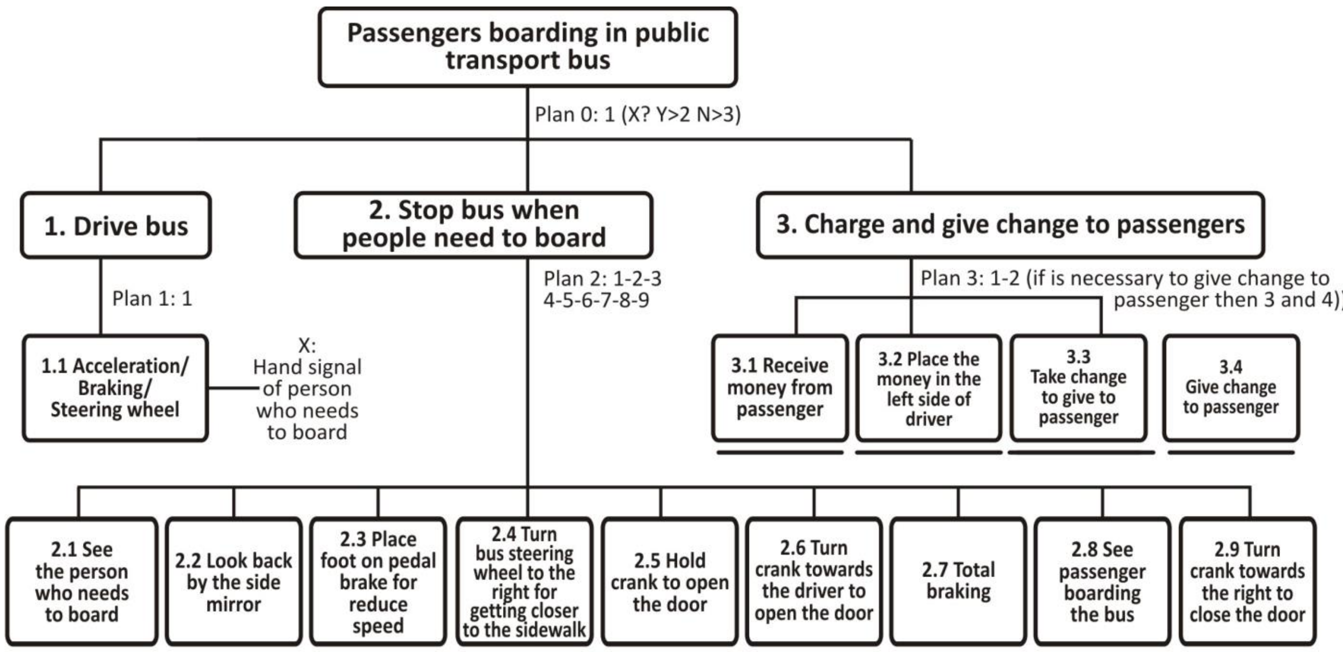

Figure 4. Hierarchical task analysis in passengers boarding a public transport bus
in Ciudad Juarez, Mexico

Stage 4 results: The evaluation made with the NASA-TLX method resulted in a high mental load level in the five drivers with the task of boarding passengers to the bus.

Table 1. Drivers' weighted scores obtained with the NASA-TLX method

Variable	Weighted score Driver 1	Weighted score Driver 2	Weighted score Driver 3	Weighted score Driver 4	Weighted score Driver 5
Mental Demand	0	0	50	0	55
Physical Demand	200	35	0	400	240
Temporal Demand	500	340	225	180	320
Performance	200	100	400	300	500
Effort	200	500	110	55	150
Frustration	400	150	500	500	0
TOTAL	**1500**	**1125**	**1285**	**1435**	**1265**

According to the score table of this method, a global evaluation of 1000 points is considered within the high load level, a medium load level would be above 500 points and below 1000 points, while a low level of mental load would be of 500 points or less.

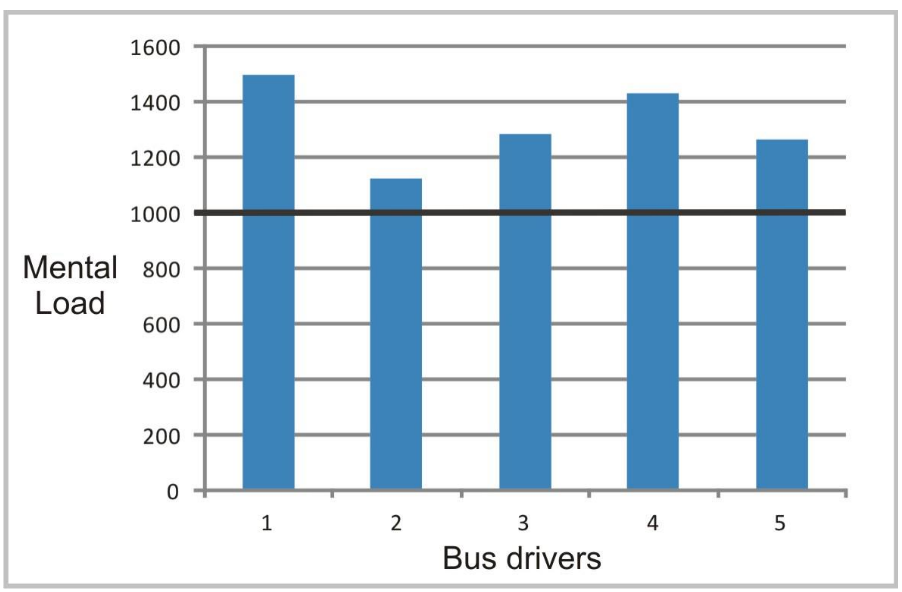

Figure 5. Results of drivers' mental load with the NASA-TLX method

Stage 5 results: With the SHERPA human error method, four errors were detected during the completion of the task, to which repair strategies were proposed.

The detected errors were classified within the action errors: correct activity in the wrong object, the activity is too short and there are a lot of activities.

The first error, stop to board passengers anywhere, and not only in the marked places took the bus to stop unnecessarily on several occasions as there were people who were waiting for other buses.

Another error detected was approach the sidewalk to board the passengers without due caution, sometimes it was omitted to see through the rearview mirror or it was done very quickly before performing the necessary actions, which could cause an accident.

Another mistake was open the door while he was driving to bring the bus to the sidewalk to board the passengers.

Finally, the time allocated for the passenger to board was very short, the person still did not finish boarding and the bus was already in motion, what forces the passenger to maintain balance so as not to fall.

Table 2. Errors detected with SHERPA method.

Task step	Error mode	Error description	Consequence	Recuperation	P	C	Repair strategy
2.1 See The person who needs to board the bus	A6	Fail to distinguish if the person wants to board or not, some people do not make a sign with their hands	Sometimes people do not board, they are waiting for another bus	Immediate	L	L	Stopping to board passengers only in the signed places
2.2 Look back by the side mirror	A1	Failure in observation through the mirror,	A probable accident with the vehicles, motorcyclists or cyclists coming	Immediate	M	M	Training in road accident prevention

		is very fast or it is omitted	behind the bus				
2.6 Turning crank towards the driver to open the door	A4	Failure to carry out this task along with driving the bus	There is no total concentration driving the bus	Immediate	L	L	Instruction to drivers of a procedure for passengers boarding
2.8 See passenger boarding the bus	A1	Failure in the time allocated for the passenger to board the bus, it can be very short	Passenger may fall or lose balance, because many times bus is set in motion during passenger boarding	Immediate	M	M	Instruction to drivers of a procedure for passengers boarding

5. CONCLUSIONS

The deficiencies that public transport presents in Ciudad Juarez, Mexico, show the lack of regulations that exist in this sector, the work conditions of public transport drivers originate in these high levels of stress.

An improvement in the public transport system would be beneficial in different aspects, such as social, environmental, economical, political and urban; in addition, this would benefit for the city to decrease the use of private vehicles.

In this study was only analyzed the task of boarding passengers to the bus, with the help of hierarchical task analysis and SHERPA human error method, four errors were detected that involved the safety of the passengers and another drivers, and could cause an accident, it is very possible that important errors would be found if other tasks performed by bus drivers were analyzed. It is concluded that boarding passengers is an important cause of stress in bus drivers, a better organization of this task, with an improvement in the times to board the bus, would help to reduce the mental load and reduce risk factors.

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ERGO-EST AN INSTRUMENT TO IDENTIFY ERGONOMIC HAZARDS AT WORK, VALIDATION REPORT

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Resumen: El objetivo de este documento es presentar las validaciones estadísticas y concurrentes del cuestionario ERGO-EST, un instrumento utilizado para identificar los peligros ergonómicos en los lugares de trabajo.

Método: Se usó un análisis factorial confirmatorio con una rotación VARIMAX para evaluar la validez del constructo. El análisis de confiabilidad de cada una de las dimensiones del cuestionario se realizó con la prueba omega de McDonald's. Se realizó la validación concurrente del cuestionario, esta validación consiste en medir qué tan bien se correlacionan las dimensiones del cuestionario con las variables esperadas, utilizando el análisis de correlación.

Resultados: El análisis factorial final incluyó cuatro componentes que explican el 61.82% de la varianza. La prueba de Kaiser-Meyer-Olin tuvo un valor de 0.887 y la prueba de esfericidad de Bartlett, un valor p = 0.000, que expresa un ajuste adecuado del modelo. La tabla 1 muestra los componentes finales obtenidos. La prueba Omega del instrumento fue de: 0.82 y los resultados para las dimensiones fueron Postura = 0.71, Repetibilidad = 0.73, Cargas de manejo: 0.84 y Uso de herramientas: 0.66. La validez concurrente tuvo resultados en la dirección esperada, la puntuación de cada dimensión y el índice de riesgo se correlacionaron positivamente con enfermedades musculoesqueléticas, fatiga y trabajo estresante
Conclusiones: El cuestionario ERGO-EST muestra un comportamiento adecuado en términos de sus dimensiones y la confiabilidad general del instrumento y de cada dimensión.

Palabras clave: riesgos ergonómicos, cuestionario, validación.

Relevancia para la ergonomía: la escala ERGO-EST es una herramienta útil para la identificación de peligros ergonómicos que permite un uso eficiente de los recursos.

Abstract
The objective of this paper is to present the statistical and concurrent validations of the ERGO-EST questionnaire, an instrument used to identify ergonomic hazards at workplaces. Methods: A Confirmatory Factor Analysis with a VARIMAX rotation was

used to evaluate the construct validity. The reliability analysis of each of the dimensions of the questionnaire was performed with the McDonald's omega test. The concurrent validation of the questionnaire was carried out, to measure how well the dimensions of the questionnaire correlates with expected variables.

Results: The final factor analysis included four components that explain 61.82% of the variance. The Kaiser-Meyer-Olin test had a value of 0.887 and Bartlett's sphericity test a value p = 0.000, which expresses an adequate model´s adjustment. Table 1 shows the final components obtained. The Omega test of the instrument was of: 0.82 and the results for the dimensions were Posture = 0.71, Repeatability = 0.73, handling loads: 0.84, and Use of tools: 0.66. The concurrent validity had results in the expected direction, the score of each dimension and the Hazard index correlated positively with musculoskeletal illnesses, fatigue and stressful work

Conclusions: The ERGO-EST questionnaire shows an adequate behavior in terms of its dimensions and the overall reliability of the instrument and of each dimension.

Keywords: ergonomic hazards, questionnaire, validation.

Relevance to Ergonomics: The ERGO-EST scale is a useful tool for the identification of ergonomic hazards that allows an efficient use of resources

1. INTRODUCTION

The Mexican social security statistics of work-related illnesses in 2017 showed 14 500 work-related illnesses, and from these 5,300 were occupational musculoskeletal diseases, we can add to these diseases more than 200 thousand head, trunk and upper limb injuries and its consequences (IMSS, 2018). Both health problems are associated to presence of non-ergonomic conditions at workplaces. These non-ergonomic conditions favor in the workers postures, movements and efforts that may result in the referred health damages.

According to the Mexican Federal Regulation of Safety and Health at Work, in its Article 42. "In relation to the Ergonomic Risk Factors of the Work Center, the employers must have an analysis of the Ergonomic Risk Factors of the jobs exposed to the same ", for the identification of the Occupationally Exposed Personnel that must be monitored and protected.

For the identification of ergonomic hazards at workplaces, there are different checklists and questionnaires, with the use of these tools the presence of different ergonomic hazards by position or area and those workers potentially exposed are identified. The information obtained by this way maybe integrated into workers' health surveillance system and the relationship between exposure to these hazards and the musculoskeletal complaints and illnesses presented by a worker can be verified.

The use of questionnaires have the advantage of allowing to have representative data of groups of workers, information that later on is complemented with the results of the medical checklists applied and with those of the specific ergonomic evaluations in critical positions.

2. OBJECTIVE:

The objective of this paper is to present the statistical and concurrent validations of the ERGO-EST questionnaire, an instrument used to identify ergonomic hazards at workplaces.

3. DELIMITATION

This work is a field study to validate the statistical behavior of the proposed instrument, its reliability and concurrent validity with other indicators of the participating population.

4. METHODOLOGY

This is a validation study of an instrument. The workers invited to participate in the study were from 9 manufacturing companies. This instrument was use in the development of a Health and Safety Diagnosis in each place.

The participants were invited to participle, and after that, they were selected for convenience, although applying a stratified method of quotas according to the distribution by areas and the sex proportion in each one.

For the validation a preliminary version of the ERGO-EST instrument was used, this instrument was elaborated based on a review of the literature and according to expert recommendations. The original version contained 24 questions that evaluated the “way of working” (5), posture (6), repeatability (5), handling of loads (5) and use of tools (3). The scale used is binary presence oy absence of the conditions (Yes or No)

A Confirmatory Factor Analysis with a VARIMAX rotation was used to evaluate the construct validity it is the degree to which an instrument measures the dimension to be evaluated. This technique distinguishes the underlying dimensions that establish the relationships between the items of the instrument. As model fitting tests, the Kaiser-Meyer-Olkin model test, that indicates the degree of intercorrelation of the variables it is considered feasible (=> 0.7), and the Bartlett's sphericity test, that indicates whether there is a correlation between the variables, and if the factor analysis makes sense; (<0.05 is adequate) were utilized. Subsequently, reliability analysis of each of the dimensions of the questionnaire was performed with the McDonald's omega test that assesses the degree of consistency with which an instrument measures what it should measure (Carvajal et al., 2011).

Finally, the concurrent validation of the questionnaire was carried out, this validation consists of measuring how well the dimensions of the questionnaire correlates with expected variables, using the correlation analysis between the instrument´s total score and of each dimension with personal and health variables of the participants. The Spearman correlation was used because the variables did not behave normally.

5. RESULTS

The studied population was of 1,551 individuals from 9 workplaces.

1. Factor analysis and reliability analysis

The initial exploratory factor analysis identified that the components of the "way of working" dimension (standing, sitting, staircase, kneeling, moving) were not grouped and do not have adequate loads, so these items were eliminated.

Table 1. Results from final factor analysis

	1	2	3	4
P1.Se agacha al trabajar		0.721		
P2.Estira su cuerpo y brazos al trabajar		0.780		
P3.Se inclina al trabajar		0.761		
P4.Se vuelve hacia atrás al trabajar		0.538		
P5.Sus manos están por encima de la cabeza		0.701		
P6.Sus codos están a la altura del pecho		0.675		
R1.Repite movimientos con los dedos			0.754	
R2.Repite movimientos de tomar-dejar con las manos			0.727	
R3.Repite movimientos de tomar-dejar con los dedos			0.786	
C1Maneja y levanta cargas/objetos de más de 6 kg.	0.754			
C2.Realiza transporte de cargas	0.731			
C3.Realiza fuerza importante	0.668			
C4.Sostiene cargas con las manos	0.747			
C5.Sostiene cargas con los dedos	0.597			
H1.Repite movimientos de atornillado				0.642
H2.Usa de herramientas que vibran				0.728
H3.Flexiona o-extiende la mano (al usar herramientas)				0.466
H4.Inclina de forma lateral la mano (al usar herramientas)				0.782

The final factor analysis eliminates the item "performs sweeping movements with their fingers". The final factor analysis included four components that explain 61.82% of the variance. The Kaiser-Meyer-Olin test had a value of 0.887 and Bartlett's sphericity test a value p = 0.000, which expresses an adequate model´s adjustment. Table 1 shows the final components.

The Omega test of the instrument was of: 0.82, and the results for the dimensions were: Posture = 0.71, Repeatability = 0.73, Handling loads: 0.84, and Use of tools: 0.66

2. Concurrent validation

For this correlation analysis, we used the scores of the dimensions and the global score or Ergonomic Hazard index, and the scores of Fatigue, Number of discomforts and musculoskeletal diseases, Stressful work and Age. The correlations are presented in Table 2:

Table 2. Spearman´s correlation of the ERGO-EST dimensions and concurrent variables (n=1552)

		Fatigue	Age	ME illnesses	Stressful work
Posture	Rho	0.036	**-.148****	**.051***	**.105****
	Sig. (bilateral)	0.156	**0.000**	**0.046**	**0.000**
Repeatability	Rho	**.090****	**-.116****	**.080****	**.056***
	Sig. (bilateral)	0.000	**0.000**	**0.002**	**0.027**
Handling loads	Rho	**.111****	**-.212****	0.046	**.147****
	Sig. (bilateral)	**0.000**	**0.000**	0.071	**0.000**
Use of Tools	Rho	0.004	**-.151****	**.083****	0.042
	Sig. (bilateral)	0.879	**0.000**	**0.001**	0.101
Hazard Index	Rho	**.075****	**-.208****	**.077****	**.136****
	Sig. (bilateral)	**0.003**	**0.000**	**0.002**	**0.000**

The correlations were low to moderate; the Hazard Index correlated positively and significantly with fatigue, discomfort and stressful work and negatively with age. The posture was positively correlated to stressful work and discomfort and negatively with age; repetition in a negative way with age; and positive with the burden, stressful work and fatigue and the use of tools in a negative way with age and positive with discomfort.

6. CONCLUSIONS:

The ERGO-EST questionnaire shows an adequate behavior in terms of its dimensions and the overall reliability of the instrument and of each dimension. The concurrent validity had results in the expected direction, the score of each dimension and the Hazard index correlated positively with musculoskeletal illnesses, fatigue and stressful work. Regarding to age, the correlation was negative, this result perhaps expresses a greater exposure of younger personnel to ergonomic hazards.

7. CONTRIBUTION TO ERGONOMICS

The ERGO-EST scale is a useful tool for the identification of ergonomic hazards. This instrument allows an efficient use of resources, given that once these hazards are detected, the areas and positions can be prioritized, to evaluate the ergonomic health risk that represent for the exposed workers.

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COMPARISON OF THE GRIP STRENGTH IN DIFFERENT ELBOW FLEXION ANGLES

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Resumen: La Sociedad Americana de Terapeutas de la Mano recomienda que la posición estándar para medición de la fuerza de agarre manual sea con el hombro a 0˚ de abducción y rotación neutral, codo a 90˚ de flexión, antebrazo en posición pronación media y muñeca en posición neutral en posición sentado. El siguiente trabajo tuvo como propósito evaluar los efectos de cuatro diferentes posiciones de flexión de codo (0 °, 45 °, 90 ° y 135°) en la fuerza de agarre medida con un dinamómetro MicroFetGrip. Participaron 30 voluntarios (15 hombres y 15 mujeres entre 18 y 25 años). Se usó cuadrados latinos para la secuencia en el orden de ejecución de los ángulos de flexión de codo para cada participante. Los participantes realizaron 3 contracciones de fuerza máxima por ángulo sin descanso entre cada ángulo. Se calculó el valor promedio de fuerza de agarre de cada participante. Se realizó una ANOVA para identificar diferencias entre grupos. Se aplicó una prueba T para comparar las diferencias entre hombres y mujeres entre ángulos. Finalmente, se concluyó que no existen diferencias significativas entre las medias de las fuerzas de agarre como causa de la variación del ángulo de flexión del codo. Sin embargo, si hay diferencias significativas en el valor medio de la fuerza de agarre entre géneros.

Palabras clave: Fuerza de agarre, ángulo de flexión, codo, dinamómetro.

Relevancia para la ergonomía: La presente investigación identificará el ángulo de flexión del codo donde se producirá la mayor fuerza de agarre y las diferencias de estas fuerzas entre géneros. Lo anterior ayudará a diseñar puestos de trabajo teniendo en cuenta la fuerza y el género.

Abstract: The American Society of Hand Therapists recommends that the standard position for hand grip strength measurement be with the shoulder at 0˚ abduction and neutral rotation, elbow at 90˚ flexion, forearm at mid-pronation position and wrist at position neutral in sitting position. The purpose of the following work was to evaluate the effects of four different elbow flexion positions (0°, 45°, 90°, and 135°) on the grip strength measured with a MicroFetGrip dynamometer. 30 volunteers participated (15 men and 15 women between 18 and 25 years old). Latin squares were used for the sequence in the order of execution of the elbow flexion angles for each participant. The participants performed 3 contractions of maximum strength per angle without rest between each angle. The average value of the grip strength of each participant was calculated. An ANOVA was performed to identify differences between groups. A T-test was applied to compare the differences between men and women between angles. Finally, it was concluded that there are no significant differences between the means of grip strength as a cause of the variation of the angle of flexion of the elbow. However, if there are significant differences in the average value of the grip strength between genders.

Keywords: Grip strength, Flexion angle, elbow, Dynamometer.

Relevance to Ergonomics: The present investigation will identify the angle of flexion of the elbow where the greater grip strength will be produced and the differences of these forces between genders. That will help to design job positions taking into account strength and gender.

1. INTRODUCTION

Mathiowetz, Weber, Volland, & Kashman (1984) have considered the position of the elbow as a variable that must be controlled in relation to the effect on the grip strength. Therefore, the American Society of Hand Therapists (ASHT) recommends that the standard position for hand grip strength measurement be with the shoulder at 0˚ of abduction and neutral rotation, the elbow at 90˚ of flexion, the forearm at the mid-pronation position and the wrist in a neutral position in a sitting position (Ng & Fan, 2001). However, the most appropriate position of the elbow to achieve maximum grip strength is not clear, and the reported findings are inconsistent (España-Romero et al., 2010).

In Mexico, some research has been conducted regarding the strength of grip. For example, Jashimoto, De La Vega Bustillos, Lopez Millan, Ortiz Navar, & Duarte (2009) have investigated the maximum grip strength that men and women can exercise with each hand when they interact with and without gloves for the population of the city of Hermosillo, Sonora. Meanwhile, Salinas, Vargas, Aveytia, &

Ibarra (2011) have measured the grip strength of the different opening levels of a manual hydraulic dynamometer to determine the optimum level opening. Although there is no consensus regarding the impact of the flexion angle of the elbow on the grip strength, Malarvizhi, Vidhya, Dhinesh, & Sivakumar (2017) have considered the elbow as a variable that affects grip strength. In addition, the gripping force is considered as an indicator of the operation of the hand (Ding, Leino-Arjas, Murtomaa, Takala, & Solovieva, 2013). For that purpose, Murugan, Patel, Prajapati, Ghoghari, & Patel (2013) have asserted that the hand dynamometer is considered a reliable instrument in the evaluation of grip strength and is used to measure the strength of the flexor muscles of the hand. Based on the lack of consensus regarding the impact of the elbow on the grip strength, this document reports the evaluation of the effect of four elbow flexion angles (0°, 45°, 90°, and 135 °) on the grip strength using a dynamometer.

2. OBJECTIVES

The objectives of the research are to determine the grip strength for different angles of flexion of the elbow (0°, 45°, 90°, and 135°), and determine the differences in the grip strength between angles and gender.

3. METHODOLOGY

3.1 Study design

The design of the study was quasi-experimental, correlational, prospective, and comparative.

3.2 Sample

A total of 30 volunteers (15 men and 15 women between 18 and 25 years old) participated in the study, all of them university students free of injuries and musculoskeletal problems.

3.3 Materials

Two devices were used during the data collection. A MicroFET® hand grip dynamometer (Hoggan Scientific, Salt Lake City), and a cardboard with angles traced as a guide (see Figure 1).

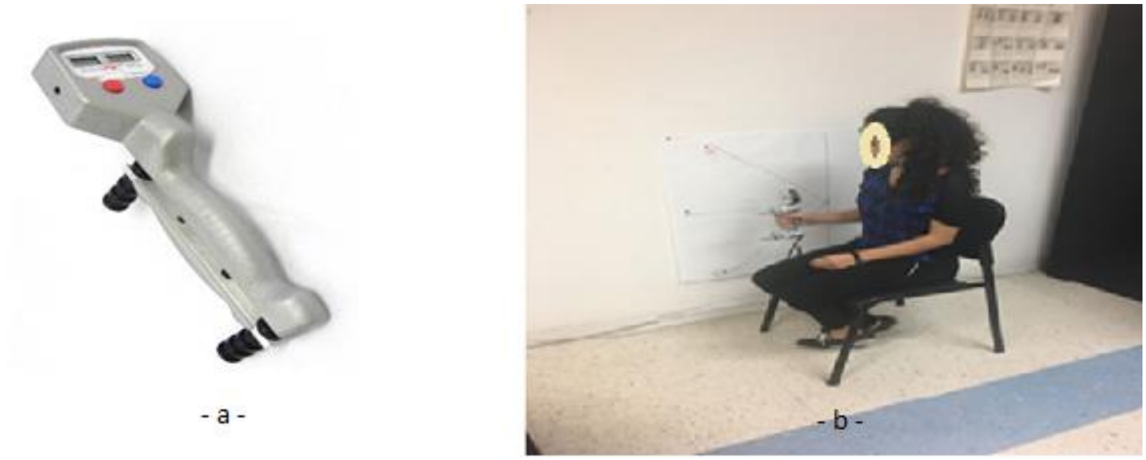

Figure 1. Devices used in the measurement of grip force. a) MicroFET® handgrip dynamometer. b) Cardboard.

3.4 Methods/procedures

The procedure was reviewed and approved by the Ethics and Bio-Ethics Committee of the Autonomous University of Ciudad Juárez-México. The participants were informed about the approval and the purpose of the procedure and signed the consent form. To standardize the strength measurement, the Caldwell et al (1974) protocol was applied during the data collection.

Following the methodology proposed in the article by Kuzala & Vargo (1992), the angles (0 °, 45 °, 90 ° and 135 ° of flexion) were drawn on a cardboard, and the angles were marked with positions: 1) 0°, 2) 45°, 3) 90°, 4) 135°. Next, the cardboard was placed on the wall, placing the vertex at the level of the participants' elbow. Then, a chair was placed next to the reference card, as shown in Figure 1b. Before starting the test, a training session was performed to explain the correct use of the dynamometer.

The grip level of the dynamometer was adjusted to an opening of 1-7 / 8 inch. Using a Latin square array, the order for the execution for each participant was established. Afterward, each participant took his turn sitting on the chair and positioning the elbow at the level of the corner opening angle. Then he performed the grip three times for each angle in the order that was established. The participant had no breaks between holds and between angles. The grip opening of the dynamometer and the height of the chair were kept constant.

3.5 Data analysis

An ANOVA test was run to test the inter-group differences of elbow flexion angles. A t-test was made to determine the differences between the grip strength between men and women.

4. RESULTS

Table 1 and 2 present the grip strength of elbow flexion angles (0°, 45°, 90°, and 13 °) of 30 volunteer subjects (15 women and 15 men between 18 and 25 years old). Also, descriptive values (mean, standard deviation, maximum, minimum and range) are shown in the tables.

Table 1. Female grip-strength.

		Elbow flexion angle- grip strength (lb)			
Subject	Gender	0°	45°	90°	135°
1	Female	17.6	17.3	13.9	17.1
2	Female	22.2	22.4	22.0	22.7
3	Female	22.4	24.4	23.4	17.0
4	Female	24,7	25,0	23.7	22.4
5	Female	17.4	17.5	17.3	17.3
6	Female	15.8	14.9	19.8	22.5
7	Female	36.1	36.4	35.8	41.7
8	Female	31.2	27.9	27.0	27.9
9	Female	20.7	19.5	23.9	24.1
10	Female	21.3	24.3	26.1	19.0
11	Female	39.3	37.6	40.8	40.9
12	Female	13.9	11.5	11.3	13.2
13	Female	21.9	18.5	20.4	21.4
14	Female	27.9	23.4	26.6	26.7
15	Female	19.2	19.8	19.5	23.4
	Mean	23.4	22.7	23.4	23.8
	SD	7.3	7.2	7.6	8.1
	Max	39.3	37.6	40.8	41.7
	Min	13.9	11.5	11.3	13.2
	Range	25.4	26.1	29.5	28.5

Table 2. Male grip strength.

		Elbow flexion angle – grip strength (lb)			
Subject	Gender	0°	45°	90°	135°
1	Male	53.2	49.5	53.5	53.8
2	Male	47.0	62.1	55.4	56.4
3	Male	72.0	62.0	56.9	52.4
4	Male	53.3	53.1	48.0	56.3
5	Male	39.4	41.8	42.8	42.1
6	Male	62.5	44.3	50.2	53.5

7	Male	38.4	34.8	41.3	37.6
8	Male	18.1	17.7	22.2	26.0
9	Male	29.0	35.7	31.0	30.8
10	Male	49.9	47.7	46.6	44.1
11	Male	55.4	49.8	60.3	53.7
12	Male	44.4	44.5	48.0	49.8
13	Male	45.2	36.2	44.4	39.8
14	Male	63.5	69.8	60.9	58.5
15	Male	54.1	48.4	53.9	41.0
	Mean	48.4	46.5	47.7	46.4
	SD	13.7	12.9	10.6	9.9
	Max	72.0	69.8	60.9	58.5
	Min	18.1	17.7	22.2	26.0
	Range	53.9	52.1	38.8	32.5

Using data from male and female participants, the ANOVA showed that there are no significant inter-group differences in flexion angles of the elbow yielding *F:0.040 and p:0.989*. The ANOVA considering only data for men and women showed that there are no significant differences (*F:0.098 and p:0.961*) for men and there are no significant differences (*F:0.058 and p:0.981*) for women. The t-test showed that there were significant differences in the grip strength means for the same angle between genders (see Table 3). Figure 2 shows the grip strengths (averages) of male and female participants.

Table 3. Comparison of the grip strength by gender.

Flexion angle of the elbow	Male Grip strength	Female Grip strength	Dif	t	gl	P-value
0°	48.36	23.44	24.92	6.224	28	0.000
45°	46.49	22.69	23.80	7.234	28	0.000
90°	47.69	23.43	24.26	6.253	28	0.000
135°	46.38	23.82	22.56	6.817	28	0.000

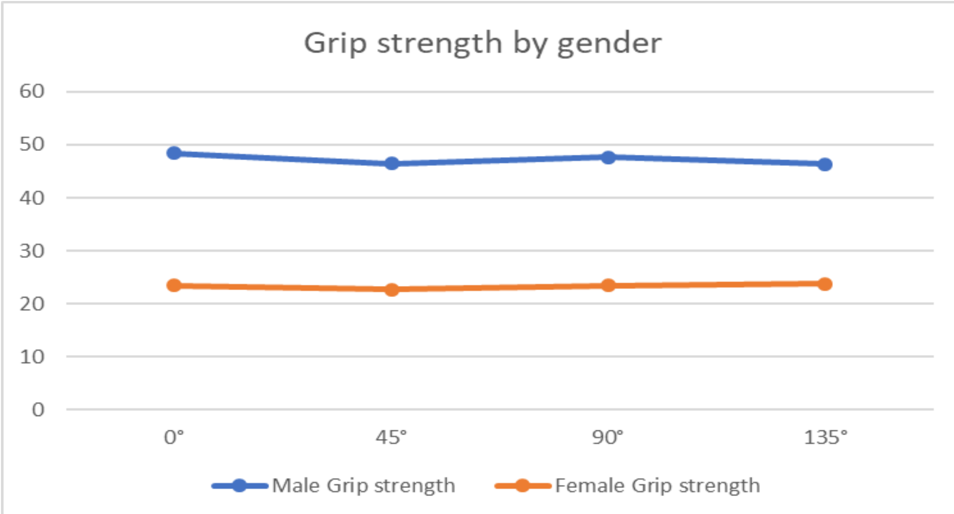

Figure 2. Grip strength by gender.

5. DISCUSSION

As was suggested by Mathiowetz, Weber, Volland, & Kashman (1984), the angle of flexion of the elbow is a variable of interest to take into account in the result of the grip strength. Then, Kuzala & Vargo (1992) determined that the hypothesis that the grip strength would be greater in 90° of elbow flexion and significantly lower in the other positions (0°, 45° and 135°) of the elbow was not supported by this study where we found that there are no differences between the gripping forces between the flexion angles of the elbow (0°,45°, 90°, and 135°). But, Limbasiya et al.(2016) found that the grip strength was maximum with the elbow in full extension, wrist in neutral and shoulder adducted and neutrally rotated. Nevertheless, Kong (2014) in their investigation did not find significant statistical evidence that the total grip strength was affected by changes in the angle of the elbow. Then, there is no clarity regarding the position of the elbow.

In our investigation, the findings indicated that there are no differences in gripping strengths between angles (0°, 45°, 90°, and 135°). In addition, no significant differences were found in the average value of grip force between angles of elbow flexion when the grip was made by the group of women or men. Then, what is expressed by Mathiowetz, Weber, Volland, & Kashman (1984), Kuzala & Vargo (1992), Limbasiya et al (2016) and Kong (2014) support the uncertainty that exists in relation to the angle of flexion of the elbow where the maximum grip strength occurs. However, we found that there are significant differences in the strength of grip between genders. This is of relief for the design of jobs, and tools considering the gender.

6. CONCLUSION

Our work indicated that there is no significant evidence that the mean value of grip strength is different between flexion angles of the elbow. However, there are significant differences in the average value in the grip rates between men and women being greater in men than in women. The aforementioned highlights the importance of validating the necessary strength to perform a task. This study will serve redesign the work environment and allow the inclusion of women in jobs where they have been segregated.

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POSTURAL EFFECT FROM BACKPACKS WEIGHT THROUGH BIOMETRIC SENSORS IN BASIC EDUCATION STUDENTS

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RESUMEN. Actualmente, el dolor de espalda es un motivo de consulta cada vez más frecuente en niños y adolescentes. Existe un acuerdo entre los especialistas en traumatología que determina que las posibles causas de alteraciones de la columna vertebral en escolares se pudieran deber a un defecto postural frecuentemente originado por la excesiva carga en la mochila escolar. Este proyecto surge de esta inquietud al buscar validar la carga máxima recomendada del 10% de su peso corporal, monitoreando el efecto postural de diversas cargas en estudiantes. Se valorarán los cambios en la espina dorsal en un grupo de individuos con diversidad de edades, complexión y género; variando los factores de cargas en su mochila escolar. El rango de edades será comprendido entre 12 a 15 años. Se identifica que el segmento de la población más afectado ante estos factores corresponde a educación básica (Secundaria).

Palabras clave: Ergonomía, sensores biométricos, postura ergonómica, espina dorsal.

ABSTRACT. Back pain is currently an increasingly common cause of consultation in children and adolescents. There is agreement among the specialists in traumatology that the possible causes of alterations of the spine in schoolchildren could be due to a postural defect often caused by the excessive load in the school backpack. This project arises from this concern seeking to validate the maximum recommended load of 10% of its body weight, monitoring the postural effect of various loads in students. Changes in the spine will be assessed in a group of individuals with age diversity, complexion and gender; Varying the load factors in your school backpack. The age range will be between 10 to 20 years of age. It is identified that the segment of the population most affected by these factors corresponds to basic and middle education (Secondary).

Keywords: Ergonomics, biometric sensors, ergonomic posture, spine.

Relevance to Ergonomics: There are many studies from backpack weight in students concluding that is frequently over ergonomics limits, but using biometric sensors could show postural changes from surpassing the 10% weight recommendations from backpack; so this study pretend to incentivize school strategies to reduce weight from backpacks at least from schoolchildren.

1. INTRODUCTION

Nowadays the students present an excessive load in the weight of their school backpacks; it is enough to raise one or two backpacks at random to be able to notice it this situation leads to growing individuals begin to suffer pains or pressures in the back. There is an agreement among specialists in traumatology that the possible causes of alterations in the spine in schoolchildren would be due to an excessive load of school material, an inadequate transport of this load, a postural defect, or a growth defect (Bollado and Beltrán, 2004). An important factor of the pathology is the great weight loaded daily by some children and adolescents. The loaded backpacks produce a displacement of the center of gravity of the body backwards, causing as compensation a slope of this forward, causing tension in the neck and back. The muscles that are forced to perform this series of postural adjustments require isometric contractions that, if repeated or maintained over time, will cause changes at the muscular level, which will end up causing contractures (Cordain, et al, 1998).

The current lifestyle in modern societies is characterized by insufficient physical activity, inadequate nutrition and the use in some cases of toxic substances (Perea, 2002). This generates the need to promote healthy lifestyles. In this sense, education for health is important, to begin in the family environment, and considering the school as a field to acquire basic habits for the defense and promotion of individual and collective health (Chakravarthy and Booth, 2004).

This does not always happen and, sometimes, the school itself may favor certain risk factors for health. Many times there are no certainties if the school furniture is adequate according to the physical structure of children and adolescents, among these aspects it is necessary to consider whether the weight that the child transports of school materials and the type of luggage, are adequate in relation to health. There is an increase in concerns regarding the effects of the use of school backpacks to disorders of the spine and shoulders. The focus of the problem is on the long-term use of heavy backpacks as a routine way of moving books and other items to and from school (Moore, et al, 2007).

Lesions of the musculoskeletal system cover a large number of disorders. The National Institute for Occupational Safety and Health of the United States (NIOSH) defines musculoskeletal injuries as: a group of conditions involving nerves, tendons, muscles and supporting structures, such as intervertebral discs. They represent a wide range of disorders, which can vary in intensity of symptoms: from mild and periodic, to chronic, serious and debilitating conditions. Examples include carpal tunnel syndrome, neck tension syndrome and low back pain (Castillo, et al, 2007).

Currently, nonspecific back pain is a reason for consultation more and more frequently in children, especially in older children and adolescents (Martínez, 2009). Specialists in traumatology, point out that the possible causes of alterations in the spine in schoolchildren are due to an excessive load of school material, an inadequate transport of this load, a postural defect or a growth defect. Backpacks loaded with excess weight produce a shift of the center of gravity of the body backwards, causing a slope of this forward to compensate, causing tension in the neck and back (Bollado and Beltrán, 2004).

Regarding the amount of weight of school material that must be transported at one time, the consensus of the international scientific community recommends that the load that the child carries does not exceed 10% of their body weight. Some authors recommend that the weight of the backpack does not exceed 5% to 10% of body weight, others set the limit between 10% and 15% (Moore, et al, 2007) and finally others base the interval between 15% and 20% (Lindstrom, 2009) (Cubiles, 2003).

In a study that represents a very rigorous approach, it is shown that the 10% cut off point is better than the 15% cut off point; so for the purposes of this research, it is recommended that the maximum weight of the backpack does not exceed 10% of body weight (Moore, et al, 2007).

Research carried out in the United States, France and the United Kingdom have shown that the excess in the amount of kilos that school children carry on their backs can cause musculoskeletal problems. One of the factors that enhance the weight of the backpack produces a physical risk in school children is the time they carry that weight. The more time passes, the damage is greater (Rateau, 2004).

Few studies have specifically assessed the effects of the design, mode of transport and load level of school backpacks on children. An investigation carried out in elementary schools located in the State of Sinaloa, Mexico, where 270 students were surveyed, measured and weighed, revealed that the conditions of access to the educational establishment force the majority of students (93.7%) to use a backpack of straps for mobility and only 6.3% use a backpack with wheels. With the analysis of the data it was found that more than half of the students carried a weight higher than that recommended by the specialists and more than 60% of the infants said they felt discomfort in their back (Luna, et al, 2015).

Some studies show that at least 42% of children under 11 suffer from back pain. This figure increases, up to 51% in children and 69% in girls between 13 and 15 years. Less heavy backpacks, sports and exercises that strengthen the muscles of the back and a correct posture when sitting are some of the habits to follow to keep healthy the backs of the smallest (Garcia, 2005).

1.1 General objective:

Validate recommended limits from back loads with postural changes caused by the backpacks weight, measuring the postural inclination effect in the body trunk, showing the impact student postures, in order to raise awareness among the community about the repercussions of use with heavy backpacks saturated with materials.

1.2 Specific objectives:

- Structure and justify the repercussions of the weight of backpacks on high school students (without exceeding the maximum recommended load of 10% of the student's weight).
- Carry out a survey about their habits regarding the daily transport of school materials.
- Make a record from postural changes due to the handling of loads in the back through their evaluation with biometric sensors
- Determine the critical ranges of muscle tension caused by the trunk inclination.

1.3 Delimitation

The study was developed based on 90 students of different sexes, grades and complexions from the federal high school No. 10 in Mexicali, Baja California, so the results are indicative only for that sample.

2. METHODOLOGY

The development of this project was carried out through a register of postural angles due to excessive load in school backpack using biometric sensors; and through a questionnaire applied to a significant sample of the existing school population in Federal High School No.10 "Octavio Paz", located in Mexicali, Baja California.

The criteria used for the selection of samples excluded children with chronic diseases that could cause habitual back pain.

Next, the methodological points that were required to carry out the aforementioned process are mentioned:

- Selection of spinal points for monitoring. Which were: neck, chest and hip.
- Use and calibration of biometric sensors. The sensors were used in the neck (by the angle that the head adopts with respect to the spine), chest and hip (by its trunk inclination) and hip, because these are the points that represent the curvature of the spine based on the overweight or weight loaded, as appropriate. The calibration was performed automatically using the application for NOTCH biometric sensors.
- Collect the data corresponding to the work angles. For which the weight and height of students was taken. The selected sample was of 90 students (surveyed and studied by means of measurements of sensors located in the neck, chest and hip), selected 10 by group (being 9 groups in total of different degrees), it was indicated to the teachers in charge of they who selected 5 men and 5 women of different statures and complexions (in some groups because

of absenteeism, the number of students of each sex was not met, therefore, it was completed with other groups). Measurement (with tape measure) and weight (with digital scale) was made to each student, in order to calculate the average of the maximum weight allowed (which should not exceed 10% of the weight of each student), for later place the sensors and proceed to place the backpack that was had as sample (which has a weight of one kilogram without load), and put on the student was loaded (filling the backpack with bags of one kg of rice according to the weight of each student), the reading of the aforementioned sensors was taken and the kilo that already represented the backpack of the analysis was increased another kilo to record the result of the curvature, this without exceeding between the suggested 10%.

• Perform the analysis of population sampling which was limited to 90 students, 10 of each grade since the secondary study has 9 groups, determining were 5 men and 5 women. For which the teachers in turn were asked to determine the 10 students considering they were of different statures and complexions. It was taken into account that the weight used when loading the study backpacks did not exceed 10% to 15% of the body weight recommended for each student.

• Conduct a study on 30 randomly selected students of different grades in order to determine the average real weight that high school students carry in their backpack including textbooks, notebooks and school supplies.

• Perform analysis and assessment of postures through readings, determining critical parameters. The application of NOTCH biometric sensors automatically showed the readings determined by the curvatures of the sensors.

3. RESULTS

Questionnaire findings are:

- Average weight: 43.992 Kg
- Average Height: 1.58 meters
- School Grade Level: First (26 students), Second (35 students) and Third (29 students)
- Age range: between 12 and 15 years.
- Most frequent transportation method: Walking by 61% of students.
- Most frequent transfer time: 5 to 15 minutes for 69% of the students.
- Most frequent straps type from backpacks: thin straps for 47 students.
- Back pain associated with backpack weight: 58 students have suffered.
- Visit to the doctor for back pain: 75 students indicated NOT to see the doctor.
- Home remedy treatment: 57 students.
- Knowledge from recommended type of backpack: 69 students.
- Not knowing the long-term consequences: 62 students.
- Willing to use the pelvic belt in a backpack: 68 students.

To measure trunk impact from back load, three biometric sensors was used. They use Bluetooth low energy technology to communicate with cell phone app. The Notch sensors were positioned in specific parts of the body. So student trunk inclination was reflected in Notch app trough the virtual mannequin. Figure 1, shows Biometric sensors location in students.

Figure 1. Students with Notch biometric sensors.

Figure 2, show the android app from NOTCH biometric Sensors, used to perform the analysis and assessment of postures through readings, determining critical parameters. This app automatically showed the readings determined by the curvatures of the sensors.

Trunk affectation findings are

- Deformations In adolescents the area that most resents the load of the backpack is the hip.
- On average, poor posture begins when the backpack exceeds 11% of the individual's weight.
- Poor posture for the average female population begins when the backpack exceeds 11% of its weight.
- Poor posture begins for the average male population when the backpack exceeds 6% to 20% of its weight.
- The total average weight of the backpacks of the students in question was 7,200 kg. and the average weight of the students is 43,992 kg. Therefore, the average weight of the backpack represents 16.36% of the average weight of the students, which implies that, on average, the students exceed the load allowed by the American Association of Pediatrics (AAP) of 10% of their weight, since, on average, poor posture began when the backpack weight exceeded 11% of the student's weight.

In this study we have tried to establish the reality about the use of excessive weight in the school backpack. Likewise, possible factors related to the presence of back pain and different variables related to the transport of materials to the school center have been identified

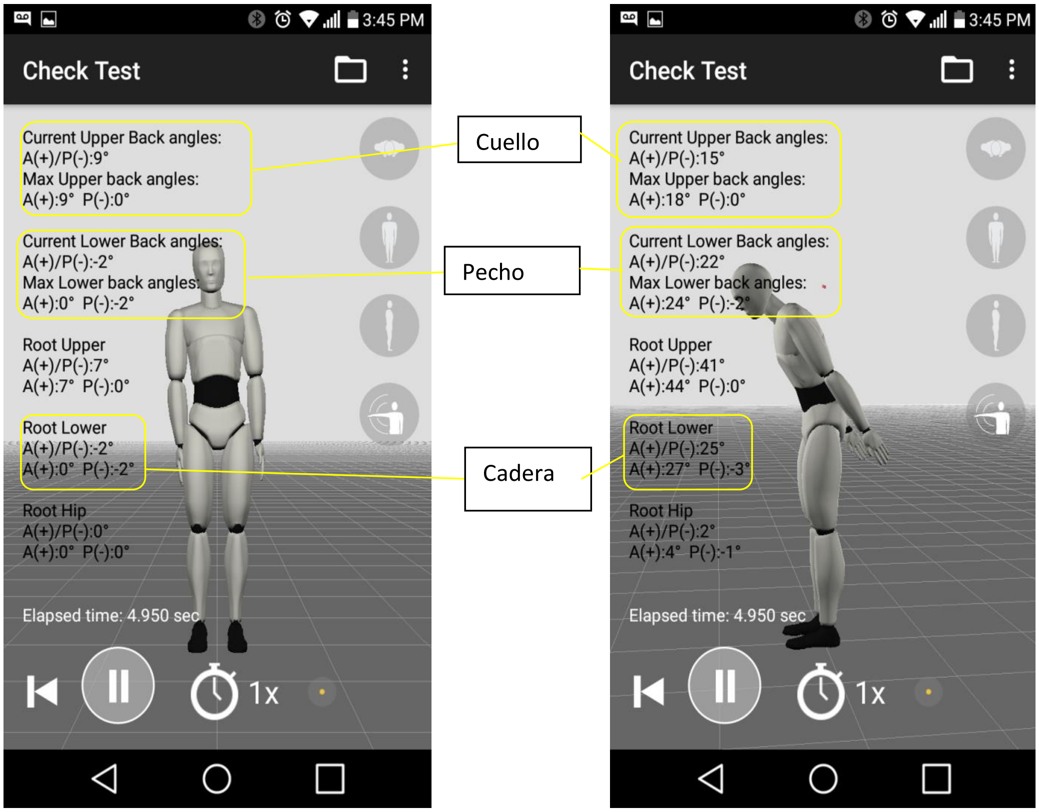

Figure 2. Image showing the angles studied.
Source: Actual image of the study taken from the NOTCH application.

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There are few studies that have evaluated the transport habits of school material in our country. An important limitation of our study is the decrease in the impact of the weight of the backpack that we can assume based on the short travel time between home and school, and vice versa, as well as the relatively frequent use of motorized transport by the other percentage.

It is observed how the backpack carried on the two straps back is the most used, although students use the thin straps. For the most part, students who attend school take an average of 5 to 15 minutes to arrive. It is evident that this situation should reduce the incidence of painful pathology in the back related to the transport of backpacks.

Not to exceed 11% of the weight of the students, is a recommendation determined based on the analysis of statistics of the study so as so as not to affect a postural deformation. Therefore, the maximum weight suggested in the backpack, considering not to exceed 11% of its average weight is 4.84 kg which is derived as a conclusion that there is an excess daily load of 2.36 kg in the weight of the adolescents backpack, considering the previous data of total weight in backpack of 7,200 kg. and average weight of students in 43,992 kg.

The transfer of students every 50 minutes from one classroom to another could increase this problem. Thus is important to raise awareness in the educational sector related to implementing as little as possible movements inside the school with the backpacks.

Carry out a campaign of awareness among parents and students looking for the usage of recommendations issued by the AAP (American Academy of Pediatrics) (AAP, 2016) to select the appropriate backpack, and to prevent injuries caused by misuse is important.

4. CONCLUSIONS

The load limit contemplated in the use of school backpacks of 10 to 15% could be restricted to a maximum of 10%; limit that is usually not respected.

As it was possible to appreciate, the students resent the weight in the hip, reason why it is recommended that, because they are in the stage in growth, the load of his backpack does not exceed 11% in relation to his weight. Since the type of transfer is primarily walking, it is important to use backpacks with braces of suitable supports, since nowadays they use thin straps, in order to prevent bad postures and future illnesses.

In summary, it can be concluded that students use the school backpack inadequately, and carry a relative weight that could be considered acceptable. However, the differences detected, raises the possibility of being able to implement actions, by the competent Public Administrations, that allow to significantly reduce the weight of these. In the same way could be important the usual routine from specific exercises to strengthen the column of students.

This study is also established the statistical relationship between the presence of back pain and modifiable parameters such as: the weight of the school and the relative weight of the backpack. It is very important expand this investigation looking to inquire about the damage to the posture that may occur when exceeding this limit. Crossing this findings different backpacks styles following AAP recommendations, also linkage with productivity measures from student performance could be important.

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THE PROCESS OF ADJUSTING THE POSITION OF DRIVER SEAT, ITS MENTAL WORKLOAD AND ITS POSSIBLE HUMAN ERRORS.

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Resumen: A lo largo de los años, el asiento del automóvil del conductor ha evolucionado en su forma, materiales e incluso en sus funciones secundarias. Hoy en día, la ergonomía ha influido significativamente en el diseño del asiento del automóvil para el conductor, al cuidar la salud del conductor. La presente investigación realiza un análisis sobre cómo los conductores ajustan su asiento a través de dos perspectivas ergonómicas cognitivas diferentes. Primero, se aplicó un perfil de carga de trabajo mental al proceso para evaluar los recursos cognitivos necesarios durante el proceso. Más tarde, un proceso de error humano identificó las tareas que posiblemente fueron confundidas o se realizaron mal. Los resultados muestran que el ajuste de la distancia entre el volante y el asiento del conductor son los recursos cognitivos más exigentes en el proceso. Además, el estudio SHERPA demuestra que la mayoría de las personas no ajustan correctamente el asiento debido a la falta de conocimiento y conciencia de la importancia de estos ajustes.

Palabras clave: Asiento de Conductor, Proceso de Manejo, Análisis Jerárquico de Tareas, SHERPA, Workload Profile.

Relevancia para la ergonomía: El estudio contribuye a la ergonomía, analizando el proceso en el que los conductores ajustan el asiento del conductor y evalúa la cantidad de recursos mentales que son utilizados en cada uno de los pasos del proceso. Así también, el estudio puede predecir los posibles errores humanos que pueden llevar a un mal ajuste en el asiento del conductor y por consecuente, una mala postura.

Abstract: Over the years, the driver car seat has evolved its shape, materials and even on its secondary functions. Nowadays, ergonomics has significantly influenced on the driver´s car seat design on taking care about driver´s health. The current investigation performs an analysis on how drivers adjust their seat through two different cognitive ergonomic perspectives. First, a mental workload profile was applied to the process to evaluate the cognitive resources needed during the process. Later, a human error process identified the tasks possibly were mistaken or poorly performed. Results show that adjusting the distance between steering wheel and driver seat is the cognitive resources most demanding on the process. Also, the SHERPA study proves that most people do not properly adjust the seat because lack of knowledge and awareness of how important these adjustments are.

Keywords: Driver Seat; Driving Process; Hierarchical Task Analysis; SHERPA; Workload Profile.

Relevance to Ergonomics: The study contributes to ergonomics analyzing the process of drivers adjust the driver seat and evaluates the quantity of mental resources used in each step of the process. Also, it can predict possible human errors which can lead to a bad adjustment on the seat and so on, with a wrong posture.

1. INTRODUCTION

Since the beginnings of the vehicle, the seats have been suffering modifications, especially the driver seat. This seat has changed along the time, going from the simple seat that just was a one whole piece without aesthetics and no other function than just seating, to a very complex, expensive and full of features car seats. According to Lara Rivero, Trujano, & García Garnica (2005) there are two main seat generations along the time. The 1st generation seat was improved with some features like; the seatbelt, a smooth foam and certain mechanisms that allow the driver to adjust the seat back inclination and the distance between the steering wheel and the driver. The 2nd generation seat, on the other hand, contains a variety of different seats equipped with electrical subsystems like the airbags, climate seat control, and memory to stock the different driver's positions, even they have a headrest that could inflate itself to prevent cervical damage in case of car accident.

All these seat improvements have contributed to prevent driver and passengers' injuries, even taking care of their lives. But, nowadays even with these improvements, people still are presenting injuries and dying because of wrong postures while they are driving. Pain in the neck, shoulders, column and joints are examples of incorrect position consequences of an incorrect position while driving (Camara, 2018).

A wrong position taken while driving can be caused by either a muscular imbalance generated by a genetic deformation or more frequently, by maintaining a static posture for a long-time period (Armas & Carlosama, 2012), which is exactly what happens while driving. That is the reason why the adjustments on driver seat and back became fundamental while the driver is seated on large distances. To assure the adjustments are the closest as possible to the optimal posture, the process of adjusting them, would be analyzed with a mental workload technique and a possible human error procedure.

Mental workload is a well-known concept and it has been studied for so long and has been worked for several authors, each of them with his own definition. For purposes of the current analysis, mental workload would be defined according to Brad Cain (2007), who after a literature review conclude that “mental workload it is a mental condition that results from performing a task under specific environmental and operational conditions, coupled with the capability of the operator to respond to those demands”.

Hancock & Verwey (1997) on their article “Fatigue, Workload and Adaptative Driver Systems” as its title mentions, evaluates fatigue and workload on the process. On the other hand, Fatima Pereira (2014) on “Mental Workload, Task Demand and Driving Performance: What Relation?” analyses the existing relationship between the driver and the cognitive resources he may need while driving. As the previous couple of studies, there are more of them evaluating workload focused on the driving process but none of them is just emphasized on workload on adjusting the driver car seat, and that is what this investigation is about, to demonstrate how this task influences the entire process of driving and how it contributes to the total mental workload.

In addition, to have a more complete understanding about adjusting the driver seat a human error process is added to the investigation, to know what may negatively affects the process when the driver does not is capable to get the optimate position to drive. To evaluate the possible human error a SHERPA (Systematic Human Error Reduction and Prediction Approach) method would be used to analyses the human reliability qualitatively and quantitatively (D. Embrey, 2009).

2. OBJECTIVE

2.1. Main Objective

Study the way drivers adjust their seat before driving, the way they manipulate the basic adjustments and how it affects in the driving process and wrong posture.

2.2. Specific Objectives

-Evaluate mental workload on the process of adjusting the driver seat.

-Analyze the possible errors may occur on the process of adjusting the driver seat.

3. METHODOLOGY

3.1. Method A, Workload Profile

The Work Load Profile is a technique that allows the investigator to identify a mental workload a person presents while performing a specific task. It is used to measure the workload in eight principle aspects; Perceptual process, response, spatial, verbal, visual, and auditory processing, manual output and speech output (Agency for Healthcare Research and Quality, 2005).

For this article the workload profile would measure the mental workload presented on a driver when he/she adjust her/his seat before driving.

The sample of the population was of 10 volunteers, 5 males and 5 females between the ages of 22 to 60 who drive frequently at least twice a day and a minimum of 45 minutes. Following the technique, the task would be evaluated for each volunteer, grading the difficulty of the mental workload in a scale from 0 to 1 where zero means that there are no resources needed from the task, otherwise if the task is ranked as 1, it would mean the task need the maximum amount of attention to be performed.

3.2. Method B, SHERPA

To evaluate the aspects that may go wrong during the process of adjusting the driver seat to the most comfortable position, a SHERPA analysis would be needed. According to Embrey (1986), SHERPA method would evaluate in a quantitative and qualitative way, the possible errors a person could make along a specific task or process and how to minimize them.

The SHERPA method has eight main steps that need to be followed to achieve a good human error analysis. First, a Hierarchical Task Analysis will be the base of the analysis (3.2.1), then all tasks need to be classified in a taxonomy already established (Action, Retrieval, Checking, Selection, Information communication and Selection). After this, the investigator needs to make a human error identification in every task of the analyzed process and define the error type with the “Error Mode Checklist” (Table 1), and describe the consequences and recovery plan of each (Harris et al., 2005).

Table 1. SHARPA Error Mode Checklist

Error Category	Error Mode	Code	Error Category	Error Mode	Code
Action	Operation too long/short	A1	Checking	Check omitted	C1
	Operation mistimed	A2		Check incomplete	C2
	Operation in wrong direction	A3		Right check on wrong object	C3

	Too little/much operation	A4		Wrong check on right object	C4
	Misalignment	A5		Check mistimed	C5
	Right operation on wrong object	A6		Wrong check on wrong object	C6
	Wrong operation on right object	A7	Communication	Information not communicated	I1
	Operation omitted	A8		Wrong information communicated	I2
	Operation incomplete	A9		Information communication incomplete	I3
	Wrong operation on wrong object	A10		Selection omitted	S1
Retrieval	Information not obtained	R1		Wrong selection made	S2
	Wrong information obtained	R2			
	Information retrieval incomplete	R3			

3.2.1. Hierarchical Task Analysis (HTA)

The hierarchical task analysis is a method emphasized on members and organization on the process. It constructs plans that shows how the order of the tasks would be done and who will do each task (Sarker, Chang, Albrani, & Vincent, 2008). Along time, the HTA has been applied to different pourposes and on different disciplines such as job aid design, error prediction, workload assesement, interface design, between others (Stanton, 2006).

On HTA, the main task are divided into subtasks which are the tasks needed to reach an objective and after it is necessary to define a plan for each subtask. The plans are the order and the conditions in which the tasks need to be done (Salavert, Caballero, & Pérez, 2017).

4. RESULTS

4.1. Method A Results, Workload Profile

Each result was averaged and presented a single workload (Table 2), this was done to know in general how many resources were needed during the process of adjusting the driver seat just before driving. As the total workload does not have a specific unit, it can be compared to another task to estimate how demanding the process would be or this could be used as a first part of a post analysis about the Theory of Multiple Resources of Wickens.

Table 2. Workload Profile Results of the driver seat adjustments.

		Average Work Load Dimensions								
		Stage of Processing		Code of Processing		Input		Output		
TASK		Per-ceptual	Res-ponse	Spatial	Verbal	Visual	Audi-tory	Manual	Speech	Total WL
1	Seating on driver seat	0.66	0.7	0.7	0	0.68	0	0.92	0	3.660
2	Adjust distance between the seat and the steering wheel	0.7	0.74	0.76	0	0.64	0	0.96	0	3.800
3	Adjust Seat Height	0	0	0	0	0	0	0	0	0.000
4	Adjust cushion angle	0	0	0	0	0	0	0	0	0.000
5	Adjust seatback angle	0.32	0.38	0.48	0	0.24	0	0.58	0	2.000
6	Adjust Headrest Height	0	0	0	0	0	0	0	0	0.000
PROCESS TOTAL AVERAGE WORK LOAD										1.892

4.2. Method B Results, SHERPA

Once the HTA was made (4.2.1), the same 10 users of the work load profile were asked to realize the needed adjustments in a driver seat just before driving and recorded to analyze the possible errors they would take. As a result, each possible error, its consequences and remedial measures were registered on table 3.

Table 3. SHARPA Human Error Analysis of adjusting the driver seat process

Task Step	Task Type	Error Mode	Description	Consequence	Recovery	Remedial Measure
2	Adjust distance between the seat and the steering wheel	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
2.1	Identify mechanical or electrical system that moves the seat forward and backward	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**2**	Search again the handle or button that does the right movement
2.2	Move the Seat Forward	**A3**	The movement was done in wrong direction	Get a wrong a position	**2.1**	correct direction
2.3	Move the seat backward	**A3**	The movement was done in wrong direction	Get a wrong a position	**2.1**	correct direction
3	Adjust seat height	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
3.1	Identify mechanical or electrical system that moves the seat up and down	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**3**	Search again the handle or button that does the right movement
3.2	Move the Seat up	**A3**	The movement was done in wrong direction	Get a wrong a position	**3.1**	correct direction
3.3	Move the seat down	**A3**	The movement	Get a wrong a position	**3.1**	correct direction

			was done in wrong direction			
4	Adjust cushion angle	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
4.1	Identify mechanical or electrical system that inclines and flex the cushion	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**4**	Search again the handle or button that does the right movement
4.2	Incline cushion	**A3**	The movement was done in wrong direction	Get a wrong a position	**4.1**	correct direction
4.3	Flex cushion	**A3**	The movement was done in wrong direction	Get a wrong a position	**4.1**	correct direction
5	Adjust cushion angle	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
5.1	Identify mechanical or electrical system that inclines and flex the seatback	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**5**	Search again the handle or button that does the right movement
5.2	Incline seatback	**A3**	The movement was done in wrong direction	Get a wrong a position	**5.1**	correct direction
5.3	Flex seatback	**A3**	The movement was done in wrong direction	Get a wrong a position	**5.1**	correct direction

6	Adjust seat height	**A8**	The adjustment was not done	Wrong position while driving	**0**	Make a sign to remember the user about the seat adjustment
6.1	Identify mechanical or electrical system that moves the headrest up and down	**I1**	Mechanism which does the movement not found	The adjustment would not be possible	**6**	Search again the handle or button that does the right movement
6.2	Move the headrest up	**A3**	The movement was done in wrong direction	Get a wrong a position	**6.1**	correct direction
6.3	Move the headrest down	**A3**	The movement was done in wrong direction	Get a wrong a position	**6.1**	correct direction

4.2.1. Hierarchical Task Analysis Results

The purpose of the HTA in this investigation is to identify those tasks which demand a bigger amount of energy and effort when the driver seat is adjusted in the desired position before driving the vehicle. This activity follows a non-lineal analysis what means that the sub-tasks must not follow a specific order during the task.

5. DISCUSSIONS

5.1. Method A Discussions, Workload Profile

In this article, the workload profile can provide the amount of resources are needed for each tasks of the entire process. As shown on Table 2, the action that need more mental resources of the process, is the manual output when adjusting the distance between the seat and the steering wheel. On the other hand, the visual input of adjusting the seatback angle was the task with less visual input, this is because the user rarely can see the seatback and in consequence, the perception of the adjust is more perceptual and spatial.

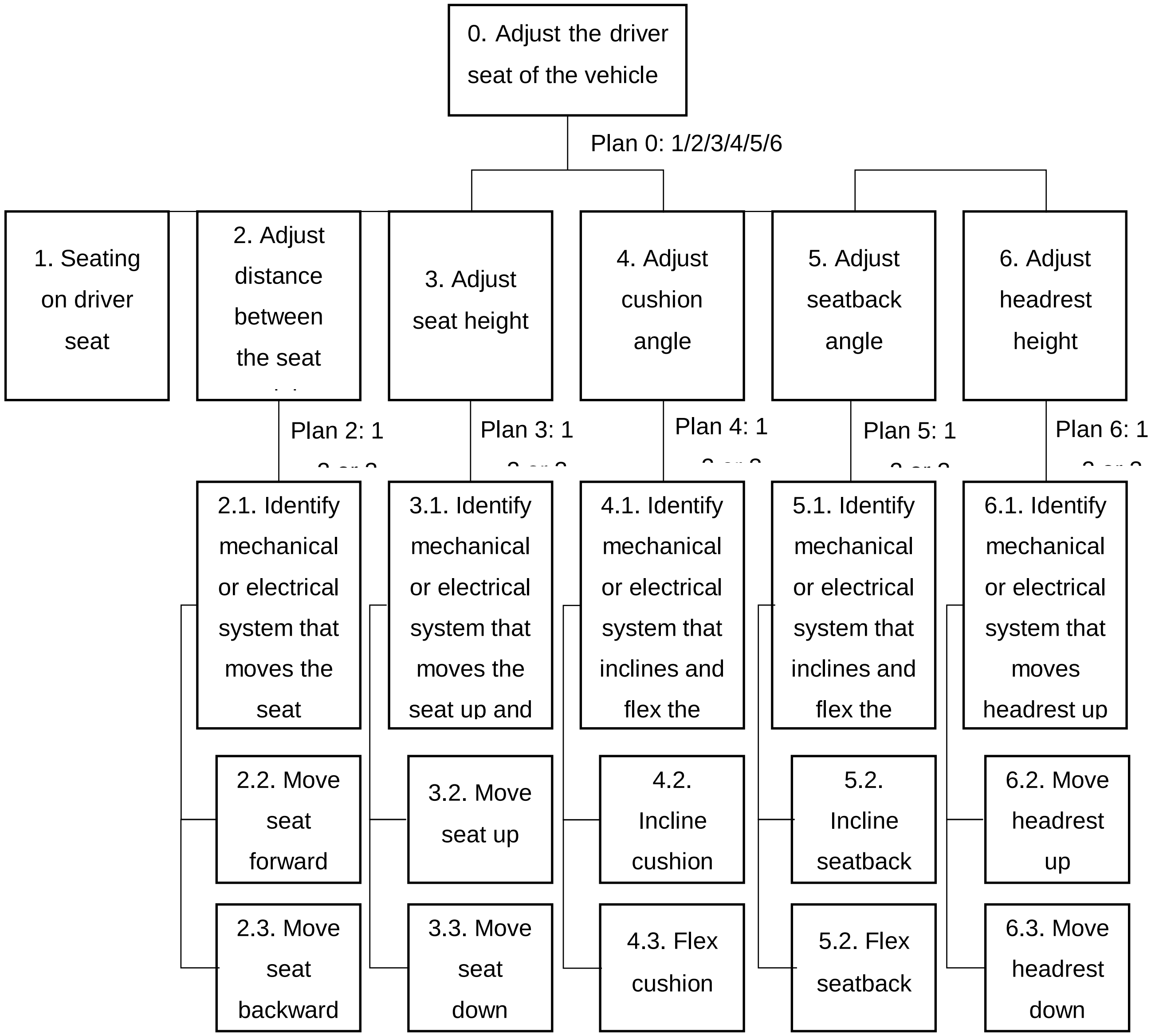

Figure 1. Hierarchical Task Analysis of the process of adjusting the driver seat.

5.2. Method B Discussions, SHERPA

As the process of adjusting the driver seat is a process in which the activities tend to be repetitive or with the same basic principles, the possible human errors are also repetitive and almost the same. On table 3 is shown all the errors but it can be detected 3 main errors; A8 (operation omitted) when the driver totally forgets to do a specific adjustment, I1 (information not communicate) this happened when the user did not find the mechanism that does the adjustment they need, and the A3 (operation in wrong direction) when a user does the adjustment but he or she got the wrong direction than the one they need.

3. CONCLUSIONS

Adjusting the driver seat before driving is not as easy as it seems to be, and it is very important to correctly drive. The work load profile method in the process proves that the amount of resources a driver needs to adjust his or her seat are considerable and according to the 1.82 of total average of a mental workload this task could hardly be done simultaneously with another one with similar characteristics or another one that requires the same resources.

In addition, the SHERPA analysis of human error shows that most common error in the process is that the driver usually forgets to adjust at least 2 of the main adjustments a driver seat must get the right position for ever user. Based on this, it can be concluded that a posture problem while driving an automobile are not done because of missing ergonomic seat but because of the driver that is not accustomed to check and perceive the right way to seat while driving.

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REDESIGN OF THE WORK AREA OF MODISTE IN LOS MOCHIS, SINALOA, USING THE METHOD GUERCHET, S.L.P. AND ERGONOMICS.

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Resumen.- La aplicación del Método Guerchet, S.L.P. y herramientas ergonómicas para el análisis de puestos de trabajo permiten crear las condiciones adecuadas para el óptimo desarrollo de las actividades laborales que cotidianamente desarrollan y evitan que se presenten afectaciones musco-esqueléticas en los operadores.

Este estudio inició cuando se detectaron DTA's en las trabajadoras de un taller de modistas establecido en la ciudad de Los Mochis, Sinaloa, lo que provocaba deficiencia en las tareas repercutiendo en la productividad.

Para la realización del estudio de DTA's, se recurrieron a los métodos RULA Y CORLETT & BISHOP, los cuales se aplicaron durante dos semanas, arrojando como resultado un severo grado de fatiga en las zonas de la espalda, cuello y muñecas a la que está expuesto el trabajador. Para posteriormente llegar a analizar su espacio laboral y cerciorarnos que cumple con el diseño adecuado para la realización optima de sus actividades; esto último llevado a cabo mediante los Métodos Guerchet y S.L.P. Se encontró que las dimensiones no eran las apropiadas para que el trabajador desarrollara sus actividades libremente y con la postura adecuada.

Finalmente se concluye el artículo con la elaboración de una propuesta de mejora en la postura y la distribución del área de trabajo.

Palabras claves.- ergonomía, modista, Método Guerchet, rediseño.

Relevancia para la ergonomía.- El presente artículo servirá como referente para aquellas investigaciones y estudios que requieran información sobre el análisis del puesto de trabajo de una modista y de qué forma es útil la aplicación de métodos de diseño y distribución de planta en este sector.

Abstract. - The application of the Guerchet Method, S.L.P. and ergonomic tools for the analysis of work positions allow to create the adequate conditions for the optimal development of the work activities that daily develop and prevent musco-skeletal affectations from occurring in the operators.

This study began when DTAs were detected in the workers of a seamstress' shop established in the city of Los Mochis, Sinaloa, which caused a deficiency in the tasks, having repercussions on productivity.

To carry out the study of DTA's, resorted to the RULA and CORLETT & BISHOP methods, which were applied for two weeks, resulting in a severe degree of fatigue in the areas of the back, neck and wrists to which are exposed the worker. In order to subsequently analyze your work space and ensure that it complies with the appropriate design for the optimal performance of your activities; this last one carried out by means of the Methods Guerchet and S.L.P. It was found that the dimensions were not appropriate for the workers to develop their activities freely and with the appropriate posture.

Finally, the article concludes with the elaboration of a proposal for improvement in the posture and the distribution of the work area.

Keywords.- Ergonomics, seamstress, Guerchet Method, redesign.

Relevance to ergonomics. - This article will serve as a reference for those investigations and studies that require information on the analysis of the job of a seamstress and how useful is the application of methods of design and distribution of plant in this sector

1. INTRODUCTION

The following case study focuses on a haute couture seamstress who develops her work individually in a very limited area, working without a set schedule and for a number of continuous hours that exceeds the average work. Different types of ergonomic tools and methods of design and planning of facilities were applied for the complete analysis of the work area and the person who works it.

Fashion designers are people who are dedicated to drawing, tracing and sewing professionally. At present, seamstresses operating in small businesses present various risks derived from their work that can cause accidents or serious illnesses, since their tools and the distribution of their work area, in most cases, are not designed under No regulatory regime or its design and distribution is not adequate to perform its activities in a better way. Some of the most frequent accidents are cuts, crush injuries of fingers and hands, musculoskeletal diseases resulting from repetitive work that your profession demands.

Seamstresses operating in small businesses have various risks arising from their work that can cause accidents or occupational diseases, some of the most common accidents are cuts or burns, injuries from crushing fingers and hands, among others.

In many activities dedicated to clothing, in addition to safety accidents occur other problems, perhaps more hidden but no less important, which have much to do with a correct approach to what is the ergonomics of the position (furniture, lighting, noise ...) and also with the organization of work (schedules, distribution of responsibilities, communication, workload). We refer to health problems such as:

muscular ailments, visual disturbances, stress or physical and mental fatigue. Many people suffer from these ailments, ignoring the relationship that may exist between their illness and a poor design of the job and the organization of work.

Since the 80's, ergonomic studies have shown that bad postures at work can create cumulative trauma disorders (DTA), which occur when the person is subjected to repetitive and stressful movements during their work; but the most common cause is poor posture during the workday.

A thesis was found related to the problems that a seamstress may have when performing haute couture, which was carried out at the FASTA University, located in Argentina, during the month of September 2016 the research about cervicalgias was carried out to student dressmakers by Lucrecia Dimuro; a short summary is presented below.

The research was conducted with the aim of analyzing the causes that lead to cervicalgia and the type of posture adopted by haute couture seamstresses between 50 and 80 years old, in the city of Mar del Plata in 2016. For such research different materials and methods were carried out, such as descriptive, cross-sectional and non-experimental research, and subsequently the data was collected through a face-to-face survey. Evenly, it was concluded that the areas indicated as most painful were the lower cervical spine and the shoulders, due to the causes of correlation between the high workload and the years of seniority; therefore cervicalgia affects the most of the interviewees, being able to affirm like this, that a relation exists between the same one and the labor activity. (Dimuro, 2016)

On the other hand, was found a thesis related to the implementation of the Guerchet and S.L.P. methods, which was carried out at the Catholic University of Santa María in Peru where a proposal was developed for the implementation of a modular production system for a garment manufacturing company to achieve its process optimization; therefore, a brief summary of the investigation is presented below.

This thesis was carried out by a company manufacturing jeans, in order to identify techniques and elements of the system which could be implemented in the company; the production process was analyzed to determine causes why the company does not work as desired. Different diagrams were used which helped to meet the objectives. The number of stations needed for the clothing area was identified, so the line balancing was used according to the procedure of the heuristic method; likewise, a proposal was created for the re-distribution of the plant using methods Guerchet Method and S.L.P, in order to reduce transport times and generate a continuous flow of work. Subsequently, guidelines were announced to achieve the optimal functioning of the module created. (Cruz Quinto, 2016).

2. METHODOLOGY

A modiste was visited in the city of Los Mochis, Sin. To which the methods of RULA and Corlet & Bishop were applied, with which the musculoskeletal risks of the same were determined; On the other hand, the methods of Guerchet and S.L.P were implemented in their work area, these were carried out during a period of two weeks with the purpose of defining the organization of the work area. The development of each of the methods used is briefly explained below.

In the RULA method, section A performs an analysis of the arms and wrists while in section B an analysis of the neck, trunk and leg is performed. Finally, an analysis is made of the data obtained in both sections, looking for the crossover value in table C that is in the lower part of the format. For sample of this study, a result of six points was obtained, which is equal to a recommendation to carry out future research and make next changes (figure 1).

In the Corlett & Bishop method, all the body parts are analyzed, dividing the analysis in and out of the working day, dividing the values in discomfort or pain, in the event of any. In relation to the beginning of the working day, this study found that both the head, neck, shoulder, high back, upper arms, lower arms, middle back, lower back, buttocks, thighs, legs as feet, there is no discomfort or pain at the beginning of the workday. On the contrary that in the zones of the wrists, hands, knees and ankles where if they appear annoyance every day when begin the working day.

In the case of the end of the working day there were no discomforts or pains in the areas such as head, upper arms, middle back, lower back, sit-ups, thighs, legs and feet. While in neck, shoulder, high back and knees, there is always pain at the end of the working day. In terms of discomfort, it was found that in the lower part of the arms, ankles, wrists and hands, there is always at the end of the working day (figure 2).

In the case of the application of the Guerchet method, the physical spaces required in the dressmaker's workshop are calculated. It is necessary to identify the total number of equipment and operators, and then, using the calculations established by the method, develop a table (see table 1) where the results are grouped. In the method, the total surface is determined, which is obtained from: static surface, gravitation surface, evolution surface, number of fixed and moving elements, number of sides used by these elements and the coefficient of evolutionary surface. The surface that throws the table is the necessary one for the suitable distribution of the equipment of work and the ideal displacement of the operators.

Finally, the SLP method by its initials Systematic Layout Planning is an organized way to carry out the planning of a distribution and is constituted by four phases, in a series of conventional procedures and symbols to identify evaluate and visualize the elements and areas involved of the aforementioned planning. Its phases are complementary, so it is not necessary for one to start after the other. Among them is the table of relations of activities, where a kind of pyramid is made, in which the departments or areas analyzed are correlated, the degree of necessary proximity between them and the value corresponding to the reason for this proximity, which It is divided into five: control, flow, safety, hygiene and convenience (see figure 3).

For additional reason, the method was also developed based on a computer program called CORELAP, where when entering the data corresponding to the study, a proposal of distribution of the elements comprising the analyzed area is shown as a block layout as shown Figure 4

3. RESULTS

For the purpose of the present study, the following methods are carried out. Below are the results in each of them.

In the first instance, we have that in the application of the RULE method we obtain as a final result, a value of 6, which is interpreted as requiring a future investigation of the case and a next change. This is due to the comparison of the value 6 and 4 corresponding to section A and B respectively, within table C.

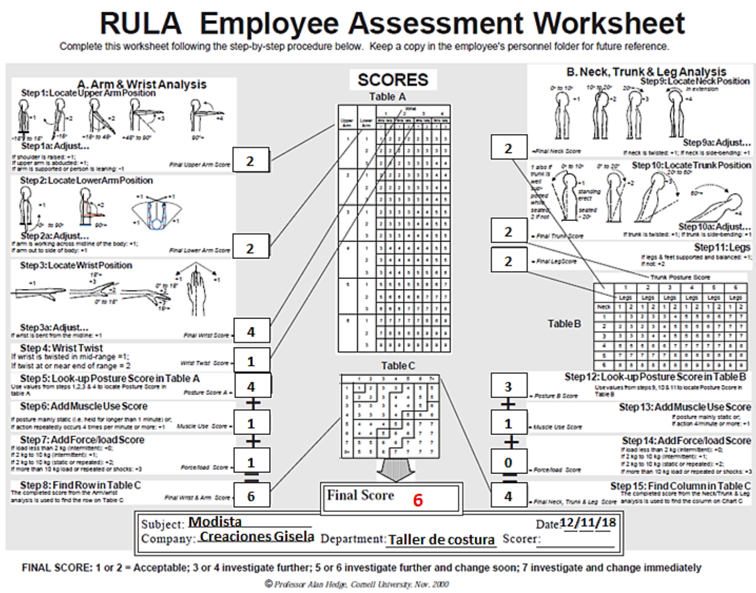
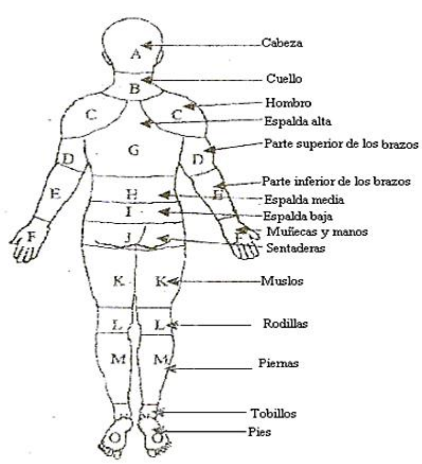


Figure 1. RULA Method evaluation of future fatigue.

The following table shows the results obtained after applying the method of Corlett and Bishop to the workshop worker, where he responded if he presented pain or discomfort at the beginning and at the end of the workday, corresponding to each part of the body exposed in the image at the left-side.



	ENTRADA							SALIDA						
	L	M	M	J	V	S	D	L	M	M	J	V	S	D
A	-	-	-	-	-	-		-	-	-	-	-	-	
B	-	-	-	-	-	-		D	D	D	D	D	M	
C	-	-	-	-	-	-		D	D	D	D	D	M	
D	-	-	-	-	-	-		-	-	-	-	-	-	
E	-	-	-	-	-	-		M	M	M	M	M	M	
F	M	M	M	M	M	M		M	M	M	M	M	M	
G	-	-	-	-	-	-		D	D	D	D	D	D	
H	-	-	-	-	-	-		-	-	-	-	-	-	
I	-	-	-	-	-	-		-	-	-	-	-	-	
J	-	-	-	-	-	-		-	-	-	-	-	-	
K	-	-	-	-	-	-		-	-	-	-	-	-	
L	M	M	M	M	M	M		D	D	D	D	D	D	
M	-	-	-	-	-	-		-	-	-	-	-	-	
N	M	M	M	M	M	M		D	D	D	D	D	D	
O	-	-	-	-	-	-		-	-	-	-	-	-	

Figure 2. Corlett & Bishop Method, map to detect discomfort in different parts of the body.

Table 1. Guerchet method shows the fixed and mobile equipment of the workshop, where subsequently the different surfaces are calculated.

MÉTODO GUERCHET										
ELEMENTO	N	n	L	A	H	Ss	Sg	Se	ST1	ST
Mesa	1	2	2.4	0.9	0.75	2.16	4.32	2.4231	8.9031	8.9031
Máquina	1	1	1.2	0.54	0.73	0.648	0.648	0.4846	1.7806	1.7806
Máquina recta	1	1	1.21	0.5	0.76	0.605	0.605	0.4525	1.6625	1.6625
Sillon	1	1	1.03	0.8	0.94	0.824	0.824	0.6162	2.2642	2.2642
Espejo	1	1	1.2	0.02	1.5	0.024	0.024	0.0179	0.0659	0.0659
Silla	1	1	0.5	0.55	1.03	0.275	0.275	0.2057	0.7557	0.7557
Burro	1	1	1.01	0.42	0.79	0.4242	0.4242	0.3172	1.1656	1.1656
Operario	1				1.68					
TOTAL										16.5976
Altura fijos	3.5									
Altura Moviles	4.68		K	0.3739						

The analysis of the table shows that it takes 16.5976 m^2 of total surface according to the necessary equipment and its correct distribution, such as table, machine, straight machine, chair, mirror, chair, ironing board and operator.

In the case of the SLP method, the graph resulting from the relationship analysis between each of the teams that make up the workshop and its degree of reason is shown below.

ESQUEMA		
A	ABSOLUTAMENTE NECESARIO	ROJO: PARED CON PARED
E	ESPECIALMENTE NECESARIO	VERDE: 1 O 2 UNIDADES DE DISTANCIA
I	IMPORTANTE	AZUL: 3 O 4 UNIDADES DE DISTANCIA
O	ORDINARIO	NEGRO: NO IMPORTA
U	SIN IMPORTANCIA	CAFÉ: LO MAS ALEJADO POSIBLE
X	INDESEABLE	CAFÉ: LO MAS ALEJADO POSIBLE

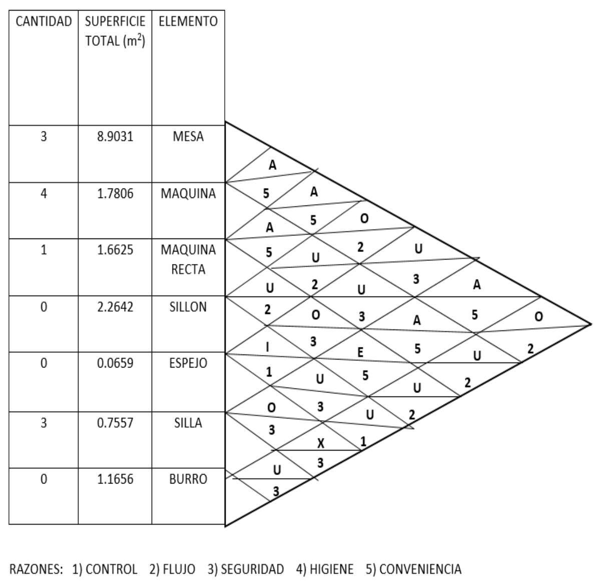


Figure 3. SLP method, to analyze the correct distribution of the elements within the sewing workshop, the SLP method was applied.

The following image shows in the lower left corner the layout proposed by the analysis resulting from the use of the CORELAP software. Where it points out that zone 1 corresponds to the cutting area, zone 2 to the machining area and zone 3 to the waiting area.

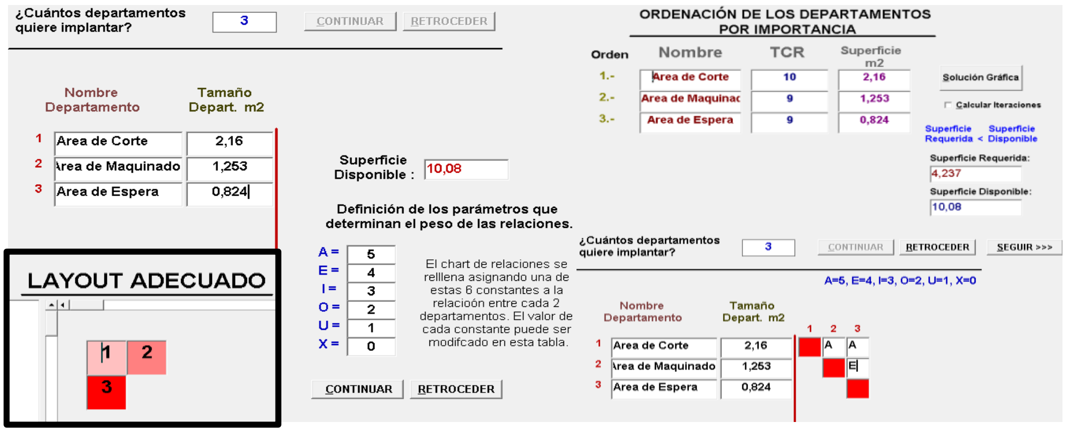


Figure 4. CORELAP, methodology used for plant distribution

It was defined that both the chair, the table and the machine are elements that must remain together for a better operation in the workshop.

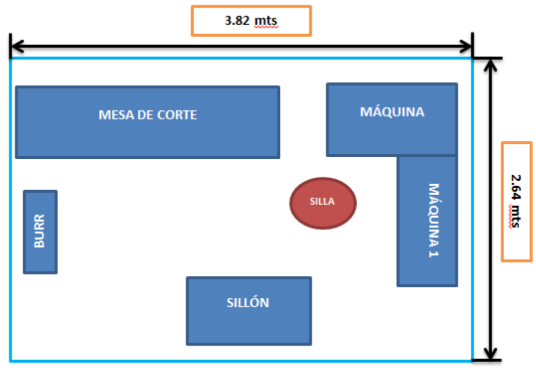
4. CONCLUSIONS

Through the methods that were applied during the investigation it was observed that the work of dressmaker usually generates ergonomic problems, mainly in hands and wrists, in the case of back and shoulder discomforts will depend on the repetitions and work time, in some cases these can become permanent damages. It is also known that all these problems are triggered due to the fact that the work area does not meet the necessary requirements or, failing that, it is not usually adapted to the seamstress.

It was concluded that it is necessary to expand the work area, since in this way the mobile and fixed equipment that are inside the workshop will be better distributed, and the same way, it will be easier for the dressmaker to move.

In the Guerchet method, it was calculated that the sewing workshop should have a dimension of 16.59 m^2, 6 meters more than the surface it currently has. Figure 5 shows the current distribution of the workshop and the distribution of the proposed area according to the results of the SLP method, in the latter a distribution estimate very similar to the one already available was shown, so it was decided not to make any modification. With all the free space that is added to expand the dimensions of the workshop the dressmaker will have a more appropriate and appropriate area to perform their tasks and the flow of people will be easier.

ACTUAL



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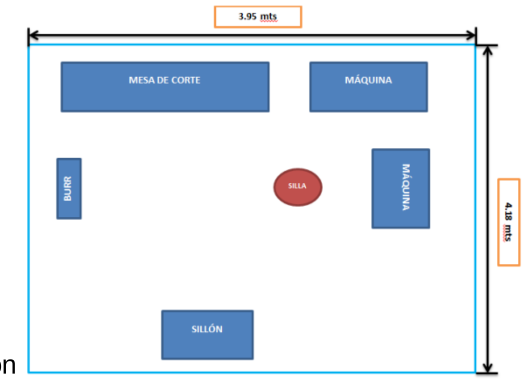
PROPOSAL



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ERGONOMIC CONDITIONS OF FURNITURE IN A UNIVERSITY SITUATED AT TIJUANA, MEXICO

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Resumen. La presente investigación tiene por objetivo evaluar ergonómicamente diversos tipos de mobiliarios empleados en procesos administrativos dentro de una institución de educación superior. Específicamente el proceso de tutoría realizada por profesores en los cubículos asignados para su uso personal y profesional. Para evaluar los riesgos implícitos en el uso de dicho mobiliario se utilizó el método ROSA. Esto involucró el uso de la computadora como equipo principal en este proceso, además de sillas, teléfono y escritorio. Aunque se encontró que existe riesgo bajo en el uso de dicho mobiliario, se puede concluir que este estudio es el paso inicial para poder realizar estudios adicionales para evaluar equipo en otras áreas y procesos de la misma institución.

Palabras clave: Oficina, Mobiliario, ROSA, Universidad

Relevancia para la ergonomía. La aplicación del conocimiento teórico y metodologías de la Ergonomía en ambientes naturales es una excelente oportunidad para mostrar sus beneficios. Particularmente, cuando se involucran individuos prestando servicios a la comunidad, como lo es el caso de docentes otorgando asesorías a estudiantes. De ahí que el mobiliario utilizado en este proceso sirve para mostrar dichos beneficios. Para ello se empleó una de las metodologías para evaluar las condiciones de uso y así mejorar su diseño.

Abstract. The objective of this research is to ergonomically evaluate diverse types of furniture employed in administrative process within a higher education institution. Specifically, the tutorial process carried out by lecturers in the cubicles assigned for their personal and professional use. To evaluate the implicit risks in the use of the furniture, the method ROSA was utilized. This involved the use of the computer as main equipment in the process, as well as chairs, telephone and desk. Although it

was found that there is low risk in the use of that furniture, it is concluded that this study is the initial step to be able to perform additional studies to evaluate equipment in other areas and processes within the same institution.

Keywords: Office, Furniture, ROSA, University

Relevance to Ergonomics. The application of the theoretical knowledge and methodologies of Ergonomics in natural environments is an excellent opportunity to show its benefits. Particularly, when individuals are providing services to the community, as it is the case of lecturers providing advisory services to students. Hence, the furniture used in this process serves to show its benefits. To do so, one methodology was used to evaluate the conditions of use to improve its design.

1. INTRODUCTION

The present research is developed within assigned offices for teachers and students in a higher education institution. These are considered as a controlled environment in which there is a particular interest in solving various problems attributable to ergonomic factors. This is because for many years teachers and students have exposed some pains, which have been attributed to some conditions of the furniture used in that institution. Moreover, there are certain conditions hiding additional details about the ergonomic risks implicit in those offices or places where those administrative activities are carried out. However, it is assumed that in these places there are no risks. In this line some administrators suggest that these places are free of ergonomic risks.

However, it is known that working in these type of places on a daily basis include a large quantity of ergonomic risks, specifically if computers are used in those contexts (Sonne, Villata & Andrews, 2012). Particularly, when the activities are improperly carried out (Cook, Burguess-Limerick and Papalia, 2004). Some results could occur resulting in absenteeism and incapacity for work that later they entail high costs affecting productivity directly or indirectly (Cruz and Garnica, 2001). These risks can include some elements of the environment in which office work is carried out and this can be observed in aspects of ergonomic nature of chairs, tables, postures of using computers, archivists, among other office equipment. Consequently, it has generated an increase in the number of incidents and symptoms of occupational diseases affecting a great number of workers. Notably, this number is associated with the risks of using computers (Robertson, Ciriello & Garabet, 2013; Rempel, Barr, Brafman, & Young, 2007).

From the above exposed, this project is carried out due to some problems detected in the area designated to the teachers offering and doing the departmental tutorials. It is important to mention that other teachers used this area in other activities required by the institution. As a result of both uses of tutors and teachers, some pains resulted of the use of the furniture that exists in the area. In addition, they suggest that this area is not confortable and do not meet the ergonomic requirements for carrying out their activities in that area. Consequently, this area is chosen to do a diagnosis of the furniture and its uses as well as the postures adopted by teachers and how they use it. Initially, it was found that teachers and students adopted diverse postures, which are presented in the subsequent parts of this document. These serve to start the evaluation.

2. OBJECTIVES

a. To evaluate the ergonomic conditions using ROSA method of the diverse types of furniture located in the office of lecturers that wok in a higher education institution;
b. To evaluate the implicit risks within environments in which the computer is the main used equipment in the mentioned institution.

3. LITERATURE REVIEW

1.1 Ergonomic Analysis of the Workplace

The selection of the ROSA ergonomic method is for the purpose of being able to have the first-hand information by teachers using this area of the institution. For this investigation they have been summarized in the ergonomic evaluation criteria that resulted from a first exploration and are those related to causing discomfort and fatigue, as follows: height of the seats, length of the seat, size of the armrest, and use of the monitor, telephone, mouse and keyboard.

1.2 The ROSA Method

The ROSA (Rapid Office Strain Assessment) method aims to identify areas of priority intervention in office work (Sonne, Villata & Andrews, 2012). To do so, the data collection can be done by direct observation or, preferably, by the study of the recorded video image. Moreover, the analyst selects the most unfavorable positions and their duration facilitated by the users of PVD positions. In addition, the method provides some examples to minimize the probability of incorrect interpretations. Particularly, the method aids to evaluate the risks, which are:

- Characteristics of the seat and the posture of sitting on the chair
- Distribution and uses of the monitor and telephone
- Distribution and uses of the peripherals, keyboard and mouse (group C)
- Duration of the exhibition

Depending on the data obtained during the observation of the positions and postures, two possible levels of action are determined:

- Scores between 1 and 4 do not require immediate intervention
- Scores greater than 5 are considered high risk and the position must be evaluated as soon as possible

The risk factors evaluated in this method are:

- Group A) Height of seats
- Group B) Seat length
- Group B.1 use of the monitor
- Group B.2 Use of the telephone
- Group C) Armrest
- Group C1) Use of the Mouse
- Group C2) Using the keyboard
- Group D) Chair back Support

4. METHODOLOGY

The methodology used was carried out in three stages, as listed below:

1. Collection of the average use information by means of a survey and taking several photographs of the work area and the furniture used, among which were the height of the seats, the length of the seats, the conditions of the armrests, the characteristics of the chain backs and the ways of using monitors, telephones, mice and keyboards assigned to the area. This information was placed on an Excel sheet to facilitate its analysis. Subsequently, the pertinent evaluations were carried out using the section of the ROSA method within the ErgoSoft-Pro program. Here, the tasks performed were added and then the physical conditions of the chairs, monitors, mice, keyboards and telephones used in them. Here the variables were introduced in direct reference to the positions adopted in the post by the various teachers and the way they are used. It is also considered the time of use of each of the mentioned elements, where finally the risk of the task with the use of mentioned elements are obtained. The data was collected in three cubicles and each cubicle contains a computer, a telephone, three chairs, a desk and an archivist.
2. In this part, the ergonomic evaluation of the students' positions was carried out when they perform the tutorials. Here, six teachers and 15 students participated in the study.
3. Finally, the evaluation and diagnosis of the furniture used was carried out. Here the dimensions of each element within the work area were determined. Likewise, the design needs of the equipment and furniture required by teachers to carry out the activities were considered. Finally, the ergonomic evaluation of mentioned furniture and existing equipment was developed. Within these stages paper, pencil, video camera, flexometer, and the aforementioned software were used. In the annex, it is presented the diverse elements that were evaluated. It is important to mention that the complete methodology is presented in the section 2 related to methods in Sonne, Villata & Andrews (2012).

5. RESULTS

Following the methodology, first, the postural risk associated with the height of the seat and the free space under the board (A). The height score ranges from 1 to 5 (3 + 1 + 1A higher score corresponds to greater risk.) The score obtained by the height is added the one corresponding to the seat length (B), with a score that ranges from 1 and 3. The score obtained by adding these two items will be the one that should be entered in the horizontal axis of the table. The entire procedure is presented in the Annex.

On the other hand, the characteristics of the armrest (with a score between 1 and 5) and the backrest are analyzed, with a score that ranges between 1 and 4. The combined score is introduced on the vertical axis of the table in section A. The result obtained from the table is added the possible risk for the duration of the position to obtain the final score of group A of the chair:

- If you remain seated <1 hour / day or <30 minutes continuously -1
- If it stays between 1 and 4 hours a day or between 30 minutes and 1 hour followed 0
- If you remain seated> 4 hours / day or more than 1 hour continuously +1

Second, in Group B the same dynamic is followed. In this group, the distribution and the use of the monitor and the telephone are analyzed; and the peripherals, mouse and keyboard, by the other. Before entering the corresponding table, the value obtained by the use of each of them must be added to the value of the duration. Once the partial indexes of the tables with the items under study are known, the risk B postural is obtained according to the table of this section.

Third, calculation of the final score. A level of risk 1 to 4 indicates acceptable work situations, and a score equal to or greater than 5 indicates situations of ergonomic intervention priority. Here, the final score was 4.

6. CONCLUSIONS AND RECOMMENDATIONS

The ROSA method helped to quantify the ergonomic evaluation of furniture used in the area of tutoring in a higher education institution. The value obtained in the application of the commented method, which was 4, suggests that the furniture used represents a low risk. However, this does not close the opportunity to seek better designs in such furniture that helps to reduce ergonomic risks. That is, although the risk of current furniture is low, it is expected that in the short term the current furniture will be replaced with another one in such a way that it will show better design that helps to reduce ergonomic risks. This allowed pointing out the necessary arguments to oppose the presented problem. That is, the evidence obtained helped us to clearly see what ergonomic risks existed in the area of tutorials in reference to the use of current furniture. In addition, this does not preclude the reuse of the ROSA method to ergonomically evaluate other types of furniture used in other areas of mentioned higher education institution.

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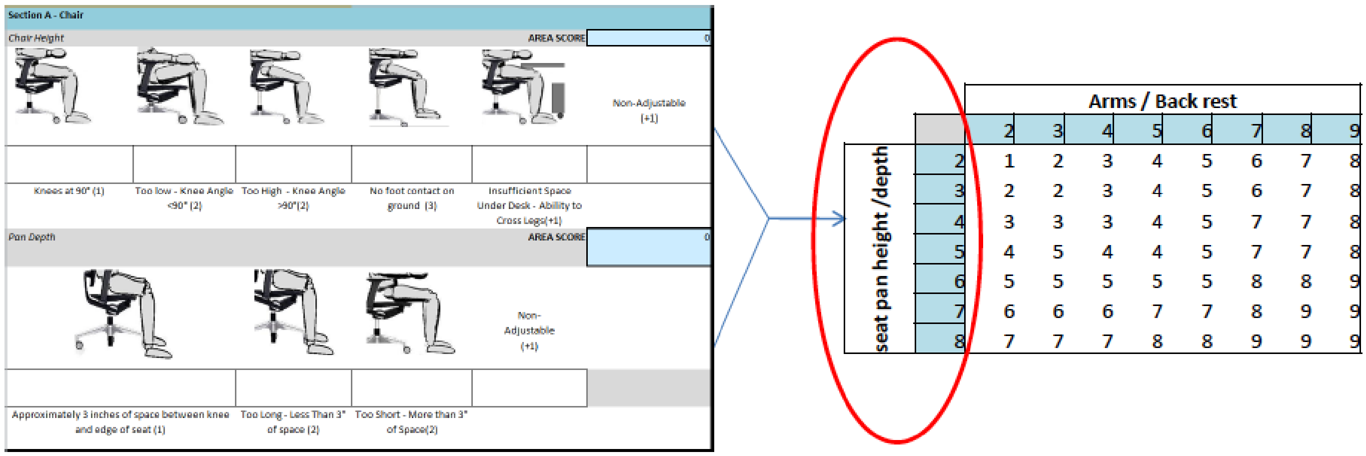
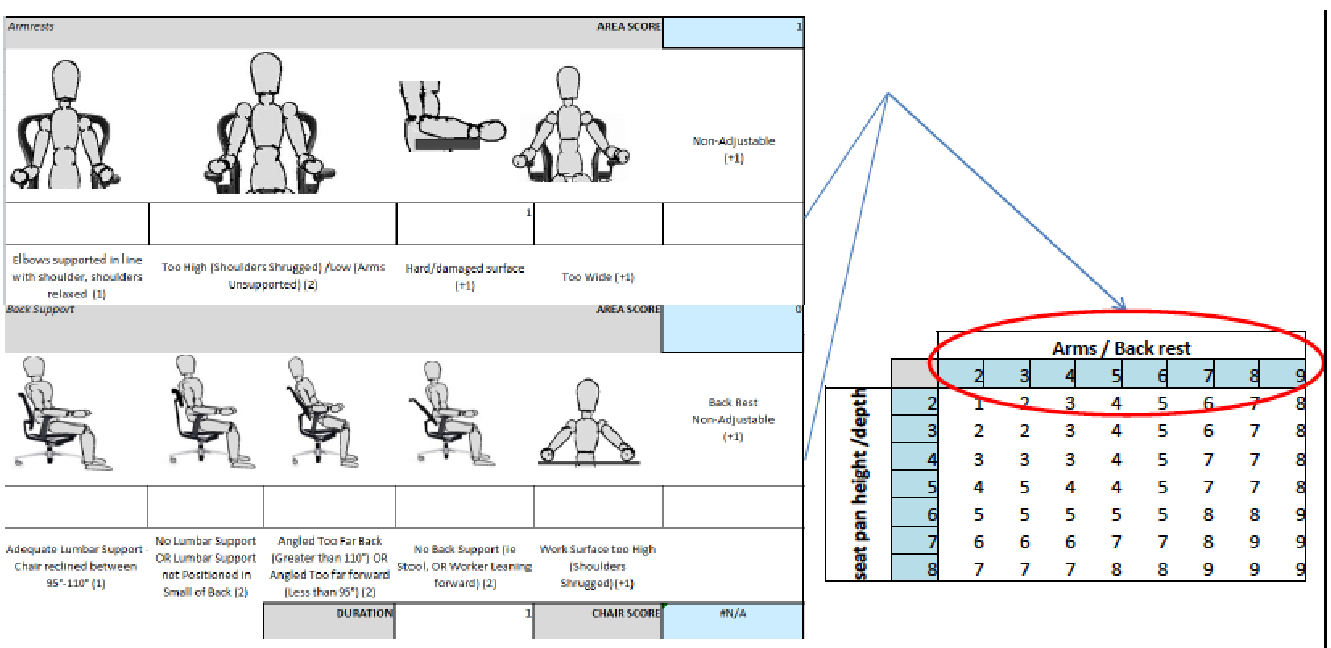
8. ANNEX

This presents the procedure followed in this study and suggested by Sonne, Villata & Andrews (2012),



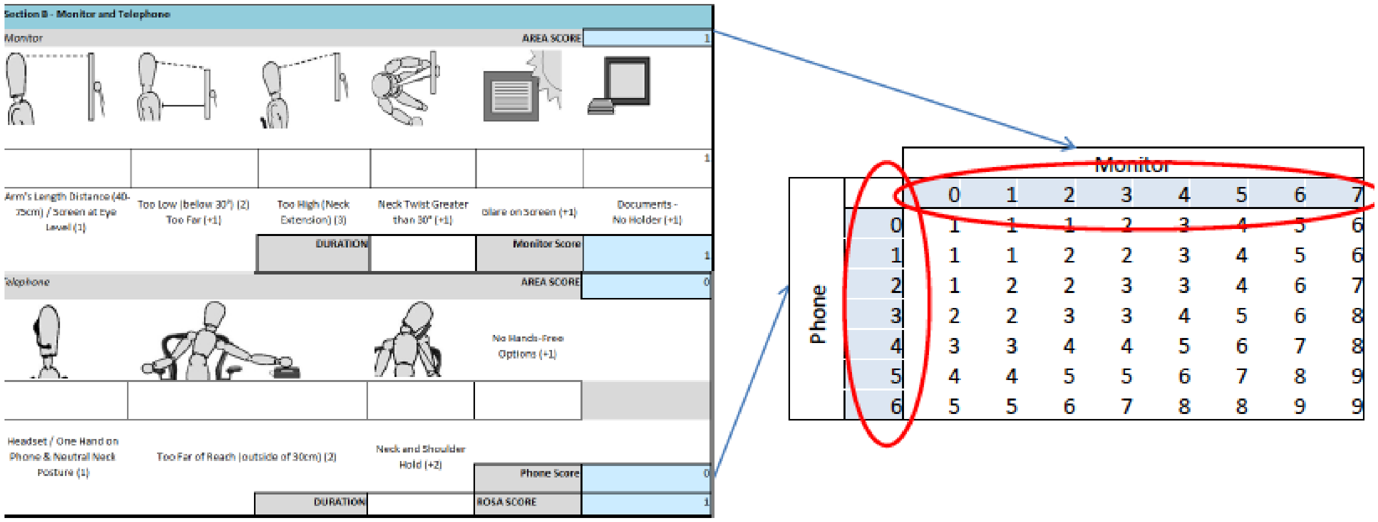
seat pan height /depth	2	3	4	5	6	7	8	9
2	1	2	3	4	5	6	7	8
3	2	2	3	4	5	6	7	8
4	3	3	3	4	5	7	7	8
5	4	5	4	4	5	7	7	8
6	5	5	5	5	5	8	8	9
7	6	6	6	7	7	8	9	9
8	7	7	7	8	8	9	9	9

Figure 1. Section A. The chair. Chair height and pan depth



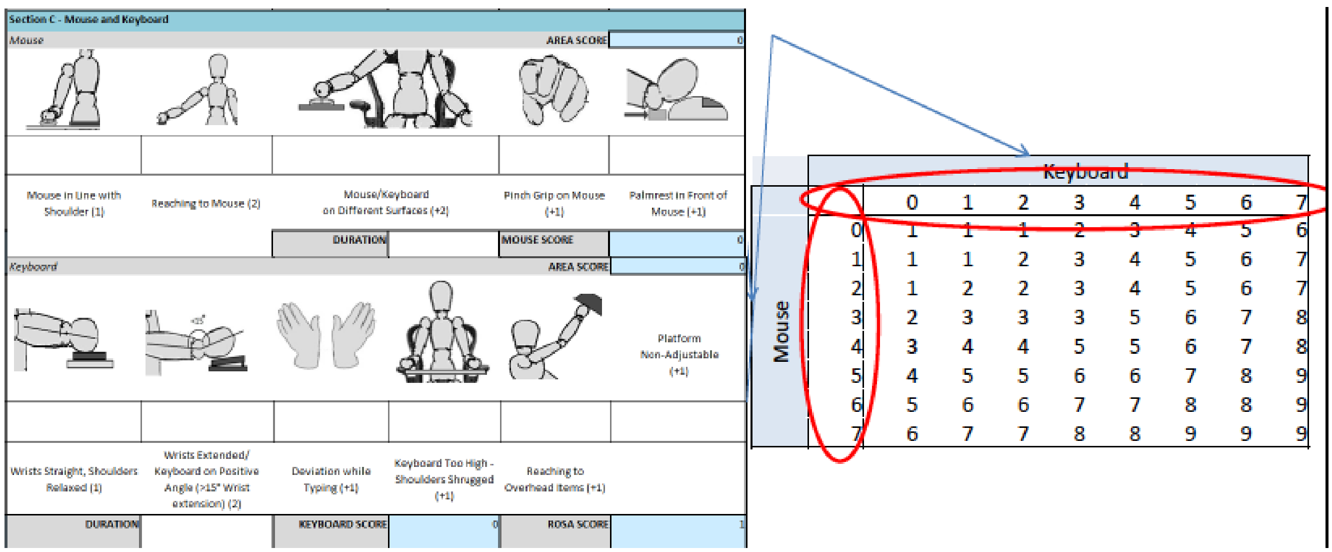
seat pan height /depth	2	3	4	5	6	7	8	9
2	1	2	3	4	5	6	7	8
3	2	2	3	4	5	6	7	8
4	3	3	3	4	5	7	7	8
5	4	5	4	4	5	7	7	8
6	5	5	5	5	5	8	8	9
7	6	6	6	7	7	8	9	9
8	7	7	7	8	8	9	9	9

Figure 2. Section A. The chair, continued. Arm rest, back suppot and duration of sitting.



Phone \ Monitor	0	1	2	3	4	5	6	7
0	1	1	1	2	3	4	5	6
1	1	1	2	2	3	4	5	6
2	1	2	2	3	3	4	6	7
3	2	2	3	3	4	5	6	8
4	3	3	4	4	5	6	7	8
5	4	4	5	5	6	7	8	9
6	5	5	6	7	8	8	9	9

Figure 3. Section B. Telephone and monitor



Mouse \ Keyboard	0	1	2	3	4	5	6	7
0	1	1	1	2	3	4	5	6
1	1	1	2	3	4	5	6	7
2	1	2	2	3	4	5	6	7
3	2	3	3	3	5	6	7	8
4	3	4	4	5	5	6	7	8
5	4	5	5	6	6	7	8	9
6	5	6	6	7	7	8	8	9
7	6	7	7	8	8	9	9	9

Figure 4. Section C. Keyboard and mouse

Phone \ Monitor	0	1	2	3	4	5	6	7
0	1	1	1	2	3	4	5	6
1	1	1	2	2	3	4	5	6
2	1	2	2	3	3	4	6	7
3	2	2	3	3	4	5	6	8
4	3	3	4	4	5	6	7	8
5	4	4	5	5	6	7	8	9
6	5	5	6	7	8	8	9	9

Mouse \ Keyboard	0	1	2	3	4	5	6	7
0	1	1	1	2	3	4	5	6
1	1	1	2	3	4	5	6	7
2	1	2	2	3	4	5	6	7
3	2	3	3	3	5	6	7	8
4	3	4	4	5	5	6	7	8
5	4	5	5	6	6	7	8	9
6	5	6	6	7	7	8	8	9
7	6	7	7	8	8	9	9	9

Monitor and Telephone \ Mouse and Keyboard	1	2	3	4	5	6	7	8	9
1	1	2	3	4	5	6	7	8	9
2	2	2	3	4	5	6	7	8	9
3	3	3	3	4	5	6	7	8	9
4	4	4	4	4	5	6	7	8	9
5	5	5	5	5	5	6	7	8	9
6	6	6	6	6	6	6	7	8	9
7	7	7	7	7	7	7	7	8	9
8	8	8	8	8	8	8	8	8	9
9	9	9	9	9	9	9	9	9	9

Figure 5. Peripherals and monitor/phone score

seat pan height /depth \ Arms / Back rest	2	3	4	5	6	7	8	9
2	1	2	3	4	5	6	7	8
3	2	2	3	4	5	6	7	8
4	3	3	3	4	5	7	7	8
5	4	4	4	4	5	7	7	8
6	5	5	5	5	5	8	8	9
7	6	6	6	7	7	8	9	9
8	7	7	7	8	8	9	9	9

Monitor and Telephone \ Mouse and Keyboard	1	2	3	4	5	6	7	8	9
1	1	2	3	4	5	6	7	8	9
2	2	2	3	4	5	6	7	8	9
3	3	3	3	4	5	6	7	8	9
4	4	4	4	4	5	6	7	8	9
5	5	5	5	5	5	6	7	8	9
6	6	6	6	6	6	6	7	8	9
7	7	7	7	7	7	7	7	8	9
8	8	8	8	8	8	8	8	8	9
9	9	9	9	9	9	9	9	9	9

Chair \ Peripherals and Monitor	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	2	2	3	4	5	6	7	8	9	10
3	3	3	3	4	5	6	7	8	9	10
4	4	4	4	4	5	6	7	8	9	10
5	5	5	5	5	5	6	7	8	9	10
6	6	6	6	6	6	6	7	8	9	10
7	7	7	7	7	7	7	7	8	9	10
8	8	8	8	8	8	8	8	8	9	10
9	9	9	9	9	9	9	9	9	9	10
10	10	10	10	10	10	10	10	10	10	10

Figure 6. The final score

ERGONOMIC EVALUATION OF LENSES MANUAL CLEANING OPERATION AT OFTALMIC COMPANY

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Resumen. La presente investigación tiene por objetivo evaluar ergonómicamente diversas posturas llevadas a cabo por el operario durante la realización de la operación denominada limpieza manual de lente con alcohol. Esta operación fue escogida por la presunción de riesgos implícitos en su realización. Para llevar a cabo la evaluación se empleó el método RULA y así descubrir riesgos potenciales que pudieran producir lesiones por requerir movimientos repetitivos durante la jornada laboral. De acuerdo a los resultados obtenidos, la operación tiene una calificación de 3 y un riesgo nivel 2. Esto implica la necesidad de realizar una evaluación detallada de la operación para realizar cambios a corto plazo. Consecuentemente, se tomó la decisión de automatizar dicha operación. Para ello fue necesario realizar el análisis de factibilidad económica de dicha propuesta. Esta propuesta fue aprobada para llevarse a cabo en el mediano plazo.

Palabras clave: Operación Manual, RULA, Proceso Oftálmico, Trabajo Repetitivo

Relevancia para la ergonomía. Esta investigación ayudó a constatar la necesidad de aplicar el conocimiento teórico en la búsqueda de solución a problemáticas que pueden ser encontradas principalmente en el área laboral. Esto trae consigo cuantificarlas de tal manera que sea necesario el descubrimiento de soluciones a éstas. Generalmente se esperan cambiar condiciones de trabajo para así reducirlas; sin embargo, también esto incluye definir otras estrategias que pueden estar inicialmente fuera del alcance de los practicantes de la Ergonomía. De ahí que descubrir formas de usar herramientas y equipo para sustituir el trabajo manual es un reto que fue tratado en esta investigación.

Abstract. The objective of the present investigation is to evaluate ergonomically various postures carried out by the operator during the operation called manual lens cleaning with alcohol. This operation was chosen because of there is the presumption of implicit risks in its realization. To do so, the RULA method was used to discover potential risks that could cause injuries by requiring repetitive movements during the workday. According to the results obtained, the operation has a rating of 3 and a risk level 2. This implies the need to perform a detailed evaluation of the

operation in order to make short-term changes. Consequently, the automation of the operation was the decision made. For this, it was necessary to carry out the economic feasibility analysis of the mentioned proposal. This proposal was approved and carried out in the medium term.

Keywords: Manual Operation, RULA, Ophthalmic Process, Repetitive Work

Relevance to Ergonomics. This research helped to confirm the need to apply theoretical knowledge for searching solutions to problems that can be mainly found in the workplace. This entails quantifying them in a way to discover their solutions. For this, it was generally expected to change the working conditions in order to reduce them; however, this also included defining other strategies that may initially be beyond the reach of Ergonomic practitioners. Hence, discovering some ways on how to use tools and equipment for replacing manual work was a challenge that was addressed in this research.

1. INTRODUCTION

One of the main resources of any company is the human resource. In order to be productive, the administrators should provide environmental conditions and particularly work stations that should avoid injuries and illnesses (Maldonado-Macías, Ramírez, García, Díaz, & Noriega, 2009). In this line, one area of knowledge that has been focused on transferring theoretical knowledge to practice is Ergonomics (Iqbal, Iqbal, Rahman, & Samsuzzoha, 2011). However, throughout its practice have been discovered multiple problems having the same number of origins. For this reasons and in order to offer better solutions to problems, they have had to develop various areas of knowledge related to Ergonomics. Additionally, each of these areas has had to face the various problems that can be addressed within their scope. In the same way, they have had to develop strategies and methods to solve the problems presented. Some of the common problems that solve are those related to the repetitive tasks, uncomfortable postures, among other risk factors. These included the current exposition of environmental factors that added to the mentioned risks, they could produce musculoskeletal disorders (Maldonado-Macías, Realyvásquez, Hernández, & García-Alcaraz, 2015).

The present study aims to ergonomically evaluate those postures execute by the operator performing the manual cleaning operation of a lens using alcohol. This operation is part of the manufacturing process of the photo chromatic lens area, which is divided into production cells. In particular, this area has a production capacity of 2,500 lenses per day and, in conjunction with the rest of the production cells, it produces 10,000 lenses a day. In general, the production process consists of four activities, which have been named: 1. Lens unpacking area and assembly of plans; 2. Cleaning the lens; 3. Lens coating, and 4. Packing area. The company in which this proposal is made is located in the city of Tijuana, Mexico. The company is mainly engaged in the manufacture of ophthalmic lenses. The company is divided into two business units: mass manufacturing and laboratory. Currently it has approximately 2800 employees, classified mainly in floor and administrative partners. Specifically, the study is carried out in the mass manufacturing business unit and, in particular, the photo chromatic lens area. Here in this area the lens is coated with a photo sensitive resin which, when exposed to the UV rays of the sun, reacts in such a way that it obscures the lens and thus protects the eye of the lens carrier. It is important to mention that this business unit represents a high percentage of the company's sales.

2. OBJECTIVES

To ergonomically evaluate the operator's postures during the operation of manual lens cleaning with alcohol using the RULA method to reduce risks from injuries from the repetitive movements that the execution of this operation represents throughout the working day.

3. LITERATURE REVIEW

1.1 Definition of Ergonomics

Ergonomics is defined as the study or measurement of work. The human being is adaptable but his capacity for adaptation is not infinite. There are optimal conditions for any activity. One of the tasks of Ergonomics is to define what these intervals are exploring undesirable effects that will occur in case of exceeding the limits. Ergonomics examines not only the passive situation of the environment, but also the advantages for the human operator and the contributions that individuals can make if the work situation is conceived to allow and encourage the best use of their abilities (Laurig and Vedder, 2016). To do so, professional of the Ergonomics apply theory, principles, data and methods to design a system in order to optimize human welfare and the overall performance of the system (Cañas, 2011).

1.2 Objectives of Ergonomics

The basic objective of ergonomics is to achieve efficiency in any activity carried out with a purpose and efficiency in the broadest sense is seen to achieve the desired result without wasting resources, without errors and without damage to the person involved or to others (Laurig and Vedder, 2016). Another objective is to ensure that the work environment is in harmony with the activities performed by the worker and it is valid by itself, but its achievement is not easy for a number of reasons. The human operator is flexible and adaptable and learns continuously, but the individual differences can be very large. Some differences such as those of physical constitution and strength are evident, but there are others such as differences in culture, style or skills that are difficult to identify (Laurig and Vedder, 2016).

1.3 RULA Method

The RULA method evaluates specific postures of the body when doing work (McAtamney & Corlett, 1993). Here, it is important to make a discrimination of postures focusing the evaluation to those, which should exhibit higher postural load (Agrawal, Madankar, & Jibhakate, 2011). The procedure to apply the RULA method can be summarized in the following steps:

1. Determine the work cycles and observe the worker during several of these cycles. If the cycle is very long or there are no cycles, evaluations can be made at regular intervals.
2. Select the positions that will be evaluated. Those that, a priori, suppose a greater postural load, will be selected, either because of their duration, because of their frequency or because they present greater deviation with respect to the neutral position.
3. Determine if the left or right side of the body will be evaluated. In case of doubt, both sides will be analyzed.
4. Take the required angular data. Photographs can be taken from the appropriate points of view to make the measurements.
5. Determine the scores for each part of the body. Using the table corresponding to each member.
6. Obtain the partial and final scores of the method to determine the existence of risks and establish the Level of Action.
7. If required, determine what type of measures should be adopted. Review the scores of the different parts of the body to determine where corrections are necessary.
8. Redesign the position or introduce changes to improve posture if necessary
9. In case of having introduced changes, reassess the position with the RULA method to check the effectiveness of the improvement.

Similarly, RULA divides the body into two groups: Group A which includes the upper limbs (arms, forearms and wrists) and group B, the legs, trunk and neck. Using the associated tables the method, a score is assigned to each body area so, depending on these scores, assign global values to each of groups A and B. The scores will be obtained in the manner described below:

- Group A: Analysis of arms, forearms and wrists.
- Group B: Analysis of the neck, trunk and legs.

With the scores obtained from tables A and B the score is added by the type of muscle activity developed and the score of the force exerted or load handled by groups A and B. The following criteria should be used:

a. Muscle activity score:

- 1 If the activity is mainly static (if the posture analyzed stays more than one minute in a row).

- 1 If the activity is repetitive (repeats more than four times per minute).
- 0 If the task is considered dynamic activity (it is occasional, infrequent and of short duration).

The muscle activity score can therefore be from 0 to 1.

b. Score of force exerted or load handled:
- 0 No resistance or less than 2kg load, intermittent force.
- 1 From 2 - 10 kg load or intermittent force.
- 2 From 2 - 10 kg load or static force. 2 - 10 kg load repetitive force.
- 3 of 10 kg or more of load or static force, of 10 kg or more of load or repeated force. Jerks or forces that increase rapidly.

In this way we will obtain two scores that we will call C and D according to the following formulas:

Score A + muscle activity score (Group A) + strength / load score (Group A) = C score
Score B + muscle activity score (Group B) + strength / load score (Group B) = D score

With the scores C and D in table F, the final score of the RULA method is obtained, see the entire procedure in figure 2 in Annex.

4. METHODOLOGY

The procedure applied was according to what was suggested with the RULA method McAtamney, & Corlett, 1993). It is relevant to mention that this was appropriate to the context under study, as follows:

a. The lens cleaning operation carried out manually was chosen because it showed greater effort on the part of the operators. In addition, this represents a risk for operators in reference to the movements required and the handling of chemical substances.
b. The making of videos of the operation under study. The Engineering and Production work team did the respective analysis using the RULA method, mainly based on the fact that the operation included repetitive movements.

Here, some considerations were done as follows:
1. Determine the work cycles and observe the operator during several of these cycles.
2. Select the positions that will be evaluated. They are selected that suppose greater postural load for their duration, frequency or present greater deviation with respect to their neutral position.
3. The evaluation of the right side of the operator was determined.
4. The required angular data was taken by taking video and camera.

5. The scores of each part of the body involved in the study operation were determined.
6. The partial and final scores were obtained and thus the risk and the level of action were determined.
7. The necessary measures were determined to apply corrections to the movements made by the various parts of the body.
8. Changes were introduced in the positions and movements of the operator, where later considerations were taken to be able to carry out the redesign of the work areas.
9. The operation was evaluated again to corroborate the changes.

It is important to mention that the operations were evaluated during the first work-shift considering that the same problem exists in the second work-shift. In addition, it is important to note that only that the study focused on those workers who had the average skill in carrying out this operation and with an experience of more than three months. 15 individuals participate in the study and are women. It is also mentioned that a video camera, a camera and various materials related to the RULA method (scoring tables) were used, see figure 2 in Annex

5. RESULTS

The evaluated posture was that of manual lens cleaning with alcohol. In this, the individual is seated in a chair that can adjust its height in relation to the height of the work-table. The operator's neck is slightly tilted down looking at the lens. With the left hand holds the lens while with the right hand has the wrist deflected when doing the cleaning movement with the towel impregnated with alcohol. Figure 1 shows the posture during the hand cleaning of the lenses with alcohol.

Figure 1. Posture during manual lens cleaning with alcohol

As a result of the analysis of the operation, it was found that the score obtained in Group A is as follows:

- Arm = 1,
- Forearm = 2,
- Wrist = 4,
- Wrist rotation = 1,
- Type of muscle activity = 1,
- Load / force ratio = 0.

Regarding the score obtained in Group B relative to neck, trunk and leg analysis, it was:

- Neck = 2,
- Trunk = 1,
- Legs = 1,
- Muscle activity = 1,
- Load ratio / force = 0.

Once the scores were obtained, the level of risk and performance was found which is:

- Final RULA score is 3,
- The risk level is 2,

Referring to the performance a detailed evaluation of the operation is required in addition to perform some changes to decrease this.

6. CONCLUSIONS AND RECOMMENDATIONS

The ergonomic evaluation of the operation manual cleaning of the lens with an impregnated towel with alcohol was carried out through the use of the RULA method. From this, the score of 3 was obtained, suggesting a required action level of 2, which can be interpreted as the need to carry out a more detailed evaluation of the operation studied and to highlight some short-term changes. However, analyzing the score related to Group A, specifically the section referring to the wrist, it was observed that the position of this is a risk for the individual since the operation is repetitive and is performed during work shifts of 12 continuous hours. Therefore, it is suggested to carry out actions and short-term changes to improve mentioned conditions. A suggested action is the purchase of a machine that automatically performs lens cleaning. For this purpose, it is suggested to carry out the economic feasibility analysis on the acquisition of said equipment.

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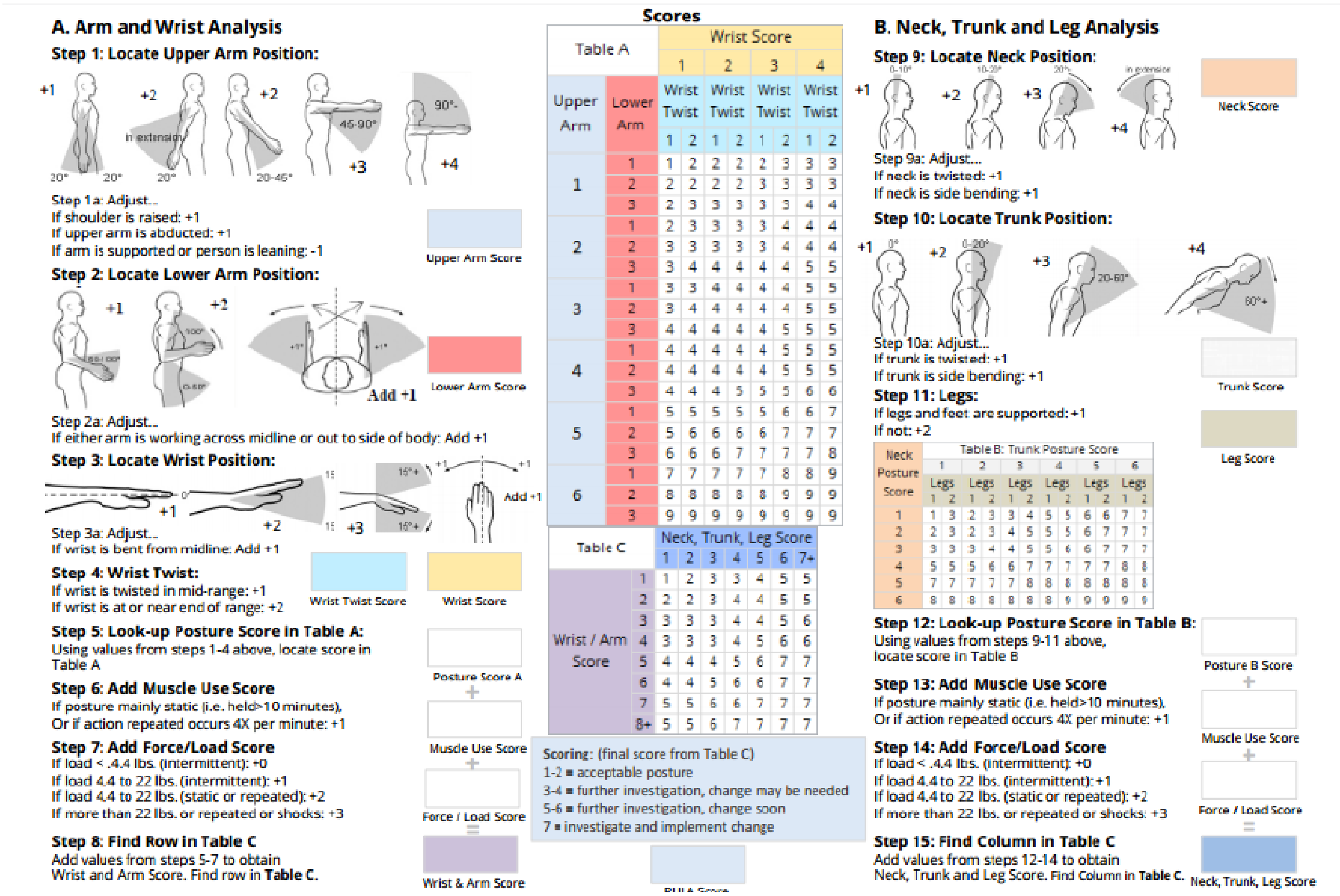
8. ANNEX



A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:

+1 +2 +2 +3 +4

20° 20° in extension 20° 20-45° 45-90° 90°+

Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

Step 2: Locate Lower Arm Position:

+1 +2 Add +1

Lower Arm Score

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:

+1 +2 +3 Add +1

Step 3a: Adjust...
If wrist is bent from midline: Add +1

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Wrist Twist Score

Wrist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

Posture Score A

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

Step 7: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**.

Wrist & Arm Score

Scores

Table A		Wrist Score 1		Wrist Score 2		Wrist Score 3		Wrist Score 4	
Upper Arm	Lower Arm	Wrist Twist 1	Wrist Twist 2	Wrist Twist 1	Wrist Twist 2	Wrist Twist 1	Wrist Twist 2	Wrist Twist 1	Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C		Neck, Trunk, Leg Score 1	2	3	4	5	6	7+
Wrist / Arm Score	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

RULA Score

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:

+1 +2 +3 +4

0-10° 10-20° 20°+ in extension

Neck Score

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:

+1 +2 +3 +4

0° 0-20° 20-60° 60°+

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

Leg Score

Neck Posture Score	Table B: Trunk Posture Score 1		2		3		4		5		6	
	Legs 1	Legs 2	Legs 1	Legs 2	Legs 1	Legs 2	Legs 1	Legs 2	Legs 1	Legs 2	Legs 1	Legs 2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B

Posture B Score

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

Step 14: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C**.

Neck, Trunk, Leg Score

Figure 2. RULA method: step by step (Middlesworth, 2007)

PROPOSAL TO REDUCE THE TIME OF MANAGEMENT OF THE RESIDENCE PROCESS PROFESSIONALS WITH HIERARCHICAL TASK ANALYSIS AND TECHNIQUES OF METHODS ENGINEERING

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Resumen En una institución de nivel superior, existe la percepción de que la gestión del Proceso de Residencia es compleja y difícil de llevar a cabo para los residentes. En una fase inicial de este proyecto para medir la magnitud del problema en términos cuantitativos, se utilizaron encuestas, entrevistas y diagramas de flujo, operación y recorrido. En una segunda fase, se elaboró un Análisis de Jerarquía de Tareas que mostró la carga mental que el residente tiene en el proceso y facilitó la determinación de la secuencia de tareas para la preparación de un diagrama PERT (Técnica de Evaluación y Revisión de Proyectos). PERT determinó la ruta crítica del proceso y las actividades que deben optimizarse para reducir la duración del proceso. De esta manera, en este proyecto, las técnicas de ingeniería y los métodos ergonómicos se unieron para evaluar un proceso de servicio y hacer una propuesta de optimización.

Palabras clave: Residencias profesionales, Gestión de procesos, Ingeniería de métodos, Análisis de Jerarquía de Tareas

Relevancia para la ergonomía: Una de las principales contribuciones de este estudio es verificar la versatilidad de la ergonomía como una ciencia útil en diversos campos, ya que el análisis jerárquico de tareas que se realizó facilitó la elaboración del diagrama PERT para visualizar las áreas de oportunidad. De esta manera, se combinaron dos técnicas, una de ergonomía cognitiva (Análisis de Tareas Jerárquicas) y la otra o Ingeniería de Métodos (diagrama PERT), tanto para evaluar como para optimizar un proceso de servicio como el de Residencias Profesionales

Abstract: In a higher level, institution there is a perception that the management of the Residency Process is complex and difficult for residents to carry out. In an initial phase of this project in order to measure the magnitude of the problem in quantitative terms, surveys, interviews, and flow operations and travel charts were used. In a second phase, a Hierarchical Task Analysis was elaborated and this showed the mental load of the resident in the process and facilitated the determination of the sequence of tasks for the preparation of a PERT diagram (Project Evaluation and

Review Technique). PERT determined the critical path of the process and the activities that must be optimized to reduce the duration of the process. In this way in this project engineering techniques and ergonomics methods came together to evaluate a service process and make a proposal for optimization.

Keywords: Professional Residences, Process Management, Methods Engineering, Hierarchical Task Analysis

Relevance to Ergonomics: One of the major contributions of this study is to check the usefulness of ergonomics as a multidisciplinary science because the Hierarchical Task Analysis of that was made facilitated the elaboration of the PERT diagram to visualize the opportunity areas. In this way, two techniques were combined, one of cognitive ergonomics (Hierarchical Task Analysis) and the other o Methods Engineering (PERT diagram), both to evaluate and to optimize a service process such as the one of Professional Residences.

1. INTRODUCTION

Quality is an implicit concept in any process products or services, since it is part of the growth and competitiveness of companies and government agencies, including educational institutions (Palominos, Quezada, & et.al. 2016). Under these terms, this research purposes to provide solid starting points to provide a better service to students who perform procedures of professional residences. According to Andreozzi (2011), this educational strategy is an "identity" passage that leaves its mark on the professional future, so it is essential to avoid excessive administrative procedures that obscure their experience and limit their purpose.
Within this methodology, tools of Methods Engineering were used, for both recording and analysis and in order to complement the study in relation to the cognitive tasks of the process, a hierarchical task analysis was obtained. All these tools agree that the process involves a mental and workload for the student so they propose some suggestions to start the optimization of the process.
Finally, it is worth mentioning the relationship of analyzes that The Engineering of Methods and the ergonomics in the service processes have (Stanton, 2006).

2. OBJECTIVES

2.1 General Objective: Develop a proposal to reduce the management time of the Professional Residency Process by optimizing its activities with Techniques of Methods Engineering.
2.2 Specific objectives:
1. Identify activities that involve delays and have a long time.
2. Design a proposal to optimize the time of activities that have delays or are long-term.

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3. METHODOLOGY

The methodological design of this research is quantitative, cross-sectional, analytical, observational and retrospective and has its foundation in the method that Niebel and Freivalds (2009) define as "Stages of a method engineering program" and according to Kanawaty (2014) as "Basic Procedure for the Work Study". This method is a systematic procedure that is used in engineering methods to develop work centers, manufacture products and offer a service such as the Residential Process (see figure 1).

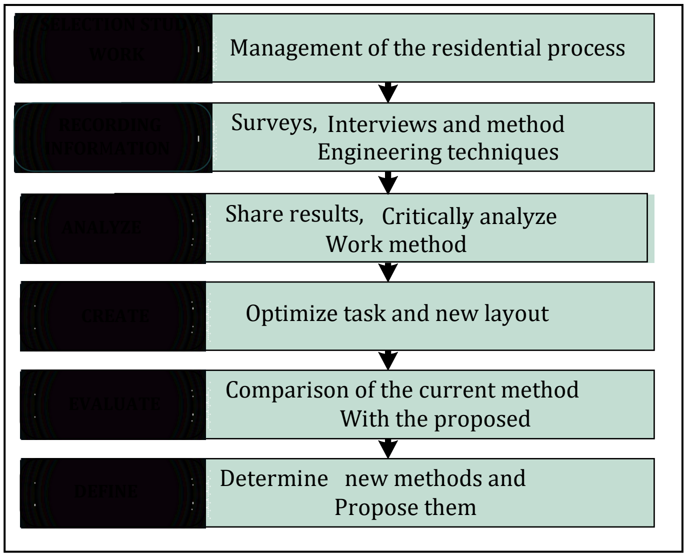

Figure 1. Procedure to the development of the Methodology

Participants: In the first phase of the investigation, rather than determining a sample, a census was conducted through contact to e-mail all prospective students who had already completed the process of residences or who were in it, in this census produced 55 participants.
For the second phase, we worked with the files of the Residents of Industrial Engineering who studied Professional Residences in the Period August- December 2018, with 60 students.
Instruments: The instruments used in the first phase were, letter of informed consent, initial survey and flow diagrams, operation, and route. In the second phase, a sheet gathering information developed a Hierarchical Task Analysis and a PERT diagram.
Procedures: The study was carried out in two phases, in the initial phase the magnitude of the problem was quantified through an initial survey and the diagrams that described the process and showed its complexity and difficulty for the residents. In a second phase, control dates were collected from each resident who participated in this phase, in order to determine the areas where delays occur and frequent errors that delay the process. Finally early times, middle and late each activity in order to find areas of opportunity through a PERT diagram is determined, and a proposal for a new distribution of the departments involved to be part of the management process residences are also made.

Analysis strategies: The analysis strategies that were used to transform the data obtained in information have their foundation in the methods of Engineering of methods, specifically in the Techniques of registry and analysis and the Techniques of exploration.
Technical recording and analysis were used mainly in the first phase were in a flowchart provided the number of operations and transport involving process management, and an initial survey measured in percentage the degree of dissatisfaction of the students and allowed them to express their comments regarding the process.
Technical scanning is mainly used in the second phase where data collection, was transformed into an optimization through a PERT chart since networks were obtained with middle and late optimal times to finally make a proposal process. A previous accomplishment of hierarchical tasks analysis was carried out to determine the mental load of the protagonists, but it was also very useful for the elaboration of the PERT diagram.

4. RESULTS

According to figure 2 and 3, in the initial phase of the study the survey on "The hardest part of the process" category, it was found that 31% of residents had difficulty "locating those involved in the process in a schedule similar to theirs " and 22% express their difficulty to" Understand the sequence of steps to be taken ". In the category "Description of the process of Professional Residences" it was found that, 27% of the residents think that “there is difficulty in knowing what the next step is and with whom to go in the process", and 24% manifest that “more is invested in looking for and waiting for the personnel involved in the process.

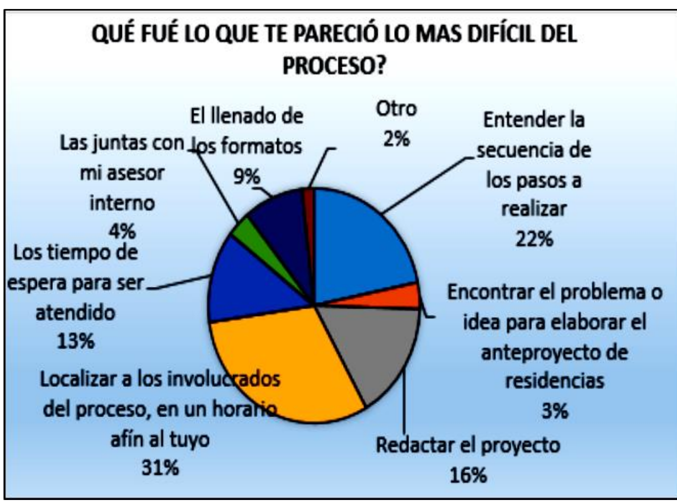

Figure 2. The hardest part of the process Process

Figure 3. Description of Residences

The hierarchal task analysis revealed that the student performs 70% of the activities, which implies a mental load for him in the process (see figure 4).

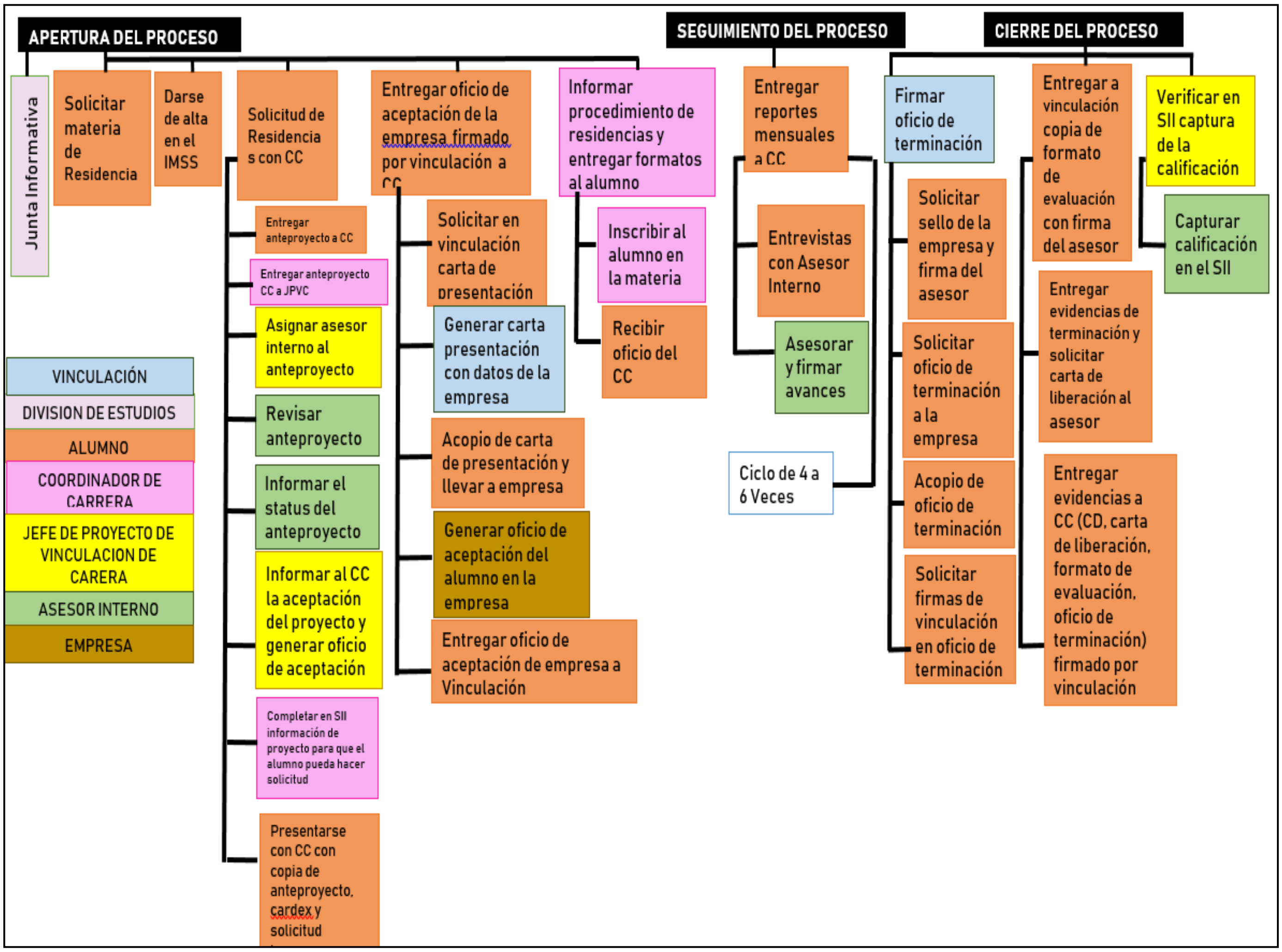

Figure 4. Residence Process hierarchal task analysis

In the flow diagrams of operation and travel, it was found that only in the opening and closing of the process the student travels 583.4 meters and invests 50 days in the management of the process considering average times immediately (see figures 5 and 6).

Diagrama de Flujo del Proceso de Residencias					
Ubicación: ITCJ	Resumen				
Actividad: Proceso de Residencia Profesional	Actividad		Actual	Propuesto	Ahorros
Fecha: 19 de Mayo 2018	Operación ●		25		
Operador: Alumno / Analista: Y. Frausto	Transporte ⇨		6		
Marque el método y tipo apropiados	Demora D				
Método: (Actual) Propuesto	Inspección □				
Tipo: (Operador) Material Máquina	Almacenaje ▽				
Comentarios: JPVC=Jefe de Proyecto de Vinculación de Carrera	Tiempo		50 días		
CC= Coordinador de la carrera	Distancia		583.49 mts		
	Costo				
Descripción de la actividad	Símbolo	Resp.	Tiempo (Días)	Distancia (Mts)	Observación
1.- Solicitar materia de residencias con CC	● ⇨ D □ ▽	Alumno	1		
2.- Asistir a plática de información de Residencia Profesional	● ⇨ D □ ▽	Alumno	1		

Figure 5. Summary of the flow diagram of the process of Professional Residencies

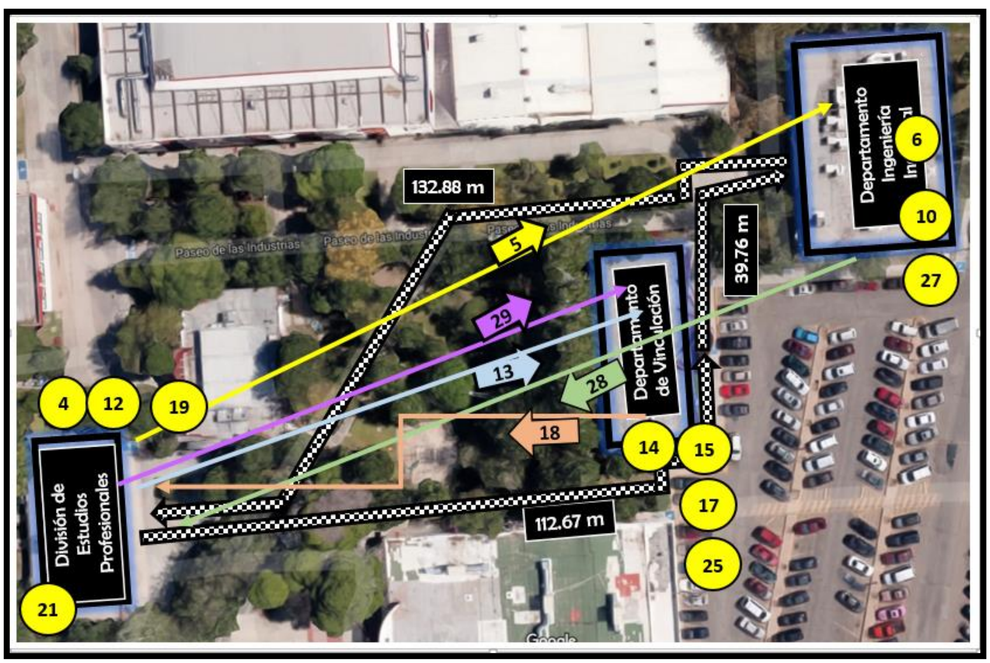

Figure 6. Route diagram of the management activities within the Residences process

In the second phase of the project it was found that the process have a critical path duration in 101 days, because the times of the activities observed exceeded by almost 50% the time initially estimated, like the figure 7 and 8 show it.

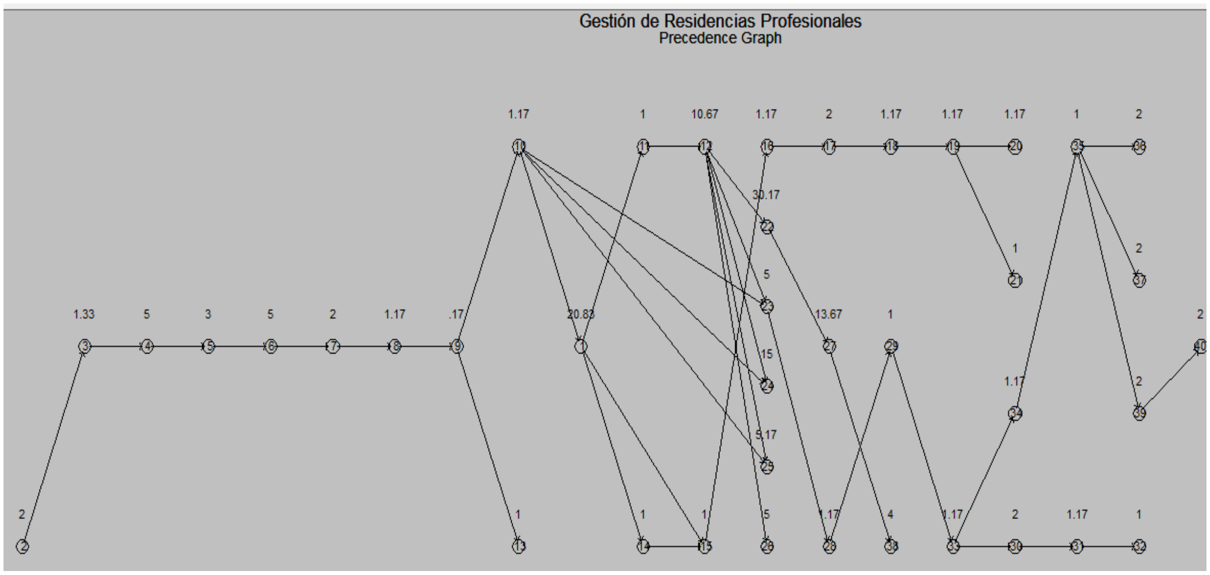

Figure 7. Precedence Graph Residence Process

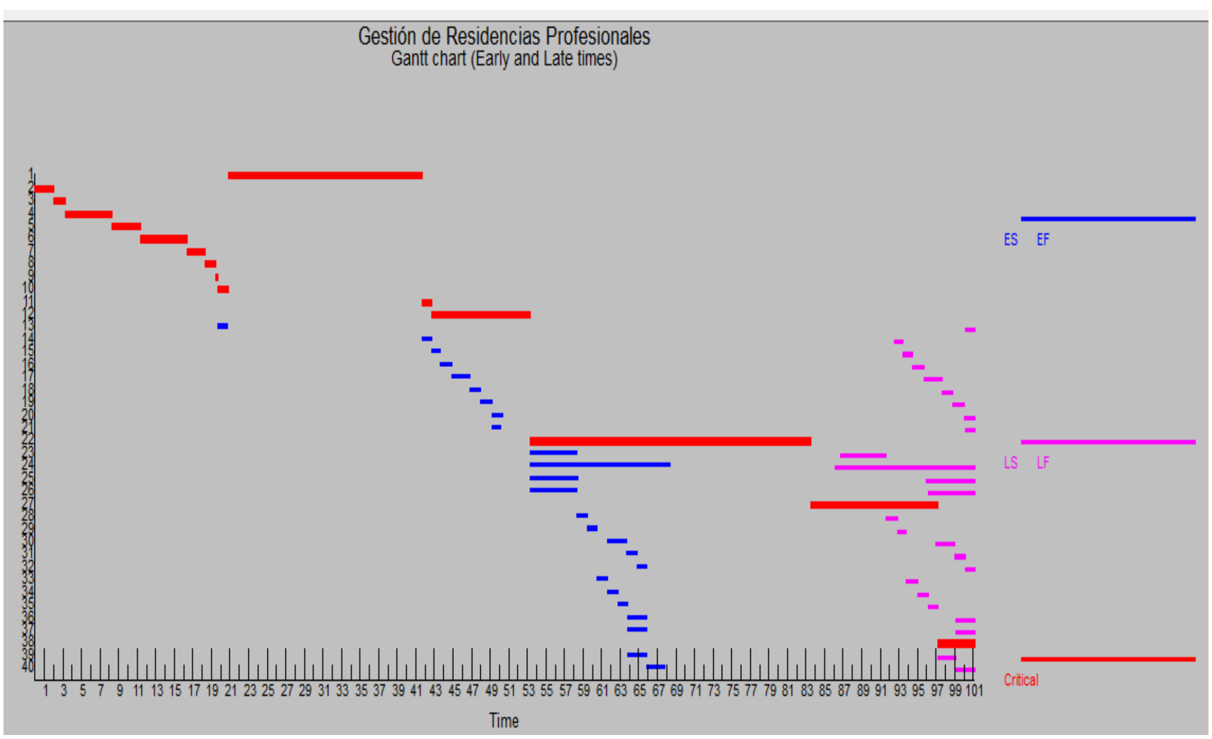

Figure 8. Gantt chart, Critical path, and Early and Late times

Under development, where up to now an optimum time of 38 days can be estimated, an average time of 50 days and a delayed time of 68 days, which represents an excellent area of opportunity to make a proposal that, meets the objectives of the study carried out.

5. DISCUSSION/CONCLUSIONS

In this study, it was verified that the perception that was had about the management of the residency process had foundation. The analysis carried out with a hierarchy of tasks and some techniques of recording and analysis of engineering methods showed that the student has a mental and workload since he performs 70% of the activities.

In addition to this, when analyzing the actual times of the last 60 cases with a PERT diagram, it was found that the management time estimated initially can be doubled since a critical path of 101 days of management was obtained.

Therefore, to optimize the process, the following actions are suggested:

As a starting point focus only on optimizing the tasks that are part of the critical path, for example by implementing the use of a digital platform to reduce the time of activities and avoid the student has to perform them personally.

Second, the hierarchy of tasks shows the amount of activities managed by each of the protagonists of the process, it is suggested to eliminate activities to the student, but responsible for the process can only take this decision.

Finally, according to Montaño (2010) it is suggested that it is essential, that the owners of the process have contact to make proposals that minimize or eliminate the duration of the activities since it is demonstrated that it is a quite complex process that requires implementing changes. The present study only provides the key information and identify the critical activities to reduce the duration of the process, but the protagonists can take the best decisions if they consider the information provided in this study.

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APPLICATION OF JSI METHOD TO EVALUATE A CARPENTER'S WORKSTATION.

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Resumen: El objetivo del lijado es eliminar imperfecciones en la madera permitiendo nivelar la superficie, con el fin de obtener una condición ideal para la aplicación de diversos productos químicos tales como: selladores, lacas y pintura; por lo tanto, el lijado es una de las actividades principales y de las que se tiene un mayor número de repeticiones por jornada laborar de un carpintero.

Dichos movimientos repetitivos pueden causar lesiones tanto a corto como a largo plazo en las extremidades superiores como son tendinitis, síndrome del túnel carpiano entre otras las cuales se pueden prevenir al utilizar las herramientas adecuadas para realizar dicha actividad.

Se aplicó el método JSI (Job Strain Index) con el fin de analizar futuras lesiones en la parte distal de las extremidades superiores debido a movimientos repetitivos, y para obtener el dato que se indica la gravedad de los movimientos realizados por el carpintero, y de esta manera proponer las recomendaciones más adecuadas y necesarias.

Palabras claves: Seguridad, Repetitividad, Desorden de Trauma Acumulado (DTA).

Relevancia para la ergonomía: Este estudio tiene como objetivo proporcionar un estudio ergonómico completo del lugar de trabajo de un carpintero específicamente en la actividad de lijado, así como proponer recomendaciones para rediseñar su lugar de trabajo y mejorar su calidad de vida, ya que la jornada laboral promedio de estos trabajadores es de 8 horas y el lijado es la actividad que se realiza con mayor frecuencia, por lo tanto, está expuesta a trastornos traumáticos acumulativos en el área distal de las extremidades superiores, como los brazos y las muñecas.

Abstract: The objective of sanding is to eliminate imperfections in the wood allowing to level the surface, in order to obtain an ideal condition for the application of diverse chemical products such as: sealers, lacquers and paint; therefore, sanding is one of the main activities and where there is a greater number of repetitions per carpenter's working day.

Such repetitive movements can cause both short and long term injuries to the upper extremities such as tendinitis, carpal tunnel syndrome among others which can be prevented by using the appropriate tools to perform this activity.

The JSI (Job Strain Index) method was applied in order to analyze future lesions in the distal part of the upper limbs due to repetitive movements, and to obtain the data indicating the severity of the movements made by the carpenter, thus proposing the most appropriate and necessary recommendations.

Key words: Safety, Repetitiveness, Cumulative trauma disorder (ASD)

Relevance to Ergonomics: This study aims to provide ergonomics with a complete study of the workplace of a carpenter specifically in the activity of sanding as well as propose recommendations to redesign their workplace and improve their quality of life since the average workday of these workers is 8 hours and sanding is the activity that is most often performed therefore are exposed to cumulative traumatic disorders in the distal area of the upper extremities such as arms and wrists.

1. INTRODUCTION

According to a thesis by Medina Nayeli (2011). "Identification and characterization of dangers in the carpentry workshop of an educational institution. Proposal of prevention and control" was taken as reference the antecedents that have been documented about the dangers that can be generated in the industry of the furniture and on the basis of this, the present document exposes the problematic of the sector of the carpentry, with this it is tried to diagnose possible injuries that the carpenters can face by the repetitive movements that make in their area of work and to improve the conditions of security and occupational hygiene of this activity. To this end, it was decided to study the JSI method and the variables to be measured by this method are: the intensity of the effort, the duration of the effort per work cycle, the number of efforts made in one minute of work, the deviation of the wrist from the neutral position, the speed with which the task is performed and the duration of the same per day of work.

1.1 Justification

In a thesis published by Medina Nayeli (2011) undesirable situations were found in the carpentry workshop such as:

- Injuries from repetitive movements affecting wrists, elbows and shoulders (Ergonomic risk - repetitive musculoskeletal movements).
- Cutting wounds and lacerations resulting from incorrect use or inadequate protection (Risk from unsafe conditions).
- Tiredness due to overwork (Psychosocial risk - overwork).

Therefore, recommendations are proposed based on the method used JSI (Work Stress Index).

1.2 Delimitation

This study is specifically aimed at carpenters especially in the area of sanding, the target population has an age range ranging from 18 to 50 years, being a mestizo population living in the northern area of the state of Sinaloa.

2. OBJECTIVE.

Apply the JSI method to evaluate the position of a carpenter in the sanding area with the purpose of proposing improvements to his work area, to avoid injuries in the medium and long term since his work involves many repetitive movements, all this with the purpose of safeguarding the integrity of the worker.

2.1 Specific objectives

1. Identify repetitive movements and predict future injuries caused by them.
2. Verify the position of a carpenter's work area in the sanding process.
3. Generate proposals from an ergonomic point of view.

3. METHODOLOGY

Due to the characteristics of the study that was developed, an applied research method was used and due to the nature of the JSI method, we used quantitative research since tables and equations were used. The field research was also used and a descriptive study was carried out with a worker from a local carpentry shop located in the central colony of the municipality Ahome Sinaloa.

The procedure for applying the JSI method is as follows:

- To determine the cycles of work and to observe the worker during several of these cycles.
- Determine the tasks to be evaluated and the observation time needed.
- Determine the value of the equation multipliers according to the values of each variable.
- Obtain the value of the JSI and determine the existence of risks.
- Review scores to determine where corrections are needed.
- Review scores to determine where corrections are needed.
- If changes have been made, re-evaluate the task with the JSI method to check the effectiveness of the improvement.

3.1 Process description.

The carpenter dedicated to the sanding area performs repetitive movements that are carried out when carrying out his work for example the door of an integral kitchen, this procedure is carried out in the following way:

1. Place the door on a completely flat surface

2. Take a sandpaper
3. Sand the most exposed and broadest parts
4. Move the door so that the most hidden details can be sanded better.
5. Take a large brush to clean up any remaining debris.

This procedure is repeated at least 4 times during the working day, reaching up to 792 movements within the working day.

In a count carried out at the local carpenter's shop, the study showed that a minimum of 198 movements were carried out. Reaching up to 11880 movements in a normal working day.

Performing 5 different movements (reach, take, move, position, apply pressure, etc.). Most of which are repeated every second, this is done without the use of personal protective equipment, which causes various injuries in the distal part of the upper extremities.

Tables are shown below to determine the value of the multiplying factors.

Table 1. Intensity of Effort.

Valoration	IE
1	1
2	3
3	6
4	9
5	13

A score of 2 was given as the effort is perceptible.

Table No. 2. Effort duration (%).

Valoration	
1	0,5
2	1
3	1,5
4	2
5	3

A score of 5 was given since the effort lasts more than 80% of the total duration of the activity.

Table 3. Efforts per minute.

Valoration	EM
1	0,5
2	1
3	1,5
4	2
5	3

A rating of 3 was given as between 10 and 13 considerable efforts per minute were observed.

Table No. 4. % hand-doll posture.

Valoration	HWP
1	1
2	1
3	1,5
4	2
5	3

An assessment of 5 was given since the carpenter had an extreme deviation greater than 25°, a flexion greater than 50° and an extension greater than 55°.

Table No. 5. Work speed.

Valoration	WS
1	1
2	1
3	1
4	1,5
5	2

A score of 3 was given because the carpenter had a normal speed of movement.

Table No. 6. Duration per day.

Valoration	DD
1	0,25
2	0,5
3	0,75
4	1
5	1,5

A value of 4 was given because the worker tends to last from 4 to 8 hours with the sanding activity in the day.

4. RESULTS

Table No. 7. Application of the JSI method

Variables	Valuation	Multiplying factors
Intensity of effort (IE)	2	3
Duration of effort (DE)	5	3
Effort per minute (EM)	3	1.5
Hand posture wrist (HWP)	5	3
Working speed (SW)	3	1
Duration of task per day (DD)	4	1
Product JSI= (IE) (DE) (EM) (HWP) (SW) (DD)		13.5

Figure 1. the sanding process

Below are more images of the carpenter sanding an integral kitchen door:

Figure 2. Workplace of the carpenter.

Figure 3. The bad postures are observed.

Figure 4. There are observed some injuries on the fingers of the Carpenter.

Figure 5. The carpenter does not have personal protective equipment.

Figure 2 shows the work area of the carpenter. Figures 3, 4 and 5 show the carpenter sanding.

Recommendations:

1. Use personal protective equipment such as safety goggles, apron, safety shoes, gloves, protective mask, among others because it was observed that the carpenter had injuries such as cuts, blows to the hands because of their work.
2. Adapt fixtures according to each piece to serve as a support and facilitate their work.
3. Use an anti-fatigue mat
4. Apply the 5 s to have more organized the work area
5. Relocate staff to major areas and avoid fatigue and repetition as much as possible.

5. CONCLUSION

On the basis of the study carried out, with the results obtained we come to the conclusion that the analysed carpenter performs a highly dangerous task since the interpretation of the JSI has a score of 13.5 that exceeds the established limits that are from 1 to 7.

So we came to the objective of our research which was to propose recommendations taking into account the score obtained by applying the established method.

For this investigation we took into account 1 carpenter inhabitant of Los Mochis, located in the municipality of Ahome, Sinaloa, Mexico.

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Ergonomic tool for holding and assembling E- Type retaining rings

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RESUMEN: El siguiente artículo cubre en detalle la manera de reemplazar el uso de las abrazaderas con punta o cualquier otro dispositivo con el que pueda ensamblar los anillos de retención tipo "e", logrando una reducción tanto del tiempo de inactividad como del malestar generado por una herramienta mal diseñada para el trabajo y la racionalización del proceso se desarrollarán de la manera más eficiente, ya que se determinó que en el proceso la herramienta utilizada no era adecuada. Para lo que se encontró un área de oportunidad para mejorar la herramienta, diseñándola de forma ergonómica para que se ajuste perfectamente a la mano y permita un mejor agarre, reduciendo el esfuerzo y acelerando el proceso de producción y, sobre todo, garantizando la salud de El usuario en el momento de su uso.

PALABRAS CLAVE: Herramienta, Sujeción, Anillos de retención tipo “e”.

RELEVANCIA PARA LA ERGONOMÍA: **L**a herramienta Ergonómica para la sujeción y ensamble de anillos de retención tipo “e” nos da un gran apoyo y aporte a la manera correcta de la colocación de los anillos de retención, ya que nos da una manera rápida y sobre todo segura y cómoda para el usuario porque ya que el ángulo de muñeca-mano es la correcta y el esfuerzo de considerablemente más bajo a comparación de las pinzas de punta(actualmente utilizadas) que perjudican a la salud(desarrollo del síndrome carpiano) y la publicación de este articulo pruebe ser la manera más eficaz de lograr el reconocimiento y la divulgación de la mejora al proceso de colocar los anillos de retención.

ABSTRACT: The following article covers in detail how to replace the use of pointed clamps or any other device with which you can assemble type "e" retention rings, achieving a reduction in both downtime and discomfort generated by a tool poorly designed for the work and the rationalization of the process will be developed in the most efficient way, since it was determined that in the process the tool used was not adequate. For what was found an area of opportunity to improve the tool, designing it in an ergonomic way so that it fits perfectly in the hand and allows a

better grip, reducing the effort and speeding up the production process and, above all, guaranteeing the health of The user at the time of use.

1. INTRODUCTION

Currently in Mexico, 23% of all documented (Social,2017) hand and wrist injuries occur because of poorly designed tools (table 1). For example, Conventional tip pliers are used to install the E-type retaining rings; however, these pliers make it difficult for the operator to mount the rings quickly and efficiently. Fortunately, we found the way to properly install the E-type retaining rings using a new tool. Often the tools used by workers are poorly suited for the tasks at hand having the following problems:

1. Muscle fatigue caused by the application of constant pressure to the pliers to prevent the retaining ring from falling.
2. Wasted time from the ring slipping or bouncing due to the lack of a good gripping tool for the operator to use.
3. Development of carpal tunnel syndrome or tenosynovitis in the operators' hands and wrists (table 2).
4. Waste.

Table1 Work Accidents According to Anatomical Region and Sex, 2014 - 2016 National.

Región Anatómica	2014		2015		2016	
	Hombres	Mujeres	Hombres	Mujeres	Hombres	Mujeres
Muñeca y mano	82,635	28,196	84,402	30,517	79,719	30,408
Tobillo y pie	38,029	19,164	39,768	21,621	36,873	19,978
Cabeza y cuello (excluye lesión en ojo y sus anexos)	31,459	15,605	34,536	18,472	31,207	15,958
Miembro inferior (excluye tobillo y pie)	30,987	13,314	33,140	15,027	30,886	14,050
Miembro superior (excluye muñeca y mano)	28,360	10,721	30,979	12,167	28,693	11,641
Abdomen, región lumbosacra, columna lumbar y pelvis	21,588	11,698	21,657	12,419	18,472	11,127
Cuerpo en general (incluye lesiones múltiples)	8,895	3,357	8,770	3,703	7,271	2,922
Tórax (incluye lesiones en órganos intratorácicos)	7,054	1,541	7,521	1,513	6,834	1,472
Ojo (incluye lesiones en ojo y sus anexos)	6,667	1,053	6,952	1,049	6,393	1,104
Varios de frecuencia menor	28,761	11,863	28,762	12,088	27,163	12,076

Fuente: Memorias estadísticas IMSS, 2014 - 2016

Table 2 Diseases of Work According to Nature of the Injury and Sex, 2014 - 2016.

Nacional

Naturaleza de la Lesión	2014		2015		2016	
	Hombres	Mujeres	Hombres	Mujeres	Hombres	Mujeres
Hipoacusias	1,561	75	1,738	52	1,809	64
Neumoconiosis	834	25	1,092	14	995	22
Dorsopatías	628	112	1,044	198	1,390	273
Enfermedades del ojo y sus anexos	376	131	719	274	982	382
Otras Entesopatías	113	360	200	451	179	521
Síndrome del túnel carpiano	49	369	60	480	72	564
Lesiones del Hombro	157	241	203	313	218	285
Intoxicaciones	270	118	658	259	554	322
Afecciones respiratorias debidas a inhalación de gases, humos, vapores y sustancias químicas	295	83	229	133	268	110
Dermatitis de contacto	172	151	330	238	301	279
Varios de frecuencia menor	1,101	1,080	1,840	1,484	805	476

Fuente: Memorias estadísticas IMSS, 2014 - 2016

SAID RETAINING RINGS ARE FOUND IN AREAS SUCH AS:

KEYWORDS

- Tools
- Subjection
- E-type retaining rings

WORK AREA

- Fatigue
- Design
- Human development

2. OBJECTIVES

Replace the needle-nose pliers and other obsolete devices previously used to assemble E-type retention rings, allowing for reduction in time wasted as well as relieving discomfort to the hands and wrists of workers **because of poorly designed tools**. By incorporating an ergonomic design, we will improve the tool, allowing it to grip better in an effort to improve efficiency and reduce fatigue of the worker.

3. DELIMITATION:

The tool is limited on account that it is only able to be used on the E-type retaining rings and not on any other rings found in today's marketplace.
There is a lack of awareness by the consumer to the tool, it is more likely that someone looking to work on an E-type retaining ring will choose the needle-nose pliers, since it is a well-established tool and better recognized by most consumers.

4. METHODOLOGY:

1. Through observation of workers, the need of a better tool to replace needle-nose pliers was discovered.
2. A study of the field analysis shows that due to the use of the inappropriate tool, the following fatigue and injuries developed: Disabilities, rotation, absenteeism etc ...
3. We took on the task of designing an ergonomic tool using anthropometric measurements of a selected population within the manufacturing area.
4. The ergonomic tool that replaces the conventional tip pliers was made, reducing fatigue, injuries and staff rotation.

5. RESULTS AND CONCLUSIONS:

The results obtained were the following:

1. Due to the implementation of both the ergonomic design and REBA method, the INCORRECT angles (image 1) were eliminated in the hand-wrist and arm. Since the handle reduces the inconvenience generated to the operator (image 2), the user is in a much more comfortable position to work on the installation of the rings.

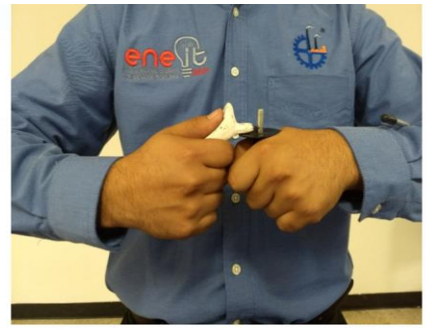


Image 1. Bad wrist-hand angle

Image 2. Good Wrist-hand Angle

1. A 24% increase in production was observed (in a production test) over the course of a week at a company located in Chihuahua.

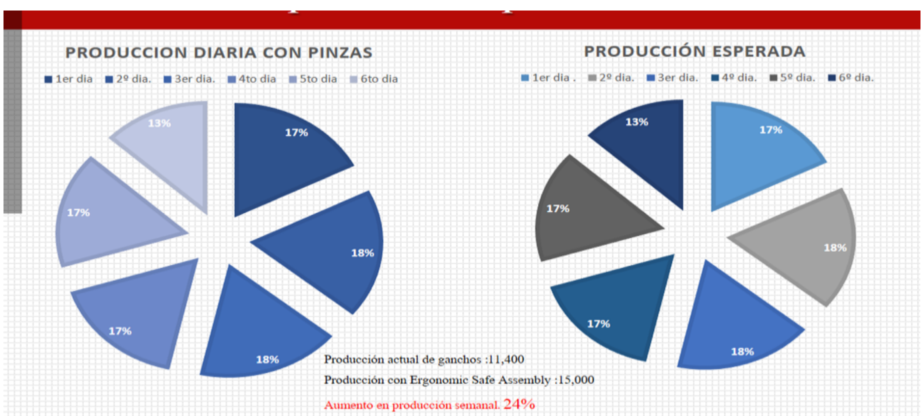


Image 3. Production comparison

3. Over time was eliminated.

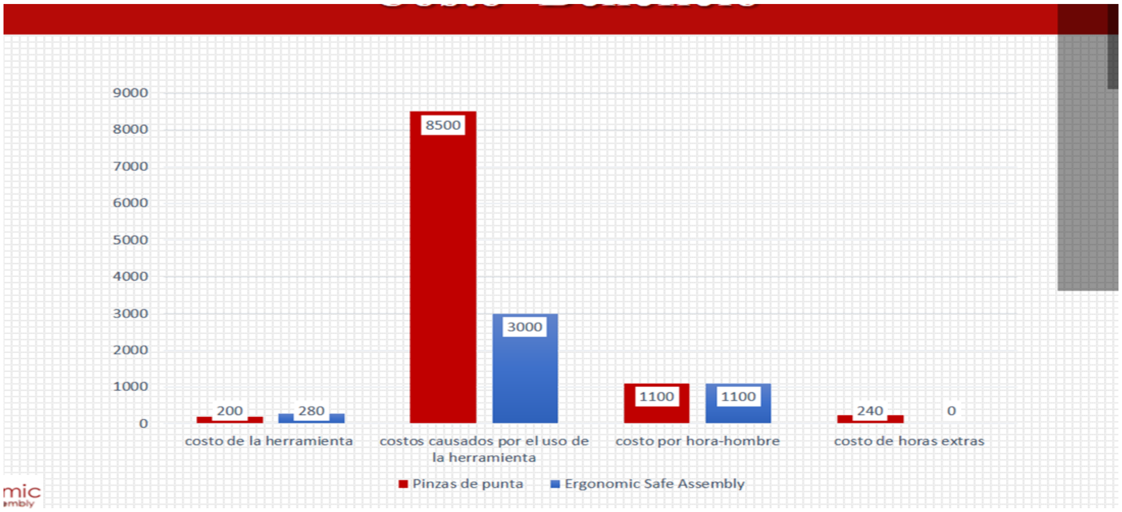


Image 4. Cost-benefit

6. CONTRIBUTION TO ERGONOMICS:

The ergonomic tool for the holding and assembly of Type E retaining rings was designed using the REBA method. We identified that the needle-nose pliers forced users to adopt inappropriate postures involving continuous or repeated motions that generated fatigue. This fatigue has the potential to develop into serious health problems.

With this in mind, an ergonomic adjustment handle (Figure1) was designed allowing the tool to properly and safely fit in the palm (Part B) and be gripped by the fingers (Part A). This results in the correction of the wrong angle of the arm and wrist that was present using the needle-nose pliers. Also, the upper part of the handle has an interchangeable head (Figure 2) fitted with a groove that allows the E type retaining rings to be adjusted easily, quickly and safely. (Part F) This prevents the user from having to apply a constant pressure to avoid the E-type retaining ring from falling and is beneficial because the pressure would otherwise cause injury to the hands and wrists.

The upper rear part of the handle (figure 3) has a place to allow the thumb to comfortably apply greater pressure when needed (Part G), allowing the user to avoid excessive force and fatigue to the hands when installing the retaining rings.

The upper front exhibits a slot that provides a secure assembly between the head and handle (parts D and E).

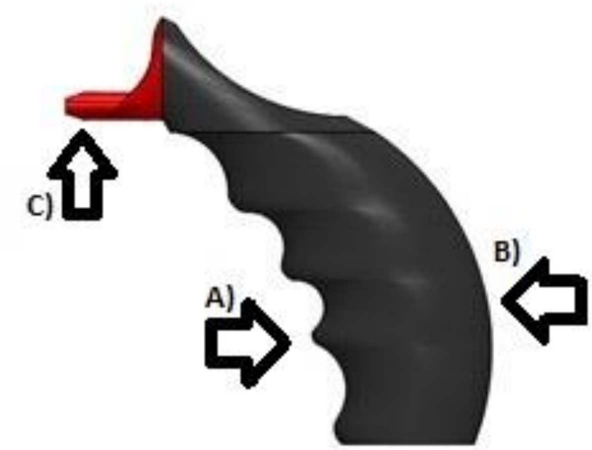


Figure 1

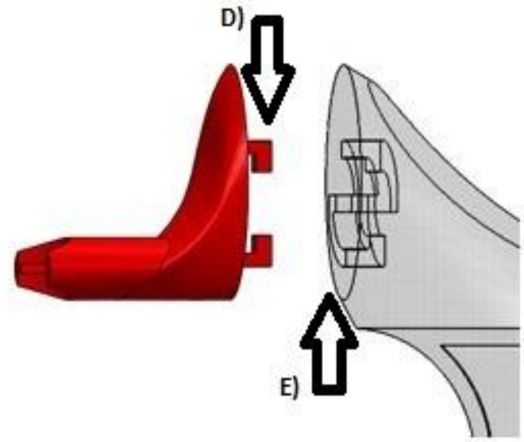
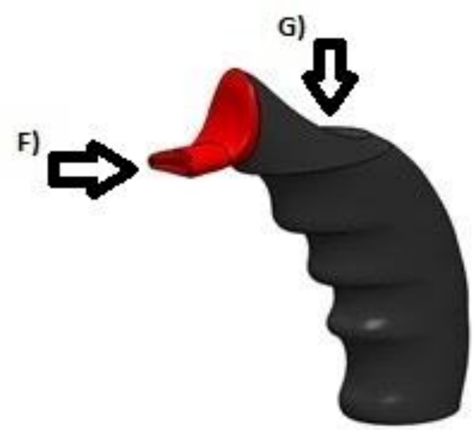


Figure 2



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ERGONOMIC STUDY OF THE FINAL QUALITY INSPECTION PROCESS BASED ON THE RULA METHOD IN AN AEROSPACE PRODUCT COMPANY IN THE CITY OF TIJUANA

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Resumen: Este proyecto de investigación se centró en el estudio ergonomía del proceso de inspección final de calidad en una nueva área de transición de una empresa del sector aeroespacial de la región, la cual tiene como característica la producción de alto volumen de piezas pequeñas. En este proceso se detectaron dos posturas que, por su alta repetitividad y las desviaciones de las partes del cuerpo, se consideraron de riesgo. Se aplicó el método RULA para la realización de este estudio, debido a que las operaciones se realizan con un impacto de carga postural mayor en los miembros superiores del cuerpo, así como con un lado predominantemente afectado. Para ambas posturas, los resultados indicaron que se requiere el rediseño de la tarea.

Palabras clave: Análisis ergonómico, RULA, Proceso final de inspección de calidad

Relevancia para la ergonomía: La contribución que esta investigación hace a la ergonomía es introducir, promover e implementar la ergonomía para la detección y evaluación de riesgos laborales en una empresa manufacturera, lo cual es algo nuevo dentro de la empresa.

Abstract: This research project focused on the ergonomics study of the final quality inspection process in a new transition area of a company in the aerospace sector of the region, which has as a characteristic the production of the high volume of small parts. In this process two postures are detected, because of its high repetitiveness and the deviations of the body parts, the risk is considered. The RULA method was applied for the realization of this study, because the operations are carried out with a higher postural load impact on the upper body members, as well as with a predominantly affected side. For both positions, the results indicate that the redesign of the task is required.

Keywords: Ergonomic analysis, RULA, Final quality inspection process

Relevance to Ergonomics: The contribution this research makes to ergonomics is to introduce, promote and implement the ergonomics for detection and evaluation of occupational risks in a manufacturing company, which is something new within the company.

1. INTRODUCTION

The postural load is a risk factor that is commonly associated with the appearance of musculoskeletal disorders, this because of the adoption of inappropriate postures during the days or the repetitive of a job. These factors in the long term tend to lead to the appearance of health problems. The incompatibility between the dimensions of the operator's body and the design of his work station, results in harmful postures, such as those that require excessive efforts to reach, bend, twist the trunk, to give some examples. If these harmful postures are carried out for a long time or repetitively this increases the risk of injuries, which decreases productivity and causes damage.

Repetition is defined as the number of movements an operator makes during the cycle time. Barbara Silverstein of the University of Michigan did a research work where she sought to establish when a work is considered highly repetitive. It was established that works with a cycle of 30 seconds or less or that at least 50% of the time of the cycle is used to execute the same activity, make this work highly repetitive (Reyes, 2017).

There are several methods to evaluate these risks produced by the postural load. One of these methods is the RULA, which is the most widespread observational method in practice, with special focus on the upper limbs of the body, taking into account the posture, the duration of the task, the frequency and the force applied in the same individually, that is, each of the positions and not together. With the results obtained through the application of this method, a score is obtained that determines a "Level of performance" that indicates whether such a position is acceptable or must act because there is an excessive postural load that may cause a problem in the person who executes it. said task (Diego-Mas, 2015).

This research project focuses on the ergonomic study of the final quality inspection process in a new transition area of a company in the aerospace sector located in Tijuana. This company makes products of great volume and weight, uses fixtures and heavy machinery. Due to this, the use of personal protection equipment (PPE) is mandatory. This PPE consists of safety shoes with caps, safety glasses and ear plugs, as well as a dress code that prohibits the use of clothing that exposes parts of the worker's body. The company manufactures products used in the assembly of turbines and fuel systems in commercial and military aircraft, and it is divided into three main business units: 1) fluid distribution, 2) electromechanics, and 3) metal-formed. This ergonomic study focuses on the final quality inspection operation of the new transition area that is part of the metal-formed business unit.

Unlike the rest of the current areas, this new area is characterized by its production of high volume of small pieces, which represents a challenge for the current measurement methods used in the company, as well as for the design of the work stations. Moreover, this represents a challenge for the workers due to the pace of work, since in other manufacturing areas, around 100 pieces are produced per month, whereas in this new area, where aluminum and titanium couplings are made, about 2,400 pieces are produced, with a growth projection at twice this current capacity. of production for the year 2019.

In an ergonomic tour in the area of quality final inspection process, it was found that the worker was forced to adopt two positions that, at first sight, were defined as risky, both for their high repetitiveness (500 times/working day) and for deviations of the postures taken by the parts of the body with respect to the neutral position of the same. It was decided to use the RULA method to carry out this study and to know the level of risk of these positions. Such decision was due to the fact that the operations are carried out with an impact of greater postural load on the upper limbs of the body, as well as with a predominantly affected side. The postures defined for the case study are: 1) the measurement of the 5 critical characteristics of the piece using a caliper (Figure 1, posture 1) and, 2) the recording of the data on paper (Figure 2, posture 2).

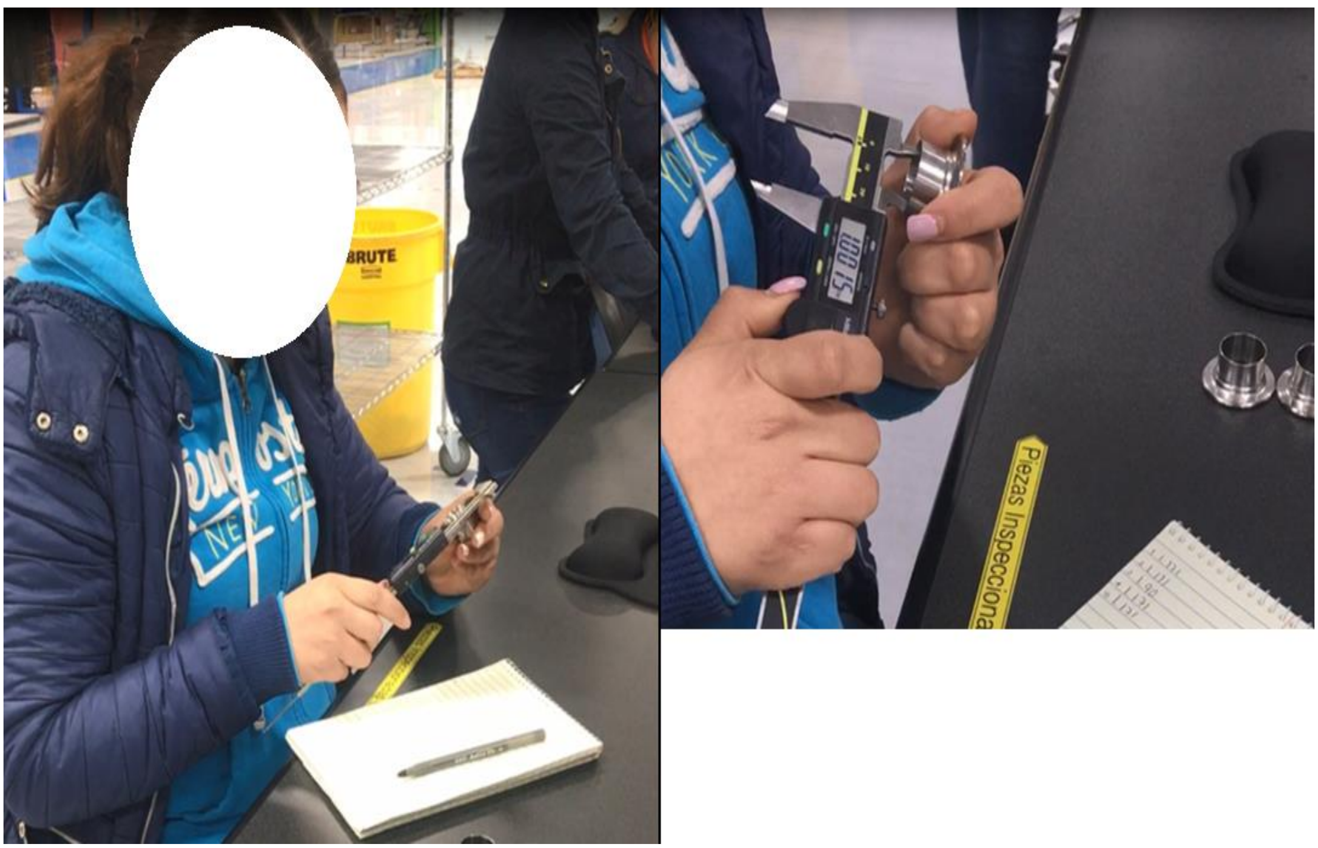

Figure 1. Measurement of the 5 critical characteristics of the piece using a caliper

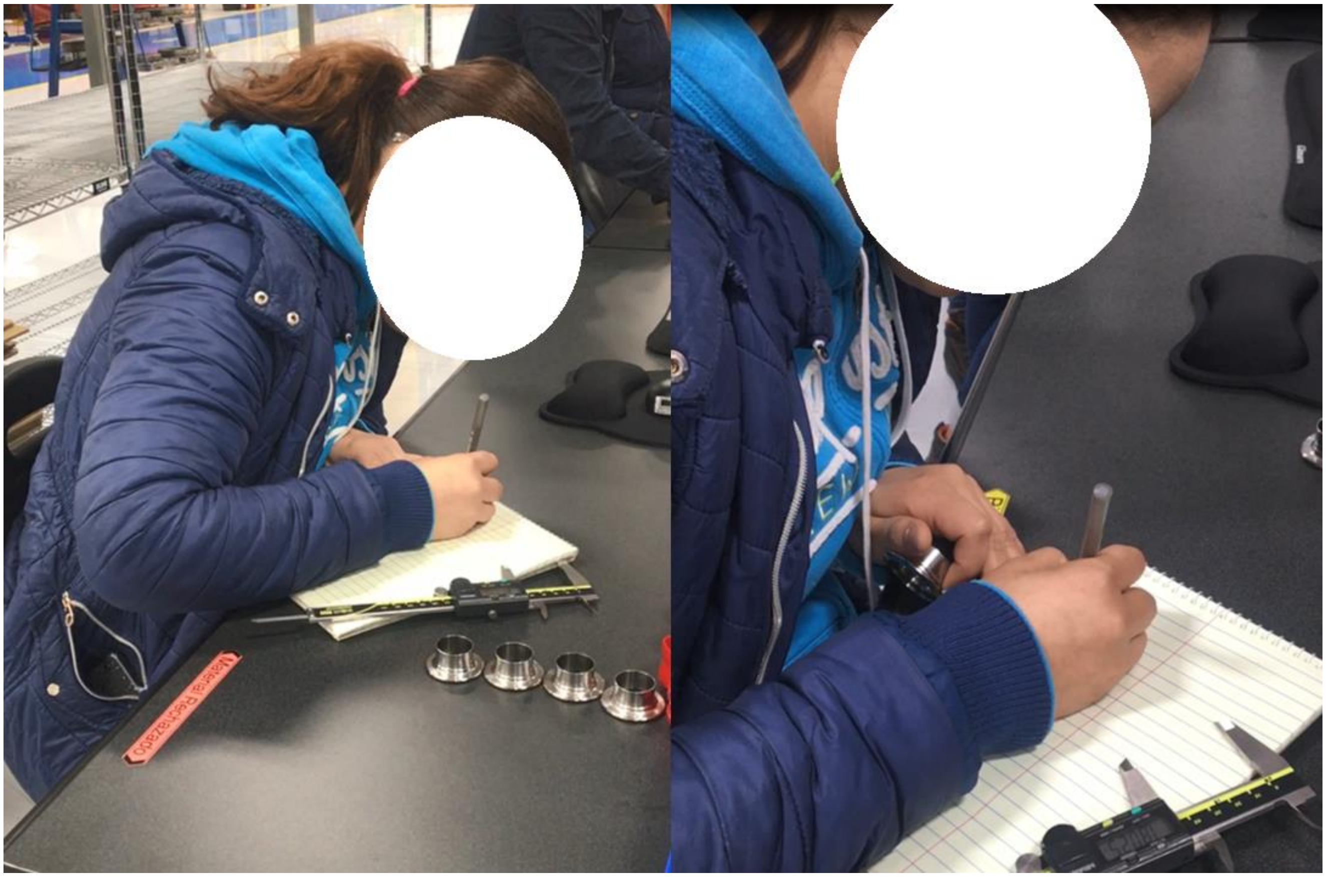

Figure 2. Measurement of the 5 critical characteristics of the piece using a caliper

2. OBJECTIVES

The general objective is to determine the risk level of postural loading in the new area of the final quality inspection process. Likewise, the following objectives are described: 1) Perform a diagnosis to identify the ergonomic conditions that prevail in the operation, 2) analyze the postures adopted by the worker and the times in which he / she maintains these positions, 3) identify opportunities for improvement of the current process.

3. METHODOLOGY

3.1 Materials

- Video camera
- 6 inches caliper
- Paper and pen

3.2 Method

The procedure to apply the RULA method can be summarized in the following steps:
Step 1: Determine the work cycles and observe the worker during several of these cycles: If cycle is very long, or there are not cycles, the analyst can perform assessments at regular intervals.
Step 2: Select the positions to be evaluated: Select those positions that, a priori, suppose a higher postural load based on its duration, frequency, or deviation from the neutral position.
Step 3: Determine if the left side of the body will be evaluated, the right or both.
Step 4: Take the required angular data: The analyst can take photos from adequate points of view to perform the evaluations.
Step 5: Determine the scores for each part of the body.
Step 6: Obtain the partial and final scores of the method to determine the existence of risks and establish the Action Level.
Step 7: If required, determine what type of measures should be adopted: Review the scores of the different body parts to determine where is necessary to apply corrective actions.

4. RESULTS

For the position adopted during the task of measuring the 5 critical characteristics of the piece using a caliper, a final RULA score of 5 was obtained, which corresponds to a level of risk 3 and therefore it is necessary to redesign the task. In the case of the position adopted during the execution of the task of recording the data on paper, the final result indicated a RULA score of 6, which also corresponds to a level of risk 3 and therefore it is necessary to redesign the task. Table 1 shows the RULA scores for the body parts of the two postures, both in the right side.

Table 1. RULA scores for the body parts of the two postures

Posture	Arm	Forearm	Wrist	Wrist twist	Neck	Trunk	Legs
Posture 1	1	3	4	1	2	1	1
Posture 2	1	1	3	1	3	4	1

Figure 3 shows the final RULA score, the risk level, and the action level for the posture 1 (locked in a red rectangle), whereas Figure 4 shows the same for the posture 2.

Score	Risk Level	Action Level
1-2	1	Acceptable risk
3-4	2	Changes in the task may be required; it is recommended to deepen the study
5-6	3	The redesign of the task is required
7	4	Urgent changes are required in the task

Figure 3. Final RULA score, the risk level, and the action level for the posture 1

Score	Risk Level	Action Level
1-2	1	Acceptable risk
3-4	2	Changes in the task may be required; it is recommended to deepen the study
5-6	3	The redesign of the task is required
7	4	Urgent changes are required in the task

Figure 4. Final RULA score, the risk level, and the action level for the posture 2

5. CONCLUSIONS

The general objective of determining the level of risk by postural load in the new area of the final quality inspection process, as well as the specific objectives, has been met as an initial diagnosis was obtained (travel ergonomic and visual evaluation), the way of working was analyzed with respect to the positions adopted by the worker and the times in which he maintains these positions, and opportunities for improvement of the current process were identified.

In the case of the measurement position of pieces with caliper, a score of 5 was obtained for the parts of the body of group A (Arm, Forearm, Wrist, and Wrist twist) and 3 for group B (Neck, Trunk, and Legs). This means a risk that must be treated and redesign the task, since the upper limbs are subjected above all, to uncomfortable positions for the wrist, and working angles exhausting for the arms. In the case of the lower members of group B, the result does not describe a risky activity, but it recommends continuing to investigate the study to improve this score and take it to a completely safe level. To reduce the postural load of this operation in the final inspection area, the use of a 3-point micrometer for the measurements of the interior diameters of the couplings, and micrometers of the alligator tip for the heights and thicknesses is suggested, so to avoid the use of the caliper that promotes these risk conditions, and make the work more efficient and ergonomic.

In the case of the data recording posture, a score of 3 was obtained for the parts of the body of group A and 6 for group B. This means a risk that must be treated and redesign of the task, that is to say the use of the lower limbs such as, since the trunk and neck are subjected above all, at a very pronounced angle in the back at the time of writing. In the case of the upper members of group A, the result does not describe a risky activity, but it recommends continuing to investigate the study to improve this score and take it to a completely safe level. To reduce the postural load of this operation in the final inspection area, it is suggested to use computer equipment to capture data in a digital log, or that the measurement equipment to be used has data output so that it is not necessary to take data.

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ANALYSIS OF THE ERGONOMIC CONDITIONS OF THE WORKING STATIONS TO IDENTIFY THE MUSCULOSKELETAL INJURIES OF THE WORKERS OF "AGROEXPORTADORA THE MAYOS"

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Resumen: En este estudio se hizo un análisis de las condiciones ergonómicas generales en las que se encuentra la empresa Agroexportadora los Mayos, ubicada en Alhuey, Angostura, Sinaloa, México, para identificar cual es la estación de trabajo con mayor riesgo de lesiones musculoesqueléticas, esto se realizó a través de los métodos: Rapid Upper Limb Assessment (RULA) y Corlett & Bishop. En el IMSS (2017), se registraron un total de 457 casos de traumatismos en hombres y mujeres, ocasionados por riesgos laborales en operadores de instalación, en relación a esta problemática se desarrolló la presente investigación teniendo como propósito principal: analizar las condiciones ergonómicas de la estación de trabajo con mayor riesgo de lesiones musculoesqueléticas, con el objeto de evaluar las posturas del operador durante su jornada laboral e identificar los factores de riesgo que pueden ocasionar lesiones en las extremidades superiores del cuerpo. Identificando las áreas que requieren un rediseño y las condiciones de trabajo de los operadores cuando realizan las actividades
.

Palabras clave: Lesiones musculoesqueléticas, Método Rula, Método Corlett & Bishop

Relevancia para la ergonomía: Este estudio aporta a la ergonomía porque ayuda como información que contribuye a la realización de acciones que mejoran las condiciones de trabajo de los trabajadores de las agroexportadoras

Abstract: In this study an analysis was made of the general ergonomic conditions in which the Agroexportadora los Mayos company is located, located in Alhuey, Angostura, Sinaloa, Mexico, to identify which is the workstation with the highest risk of musculoskeletal injuries, this is carried out through the methods: Rapid Upper Limb Assessment (RULA) and Corlett & Bishop. In the IMSS (2017), a total of 457 cases of injuries were recorded in men and women, caused by occupational hazards in installation operators, in relation to this problem the present investigation was developed having as main purpose: to analyze the ergonomic conditions of the workstation with the highest risk of musculoskeletal injuries, in order to evaluate the operator's postures during his working day and identify the risk factors that can cause injuries in the upper extremities of the body. Identifying the areas that require a redesign and the working conditions of the operators when they carry out the activities

Keywords: Musculoskeletal injuries, Rula method, Corlett & Bishop method

Relevance to Ergonomics: This study contributes to the ergonomics because it helps as information that contributes to the realization of actions that improve the working conditions of the workers of the agroexport

1. INTRODUCTION

Ergonomics this science has the objective of adapting equipment, tasks and tools to the needs and capabilities of human beings, improving their efficiency, safety and well-being according to the official definition adopted by the Society of Ergonomists of Mexico A.C. (SEMAC, 2018). Musculoskeletal injuries have a huge and growing impact worldwide, from the perspective of productivity and economy of the industry. In Mexico, the musculoskeletal pathology is one of the leading causes of morbidity, as established by the evidence according to the IMSS statistics for 2011, where it is reported that the number of work risks in total was 536,322 cases (IMSS, 2014).

In this study an analysis was made of the general ergonomic conditions in which the Agroexportadora los Mayos company is located, which has a total of 170 operators in plant and 300 working in the field. A workstation was located that is causing inappropriate positions for the operator. This research seeks to analyze and identify the musculoskeletal injuries of workers, this through two of the different tools that Ergonomics gives us, it is known that ergonomic evaluation is done through the methods: Rapid Upper Limb Assessment (RULA) and Corlett & Bishop. Agriculture and its relationship with companies, such as agro-exporters are a great economic driver in the state of Sinaloa. According to CODESIN (Council for the Economic Development of Sinaloa), the state of Sinaloa has been exporting vegetables for more than a century. The horticulture, like this, has become with the step of the years in one of the main economic activities of Sinaloa; not only because it is the main source of the state's exports (which in 2012-2013 reached 943 thousand tons), but also because during the winter it actively participates in the national supply with another million and a half tons. Its economic importance is highlighted by the attraction of foreign currency amounting to more than 900 million dollars; employment for more than 150 thousand day laborers, mostly migrants and another 50 thousand seasonal jobs for Sinaloa workers in the upper and upper middle of the state. Workers from different economic sectors develop diseases with a characteristic regionalization of musculoskeletal damage (Sánchez, Pérez and González, 2011). It is known that in Mexico, for 2016, the IMSS registered 12 thousand 622 cases of occupational diseases, of which 4 thousand 683 (37.1%) were musculoskeletal, placing them among the groups of occupational diseases with the highest rate of occurrence. The above, is equivalent to 2 out of 5 cases of work-related illnesses is related to this type of diseases (Work, 2017).

Patients with musculoskeletal disorders usually present in the arm and neck. The repetition of movements in the work process contributes to the symptoms in a significant proportion in those patients. Repetition, force, forced postures, vibrations, and jobs that require speed are occupational risk factors that can contribute to the development of those conditions.

In Mexico there were no records of ergonomic studies of musculoskeletal injuries in vegetable agroexporters. that provide an analysis of the work stations of these types of companies and provide an increase in the quality of life of the worker.

2. OBJECTIVE

Analyze the ergonomic conditions of the work stations to identify the musculoskeletal injuries of the workers of the Agroexportadora Mayos.

3. METHODOLOGY

To carry out this study where the activities were analyzed and the conditions were identified.

1.-Make a diagnosis of the company, identifying the characteristics of workers, work stations, and analyzed the physical conditions in which the facilities and ergonomic principles are.

2.-The work stations of the different areas of the company were analyzed, during a period of around 12 weeks, identifying risk factors in the finished product bagging work station (box with pumpkin).

According to Bascuas (2012), in ergonomics it is considered that a design is correct when it adapts, at least, to 90% of the population of users of the labor system considered.

It was observed that the positions in which the operators were found were not favorable for their health, and when talking with them they showed uneasiness and discomfort in their work station.

3.-The methods of evaluation applied were the map of Corporal Disorders (Corlett & Bishop), Rula and labor fatigue test, as well as the Rula Method these were applied to the operators of the station that was detected with greater risk.

4. RESULTS

The physical conditions in which the company is located comply with the permissible parameters.

When evaluating the 12 ergonomic principles we realized that of the 12 are not met; Principle No. 1. Maintain the full scope, Principle No. 4. Find the correct position for each task, Principle No. 8. Adjustment and change of position, are not met.

Figure 1. Product linking area.

Figure 2. Product binding area (the pector is observed with inadequate posture)

The methods of ergonomic evaluation were applied, resulting in a level 7 in the application of the Rula method, which says (McAtamney, 1993) that a redesign or change of the work station is necessary immediately as a result of which the operator sees involved in a situation of high risk because the position in which he finds himself is damaging his healt

We analyzed two operators corresponding to the female sex of 18 and 38 years of age, which have a working day of 7-10 hours (this is variable according to daily production), the operators at the beginning of the day have no symptoms of pain or discomfort, at the end of the workday the first operator At the end of the day shows discomfort in the head and middle back, as well as pain in the lower back the second operator at the end of the day shows the high rates of shoulder pain, middle back and lower back, which brings repercussions for your health.

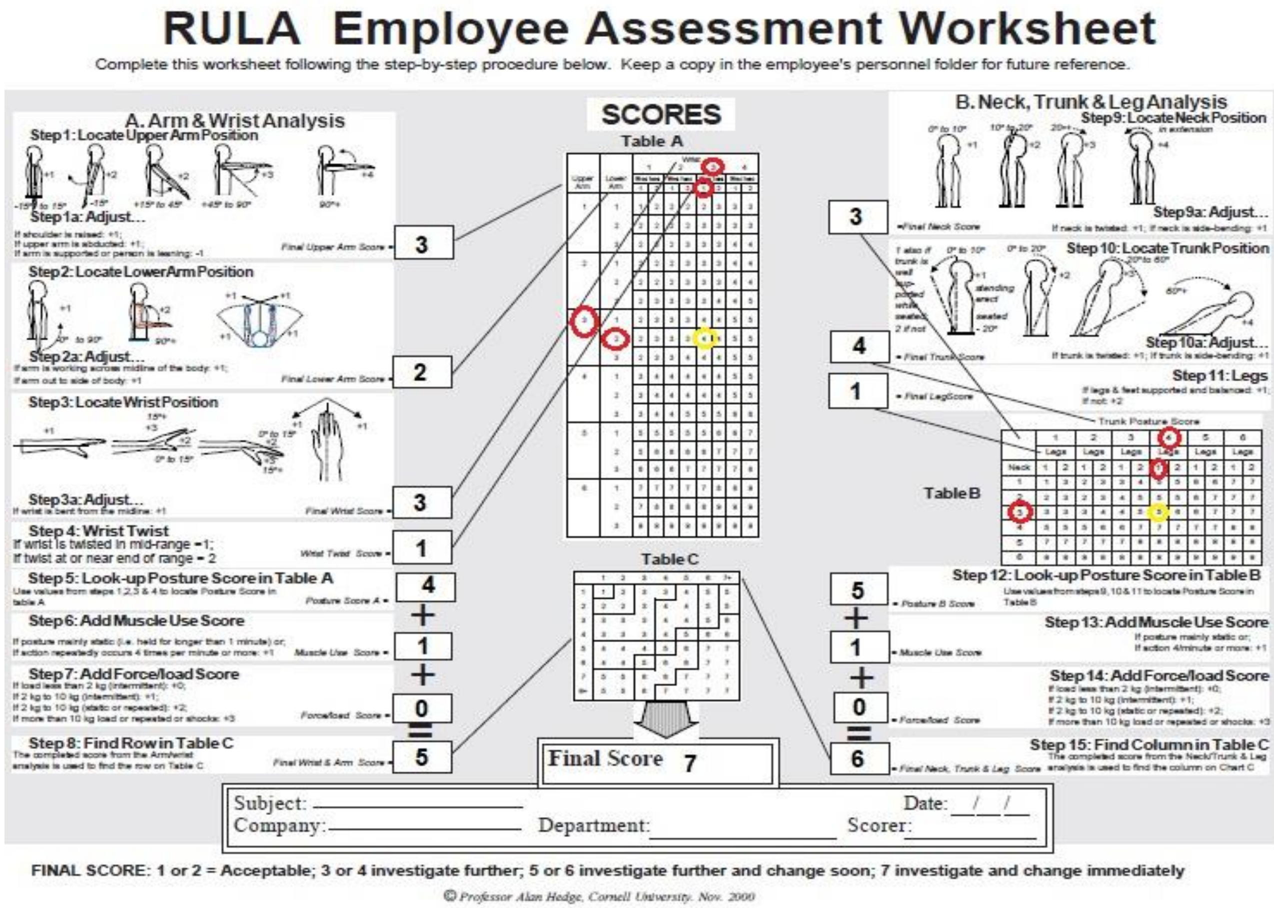

Figure 3. RULA evaluation method

The application of the Corlett & Bishop Method was to identify parts of the body that represented discomfort and pain in 80% of the workers, mainly in the lower back, shoulders, legs and arms.

5. DISCUSSION/CONCLUSIONS

The ergonomic intervention allowed analyzing and identifying the risk factors in the work station closing bags of finished product; where risks and dangerous conditions were found for the operator, because the operator's position was not favorable or correct, because that area has a limited height.

The applied evaluation methods helped to have a better overview of the ergonomic risk levels that affect the health of the operator in the finished product packing station, as well as: Rapid Upper Limb Assessment (RULA) and Corlett & Bishop, the test of labor fatigue, ergonomic principles, etc.

The achievement of a proposal for ergonomic improvement in the area, through the proposed redesign of work was based on Official Mexican Standard 001.
The most feasible and opted by the company solution was to insert in the work area a support for knocks, coating of the platform that is on top of said work station and the support tube of the platform, as well as a warning sign for the operators.

The benefits provided by the improvement of the workstation to the worker are very significant compared to the design and structure that was previously considered, since in this way the operator is prevented from having an inclined posture, blows to the shoulders and head, or present musculoskeletal injuries with this increases the quality of life of the operator and productivity in the process; because the worker is in a secure work station. And at the end of accounts is what every company should always take care of; your productivity and your workers.

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REDESIGN OF THE WORKSTATIONS IN A COMPANY BASED ON PHYSICAL CONDITIONS, OFICIAL MEXICAN NORMS AND ERGONOMIC PRINCIPLES

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Resumen. La ergonomía es responsable de conocer la interacción entre el ser humano y los otros elementos de un sistema, y esto se adapta a los operadores, para garantizar que las operaciones se realicen de forma segura, cómoda, sin errores, sin fatiga excesiva y que el resultado. Es un trabajo más efectivo y eficiente. El objetivo es rediseñar las estaciones de trabajo en una empresa de restaurantes, en base a los principios ergonómicos y los métodos ergonómicos de evaluación, así como identificar el cumplimiento de las Normas Oficiales Mexicanas de la STPS en las condiciones físicas. Los resultados obtenidos consisten en rediseñar el área de trabajo mediante un sistema de producción de células que define la creación de subsistemas que, cuando se combinan, forman un sistema total y cada estación es importante para el proceso. Además, este tipo de sistemas es ideal para los problemas que surgen en la empresa, que son tiempos de respuesta para la entrega al cliente.

Palabras clave: Ergonomía, rediseño, producción celular.

Relevancia para la Ergonomía: Este estudio contribuye a la ergonomía porque ayuda como información que contribuye al desempeño de acciones que mejoran las condiciones de trabajo de los trabajadores de las empresas de restaurantes.

Summary. Ergonomics is responsible of knowing the interaction between the human being and the other elements of a system and it and this seeks to adapt to the operators, to ensure that operations are carried out safely, comfortably, without errors, without excessive fatigue and that the result is a more effective and efficient work. The objective is to redesign the workstations in a restaurant company, based on the ergonomic principles, and the ergonomic methods of evaluation, as well as identifying the fulfillment of the Oficial Mexican Norms of the STPS in the physical conditions. The obtained results are to redesign the work area by means of a cell production system that defines the creation of subsystems that, when combined, form a total system and each station is important for the process. In addition, this type of systems is ideal for the problems that arise in the company, which are response times for customer delivery.

Keywords: Ergonomics, redesign, cell production.

Relevance for ergonomics: This study contributes to ergonomics because it helps as information that contributes to the performance of actions that improve the working conditions of the workers of the restaurant companies.

1. INTRODUCTION

According to the Mexican Ergonomist Society, SEMAC, ergonomics in human factors, is the scientific discipline related with the knowledge of the interaction between the human being and other elements of a system, and the profession that applies the theory, principles, data and methods to design seeking to optimize human well-being and execution of the global system. (SEMAC, 2019) Since its beginnings, it looked to adapt and optimize the work environment in the manufacture companies to the people's characteristics, guaranteeing a quality work-life and diminishing the risk of contracting occupational diseases on the long term. (Henrich, 2013)

According to Seifert (1998), diseases and skeletal-muscle symptoms represent one of the most important health problems for workers, firstly because they are found among the most common problems and secondly because they represent the biggest part of the cases of occupational diseases. One of the reasons is that the relation between a workplace accident and an occupational injury are vastly clear, but there exists a great difficulty when it is about relating the chronic type skeletal-muscle problems with the work conditions.

In Mexico, according to data from IMSS in the year of 2019 a total of 12 992 workplace accidents were registered in cook both men and women, out of which they experienced superficial traumatism, dislocations, sprains, fractures and muscle tear. In Mexico, the 38% of workplace diseases are because of the muscle skeletal disorders, moreover 7 out of 10 workers inform having experimented pain associated with the muscle skeletal disorder. (Villaseñor, 2013).

Mexican gastronomy is known for its flavor riches and ingredients, and has been declared Humanity's Immaterial Cultural Patrimony by the United Nations Educational, Scientific and Cultural Organization (UNESCO), which favors our economy by being one of the attractions for national and foreign tourists. Sanchez (2018) assures that restaurant industry in Mexico is a sector of great importance for national economic activity and, particularly, for thousands of national and international tourists that come to the country. In Mexico, the restaurant industry is the second biggest employer on a national level and the first in self-employment; furthermore, most of the shops and restaurants are integrated by small and medium size companies.

Nowadays, implementing ergonomics for the design and redesign of the stations has become in a competitive advantage since through the realization of studies the risk level of tasks can be identified, the information obtained is strategical in the design of the security improvement plans that directly affect productivity. (Gonzalez, 2019) Hence the importance of conducting a redesign of the workstations because not only does it help preventing muscle skeletal injuries in workers for bad postures or repetitive operations, it also helps improving the production they have.

2. GENERAL OBJECTIVE

To redesign the workstations in a restaurant company based on the physical conditions, Oficial Mexican Norms and ergonomic principles.

2.1 SPECIFIC OBJECTIVES

- To perform the current diagnosis of the workstations.
- To identify the Official Mexican Norms that apply to the workstations.
- To determine the ergonomic principles that apply to the workstations.
- To propose a redesign to the workstations in a restaurant company.

3. METHODOLOGY

Various methodologies were carried out that facilitated the process analysis, such as flow diagrams, flow process and operations, to determine the operational sequence and to study area by area where each operation is done and to find where bottlenecks or opportunity areas are presented.

Similarly, ergonomic principles, which affect mainly the workers, were identified, it is worth to not that in the kitchen area 4 cooks were registered, which were analyzed to determine which ergonomic principles were met in said company.

On the other side, the security and hygiene conditions were measured based on the norms from the Work and Social Foresight Secretary where the following norms need attention because they require improvement to provide a better security and hygiene to the workers: NOM-O15-STPS-2001 THERMAL CONDITIONS y NOM-016-STPS-1993 VENTILATION

Furthermore, a work stress test provided by IMSS was applied with the goal of identifying the stress level that the kitchen area presents and to examine the size and rhythm of the workload for the workers.

To finalize, ergonomic evaluations were made using the RULA method and the Corlett and Bishop Method, which provided information of the workers, and their postures were studied.

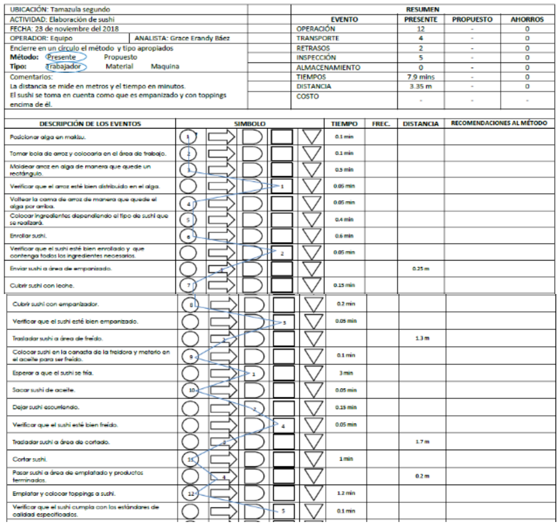


Figure 1. Process flow chart

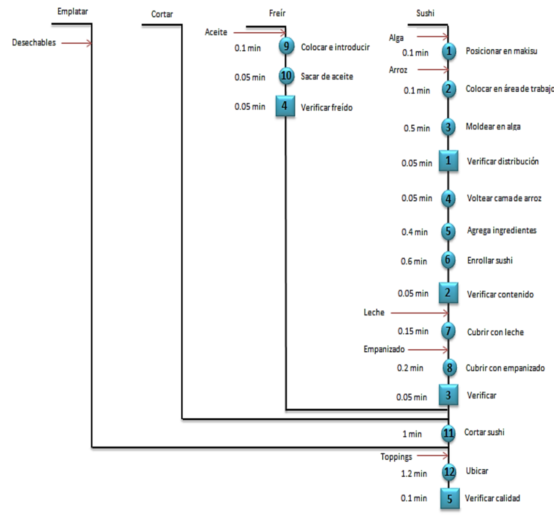


Figure 2. Process operations diagram

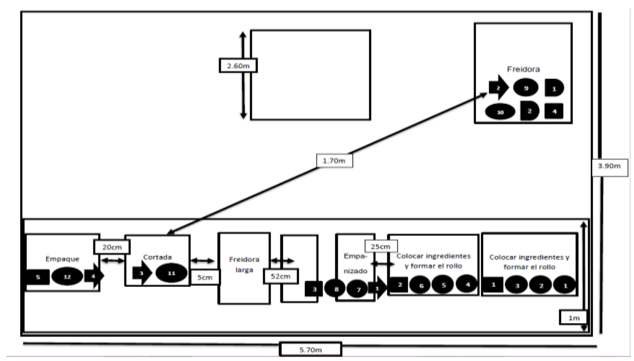


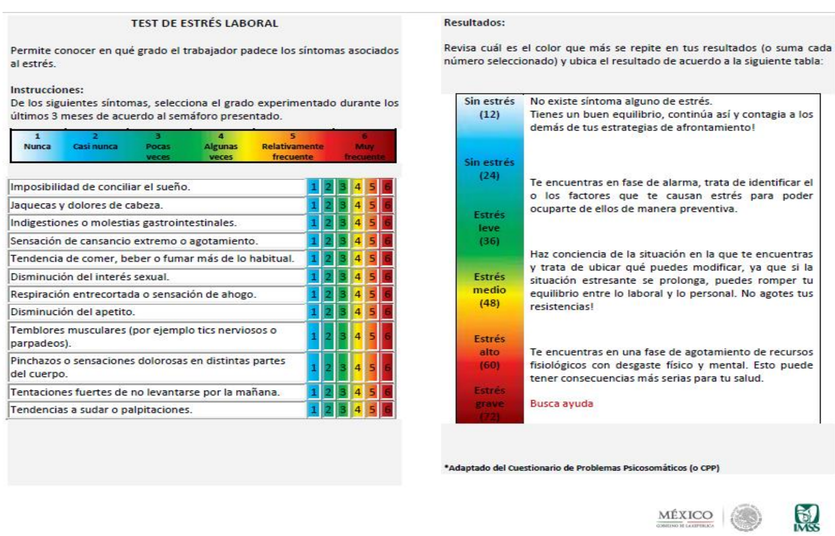
Figure 3. Process flow diagram

Table 1. Ergonomic principles

ERGONOMIC PRINCIPLE	IT COMPLIES – IT DOES NOT COMPLY	JUSTIFICATION
1. To keep everything within reach	It does not comply	During the visits we have done to the company we have noticed that the station has certain deficits on the production line elaboration, because the operator does not have everything at reach which leads to a bad design of the station, thus it takes longer in the production of sushi.
2. To use the elbow height as reference	It does not comply	The table where the sushi elaboration process is carried out does not meet this point, which indicates that the operator has to be very inclined when performing this activity.
4. To look for the correct position for each task	It does not comply	At the moment of not having a well-designed station a bad posture is going to be had, that is what occurs, in this case the height of the tables are not to the height of the elbows and that is tiring for the operator to be crouched to the table for eight hours daily and without a chair to rest.
7. Adjustment and posture change	It does not comply	Because the adjustments to determine the best way of distributing the workstations are not done, a correct change in posture is not done.
8. Arrange of spaces and accesses	It does not comply	The arrangement of the company is not adequate, it needs to make an analysis by area to determine what it really needs, because the spaces are very saturated and the operator has the flor too limited.

. Table 2. Thermal conditions

NOM	OBJECTIVES	AREAS	JUSIFICATION	PROTECTIVE EQUIPMENT
NOM-O15-STPS-2001 THERMAL CONDITIONS	To establish the security and hygiene conditions, the levels and maximum permissible times of exposition to thermal conditions, that for its characteristics, typo of activity, level, time and frequency of exposition, are capable of altering the workers' health. The permissible limits for this norm are: In light work it is considered from 30°C to 32.2°C, in moderate work from 26.7°C to 31.1°C and on heavy work it indicates 25°C to 30°C, with an exposition percentage that goes from 25% to 100%	Kitchen	The application of this norm establishes the thermal conditions a body can handle and that this factor does not affect the performance and productivity, because work is done with heat in the kitchen. It is applicable in the restaurant area because there must be excellent conditions for the client to feel comfortable.	Light and breathable clothing so it does not have a rise in corporal heat. Copings
NOM-016-STPS-1993 VENTILATION	To establish the necessary ventilation through a natural or artificial system that contributes to preventing the damage to the workers' health. The permissible limits to this norm are: The air extraction systems must be as far away from the worker as possible, and if there exists and air extractor there must be an equipment that signals it as well to prevent the possible damage to the breathing of the people that labor in that place.	kitchen	This norm is applicable to the sushi area because it presents extreme thermal conditions and lack of ventilation. A strategy is the installation of extractors that eject the heat to the outside to count with availability of air with adequate oxygen for the favorable breathing of the workers.	There is no personal equipment for ventilation, only lack of ventilation reduction ways.


TEST DE ESTRÉS LABORAL

Permite conocer en qué grado el trabajador padece los síntomas asociados al estrés.

Instrucciones:
De los siguientes síntomas, selecciona el grado experimentado durante los últimos 3 meses de acuerdo al semáforo presentado.

1 Nunca	2 Casi nunca	3 Pocas veces	4 Algunas veces	5 Relativamente frecuente	6 Muy frecuente

Imposibilidad de conciliar el sueño.	1	2	3	4	5	6
Jaquecas y dolores de cabeza.	1	2	3	4	5	6
Indigestiones o molestias gastrointestinales.	1	2	3	4	5	6
Sensación de cansancio extremo o agotamiento.	1	2	3	4	5	6
Tendencia de comer, beber o fumar más de lo habitual.	1	2	3	4	5	6
Disminución del interés sexual.	1	2	3	4	5	6
Respiración entrecortada o sensación de ahogo.	1	2	3	4	5	6
Disminución del apetito.	1	2	3	4	5	6
Temblores musculares (por ejemplo tics nerviosos o parpadeos).	1	2	3	4	5	6
Pinchazos o sensaciones dolorosas en distintas partes del cuerpo.	1	2	3	4	5	6
Tentaciones fuertes de no levantarse por la mañana.	1	2	3	4	5	6
Tendencias a sudar o palpitaciones.	1	2	3	4	5	6

Resultados:

Revisa cuál es el color que más se repite en tus resultados (o suma cada número seleccionado) y ubica el resultado de acuerdo a la siguiente tabla:

Sin estrés (12)	No existe síntoma alguno de estrés. Tienes un buen equilibrio, continúa así y contagia a los demás de tus estrategias de afrontamiento!
Sin estrés (24)	Te encuentras en fase de alarma, trata de identificar el o los factores que te causan estrés para poder ocuparte de ellos de manera preventiva.
Estrés leve (36)	
Estrés medio (48)	Haz conciencia de la situación en la que te encuentras y trata de ubicar qué puedes modificar, ya que si la situación estresante se prolonga, puedes romper tu equilibrio entre lo laboral y lo personal. No agotes tus resistencias!
Estrés alto (60)	Te encuentras en una fase de agotamiento de recursos fisiológicos con desgaste físico y mental. Esto puede tener consecuencias más serias para tu salud.
Estrés grave (72)	Busca ayuda

*Adaptado del Cuestionario de Problemas Psicosomáticos (o CPP)

MÉXICO GOBIERNO DE LA REPÚBLICA IMSS

Figure 4. Work stress test

4. RESULTS

It was identified that in the company exists an improvement opportunity, it does not comply the conditions of the ergonomic principles and the conditions of the Hygiene and Industrial Security from the Work and Social Foresight Secretary (STPS). Likewise was identified that the workers presented discomfort on the feet after finishing their working day of 8 hours and light stress.

Figure 5. Current production area and its different processes (preparation, breading, frying, and cut)

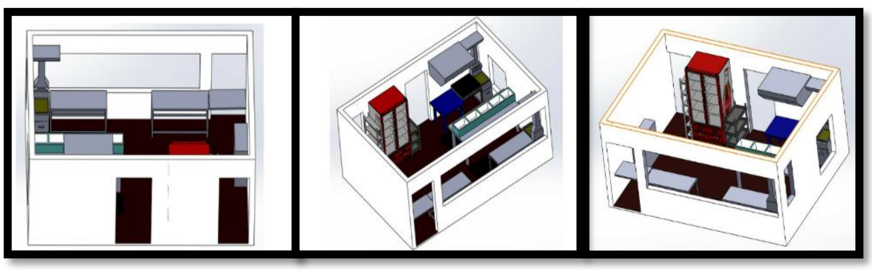


Figure 6. Redesign of the cell production working area

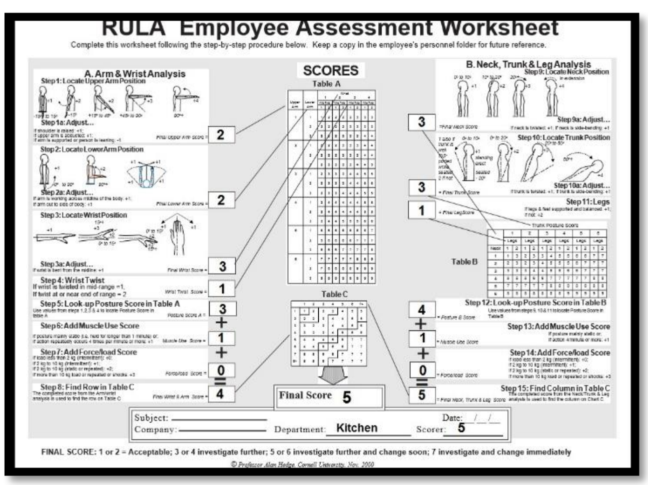


Figure 7. RULA method applied in the kitchen area

5. CONCLUSIONS

The implementation of different methods to carry out different corresponding evaluations was essential to obtain a result.

After having analyzed positions, flows, stress, movements, among others. The proposal was made to redesign the area by applying a cell production, bringing with it many benefits to the process and to the workers themselves, with this production system it is intended to divide the process into subsystems in such a way that each station has its assigned task and the person in charge of carrying it out is an expert in this, making the process more productive.

It is here where based on the flow diagrams, route and operations, it was possible to detect that the process did not follow a flow, for that reason there were unproductive times of transfer, so it was decided to establish a continuous flow in which the cook was responsible for just doing the assigned tasks without moving and wasting time.

Regarding ergonomic principles, keep everything within reach, use the height of the elbow as a reference, find the correct position for each task, adjust and change posture, arrange spaces and accesses, those that did not comply with the facilities were retaken, so that in the new redesign they do meet and facilitate the work to the cooks.

On the other hand, an important factor of safety and hygiene conditions is the implementation of the STPS standard, where lighting, ventilation and thermal conditions were the main factors taken into account in the remodeling, as more ways of giving were considered ventilation to the kitchen area bringing benefits in the thermal conditions.

To finish with the application of methods of analysis, we worked with the work stress test provided by the IMSS, also with the RULA method and finally with the Corlett and Bishop method, a study was carried out and the people involved were interviewed, this case was worked with 4 men, with an age range between 20 and 25 years where at the end of their day of 8 hours they presented a low level of fatigue and a lot of tiredness in the feet and part of the back, this with a bad origin postures that were determined by the RULA method.

Thanks to the redesign of stations, the cook will finish his eight-hour day with a lesser degree of fatigue and tiredness since it will be designed with heights and previous measures to reduce injuries. It can be ensured that the company will increase its productivity and that each cook will be trained to carry out their work without any inconvenience.

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ERGONOMIC DESIGN IN THE PROCESSES OF MIXING AND DISTRIBUTION OF BALANCED FOOD FOR BOVINE CATTLE.

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Resumen: Sinaloa es reconocido como uno de los principales estados productores de alimento en México. Las actividades más representativas son la Agricultura y la Ganadera, en esta última se ocupa el cuarto lugar en volumen de producción de carne en canal del total nacional representado con 5.03%. Siendo estas las actividades generan más fuentes de empleos y divisas derivadas de las exportaciones agroalimentarias sirviendo como motor económico del estado. (CODESIN, 2019).

En la región norte del estado de Sinaloa una empresa ganadera manifestó el interés en participar en el desarrollo de un proyecto para generar una propuesta de diseño ergonómico en los procesos de mezclado y distribución de alimento balanceado para el ganado bovino. Para mejorar las condiciones de trabajo y productividad en las áreas.

El diseño plantea una solución significativa para la mejora de procesos, a través de seguridad, ergonomía condiciones de trabajo, disminución de rotación de personal, accidentes, reducción de tiempo, y aumento de la productividad con base a la normatividad de la STPS, condiciones ergonómicas.

Palabras clave: Diseño ergonómico, Planta de alimento de ganado bovino, Condiciones ergonómicas

Relevancia para la ergonomía: El diseño de los espacios de trabajo es esencial en la productividad de los procesos. La aportación de la ergonomía garantiza la optimización de los recursos y la optimización de los sistemas Hombre- Máquina. Generando un sistema más eficiente en sus operaciones, cuidando la seguridad y salud del trabajador

Abstract: Sinaloa is recognized as one of the leading food producing states in Mexico. The most representative activities are Agriculture and Livestock, in this last one it occupies the fourth place in volume of meat production in channel of the national total represented with 5.03%. Since these activities generate more sources of jobs and foreign currency derived from agro-food exports, serving as the economic engine of the state. (CODESIN, 2019).

In the northern region of the state of Sinaloa a livestock company expressed interest in participating in the development of a project to generate an ergonomic design proposal in the processes of mixing and distribution of balanced feed for cattle. To improve working conditions and productivity in the areas.

The design poses a significant solution for the improvement of processes, through safety, ergonomics, working conditions, reduction of personnel turnover, accidents, reduction of time, and increase of productivity based on the regulations of the STPS and ergonomic conditions.

Keywords: Ergonomic design, Cattle feed plant, Ergonomic conditions

Relevance to Ergonomics: The design of the workspaces is essential in the productivity of the processes. The contribution of ergonomics guarantees the optimization of resources and the optimization of Man-Machine systems. Generating a more efficient system in its operations, taking care of the safety and health of the worker

1. INTRODUCTION

"Ergonomics is the scientific discipline that deals with the interactions between human beings and other elements of a system, as well as, the profession that applies theory, principles, data and methods to design in order to optimize the well-being of the human being and the result global system ". (EIA, 2000).

It is important to note that organizations must establish the provisions on Occupational Health and Safety to be observed in the Work Centers, in order to have the conditions that prevent risks and, in this way, guarantee workers the right to carry out their activities in environments that ensure their life and health, based on what is stated in the Federal Labor Law. (Beltran, 2014)

Musculoskeletal injuries have a huge and growing impact worldwide, from the perspective of productivity and economy of the industry. In Mexico, the musculoskeletal pathology is one of the leading causes of morbidity, as established by the evidence according to the IMSS statistics for 2011, where it is reported that the number of work risks in total was 536,322 cases (IMSS, 2014).

Based on this the cattle company decided to work in the area of mixing and distribution of cattle feed, as it presents many irregularities of safety and health for the worker. Mainly staff turnover problems, musculoskeletal injuries, downtime jobs, low productivity. , with a 60% turnover of personnel and accidents at the plant, 40% are presented in the areas of mixing and distribution of the plant, as well as not having any safety regulations that the Secretary of Labor of Social Security These actions general accidents, occupational risks and low productivity in workers.

2. OBJECTIVE

Perform the ergonomic design in the processes of mixing and distribution of balanced feed for cattle

3. METHODOLOGY

1.- Make a current diagnosis of the areas of mixing and distribution processes.
2.-Identify the NOM´S of the STPS
3.- Identify ergonomic and health aspects in the operations of each process
4.- Design the ergonomic and safety conditions in the processes

4. RESULTS

The diagnosis made is described In the plant area, 4 bosses and 6 workers were identified in the different work stations, the same areas are: input warehouse, rolled, ground and mixed, detecting that the physical conditions that mark the standards are not met Mexican STPS officers, as well as do not use personal protective equipment. As well as bad postures, musculoskeletal injuries, and repetitive work performed by operators in their work stations were identified.

Figure. 1 Current conditions of the food plant

Standards	
NOM-002-STPS-2010	NOM-019-STPS-2011
NOM-017-STPS-2008	NOM-015-STPS-2001
NOM-026-STPS-2008	NOM-007-STPS-2000
NOM-029-STPS-2005	NOM-006-STPS-2014
NOM-003-SEGOB-2002	NOM-020-STPS-2011
NOM-154-SCFI-2005 NOM-011-STPS-2001	NOM-025-STPS-2008

Figure 2 Identification of Mexican Official Standards of the STPS that does not comply with the company

The ergonomic evaluation was carried out in each work station based on the operations performed by the worker. This evaluation was in a period of 3 weeks, observing and analyzing each of the activities carried out in the plant, through the Corlett & Bishop Method, the ergonomic principles and the identification of ergonomic risks, and a fatigue questionnaire. These reflected postural problems in the 2 processes and 80% of the workers presented fatigue, musculoskeletal injuries mainly in the lower back and middle back, shoulders, legs and arms. They also present accidents constantly because they do not work with personal protective equipment. Mainly in the loading and unloading of raw materials and food. Another cause for which they present a problem is that the workers state that they have no knowledge of the safety norms and the hand of burdens.

The design of the ergonomic conditions will benefit the workers since, when applied, unnecessary movements or actions will be eliminated when executing the tasks, workers will be provided with better working conditions and more security so that they can carry out their activities without risks can happen some work accident.

Figure 2. Design of plant work stations

Figure 3. Design of work stations of plant 2

5. DISCUSSION/CONCLUSIONS

The project is a proposal of ergonomic design for the processes of mixing and distribution of cattle feed. That gives a feasible solution to all the problems that arise. This is based on the application of the regulations of the STPS for the physical conditions to which the workers are exposed, the ergonomic principles were considered, and the results of the Corlett & Bishop methodology, fatigue questionnaire and the identification of ergonomic risks, Design software such as SketChup was used.

These proposals of ergonomic design took the specifications of the official regulations. It was presented at the company, where significant changes have been made in the processes, generating a decrease in downtime, staff turnover under 4%, accidents have dropped.

As well as a safety training program and ergonomic actions were presented to the workers to manage the activities they carry out.

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DESIGN OF LAYOUT FACILITIES FOR INDUSTRIALIZING PLANT OF A DRY MEAT PRODUCT

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Resumen: "Una estrategia para la distribución de instalaciones debe surgir a través de un plan estratégico en donde intervengan el producto, la manufactura, distribución de marketing, gerencia y el recurso humano, los cuales tendrán un impacto directo en la distribución de instalaciones" (Tompkins, White, & Tanchoco, 2011).

Si la distribución está mal diseñada, las empresas se enfrentarán constantemente con costosas ineficiencias o con redistribuciones muy caras. Por lo que la primera instalación debe ser adecuada, para minimizar los costos de posteriores modificaciones. Para lograr lo anterior, los cambios de ubicación de las maquinas deben realizarse en la etapa de planificación y con el tiempo suficiente para hacer pruebas, que es el principal componente de esta actividad (Vaugh, 1988).

La necesidad de una empresa del sector ganadero de la región Norte del Estado de Sinaloa, genera grandes cantidades de carne fresca que no comercializa con frecuencia, surgiendo el interés de crear un producto cárnico seco para darle valor agregado a esta carne, creando de esta manera una nueva línea de producción en sus instalaciones ya existentes. En esta investigación se presenta el diseño de un Layout para el proceso de producción de una nueva línea para la elaboración del producto cárnico seco, haciendo uso de la metodología SLP (Systematic Layout Planning) y la aplicación de la normatividad mexicana (NOM-001-STPS-1999, NOM-213-SSA1-2002 y NOM-008-ZOO-1994) a este tipo de procesos, al igual que la certificación TIF (Tipo Inspección Federal). También la utilización de herramientas de diseño como AutoCAD y SketChup, con la finalidad de proyectar las instalaciones en 2D y 3D. El área disponible en la empresa fue de 98 m^2, siendo el espacio una limitante en este proyecto. Otro factor importante para el diseño del Layout fue la flexibilidad de las instalaciones que se planean diseñar, con la finalidad de generar una planta de producción flexible para ajustar o reordenar en poco tiempo y a un menor costo el proceso de producción. "En la actualidad en la industria, el ubicar en su justo sitio maquinas, herramientas y accesorios; el dar entrada y salida racionales a las materias y productos antes, durante y después de su proceso en planta, pasando desde los almacenes de materias a los departamentos de depósito, embalaje y expedición, y el lograr, en definitiva, que las operaciones propias de la actividad industrial se produzcan con mínimos movimientos de materiales y de hombres; son de suma importancia para la optimización de recursos en cualquier empresa” (Muther, Distribucion en Planta, 2000). La distribución de planta genera diferentes beneficios que ayudan a las empresas a mejorar sus procesos de producción, mejorando el manejo de materiales, reduciendo el tiempo de producción, y además se obtiene un correcto flujo de trabajo al diseñar una distribución determinada según el proceso de producción, y como resultado final se llega a una optimización de los recursos de la organización, el presente proyecto muestra información de una investigación que se desarrolló con la finalidad de crear un diseño y distribución de instalaciones en el sector industrial, considerando diferentes aspectos de la empresa beneficiada.

Palabras clave: Diseño de Lay Out, Operaciones de proceso, Producto Cárnico Seco

Relevancia para la ergonomía: Uno de los objetivos de la Ergonomía es la optimización de los Sistemas Hombre- Máquina, y para lograrlo es sumamente importante el diseño de los espacios de trabajo a las características del procesamiento de un productos, considerando el personal que trabajara con base a una capacidad de producción y siguiente las normativas de seguridad e inocuidad correspondientes.

Abstract: "A strategy for the distribution of facilities must arise through a strategic plan involving the product, manufacturing, marketing distribution, management and human resources, which will have a direct impact on the distribution of facilities" (Tompkins, White, & Tanchoco, 2011). If the distribution is poorly designed, companies will constantly face costly inefficiencies or very expensive redistributions. So, the first installation must be adequate, to minimize the costs of subsequent modifications. In order to achieve the above, changes in the location of the machines must be made at the planning stage and with sufficient time for testing, which is the main component of this activity (Vaugh, 1988).

A company in the livestock sector of the northern region of the State of Sinaloa, generates large quantities of certain cuts of fresh meat that does not market frequently, raising the interest of creating a dry product giving an add value to them, creating a new production line in its existing facilities. This research presents the design of the Layout for the new dry meat product line, making use of the SLP (Systematic Layout Planning) methodology and the application of Mexican regulations (NOM-001- STPS-1999, NOM-213-SSA1-2002 and NOM-008-ZOO-1994) as well as the TIF certification (Federal Inspection Type) for this type of processes. Design tools such as AutoCAD and SketChup were used, in order to project the facilities in 2D and 3D.

The available area in the company was 98 m2, being space a limitation to this project. Another important factor for the layout design was the flexibility of the facilities that are planned to design, with the purpose of generating a flexible production plant to adjust or reorder in a short time and at a lower cost to the production process.

"Currently in the industry, to place in its right place machines, tools and accessories; the rational entry and exit to materials and products before, during and after the process in plant, passing from the warehouses of materials to the departments of deposit, packaging and dispatch, and achieving, ultimately, that the operations of industrial activity occurs with minimal movements of materials and men; they are very important for the optimization of resources in any company "(Muther, 2000).

Plant distribution generates different benefits that help companies to improve their production processes, improving material handling, reducing production time, and also obtaining a correct work flow when designing a certain distribution according to the production process , and as a final result it is possible to optimize the resources of the organization, the present project shows information of a research that was developed with the purpose of generating a design and distribution of facilities in the industrial sector, considering different aspects of the company benefited.

Keywords: Lay Out Design, Process Operations, Dry Meat Product

Relevance to Ergonomics: One of the objectives of the Ergonomics is the optimization of the Human-Machine Systems, and to achieve it is extremely important the design of the work spaces to the characteristics of the processing of a product, considering the personnel that will work based on a production capacity and following the corresponding safety and safety regulations.

1. INTRODUCTION

Plant distribution involves the physical ordering of industrial elements. This arrangement, already practiced or planned, includes both the spaces necessary for the material movement, storage, indirect workers and all other activities or services, such as the work team and workshop staff. (Muther, 2000). In this context reference will be made to various studies on the subject by different authors to introduce the subject.

"It is said that 50% of total operating expenses can be reduced if the layout of the installation has been designed properly." (Orozco & Cervera, 2013). It is here, where the term that was initially associated with the layout of space on the decks of the aircraft carriers of the war of the middle of the last century, Layout arises. This term in time, turned into what today is known as the design and distribution of plant, whose main contributor is Richard Muther with the SLP (Systematic Layout Planning). Orozco & Cervera mention that currently the plant distribution is widely recognized having a great impact on the overall costs, efficiency and operation of a facility.

For Blanco, Martínez, et al. (2014), the Layout of a company is the process of physical arrangement of the industrial elements to constitute a productive system able to meet the objectives set in the best possible way. For this purpose, three key factors should be taken into account in the development of the Layout: 1. Flexibility of the Layout, 2. Utilization of the productive area, 3. Proximity. It is worth mentioning that Blanco et al. highlights the aspect of flexibility, because according to its perception, companies are constantly changing their production processes due to changes in production volumes or changes in the design of their products, which consequently requires constantly changing their plant distribution, otherwise these changes will generate high costs.

According to Wiendahl & Nyhuis (2016), the areas of planning, should be structured in the following phases: 1. Specify the purpose of the facilities, 2. To analyse information, 3. Plan the concept of facilities in general , 4. Planning in detail of the facilities, 5. Execution of the works, 6. Supervision of the works, 7. Start-up and start of operations.

Muñoz Cabanillas in 2004, conducted a study for the development of a layout design for a textile company in the city of Lima, Peru. In which a team of 9 people was formed for the realization of the design of what would be a completely new plant, which would make possible the transfer and unification of existing facilities. The methodology used was Systemic Planning of the Distribution that divides the project in four phases: 1. Establishing the problem, 2. Obtaining real data, 3. Rethinking the problem, 4. Analyzing and deciding the best solution.

We agree with the authors in their different steps to develop a project of planning and designing facilities, but the systemic thinking approach is very important because the process is not considered in a linear way, but rather establishes a feedback cycle, so that the design is in accordance with a short-term need, and at the same time has the flexibility to adapt to future changes or modifications due to the quantities of production or new dispositions of the organizations.

Regarding the perspective of 2D design, and the inclusion of new technologies, such as virtual reality and simulated 3D environments, the following review of authors is presented that reinforce the technological tools that were used for the development of this research.

Aguilar Jaen (2017), carried out a study to design a new plant infrastructure for the production line of the Buller and Linner 12 models in DINA TRUCKS, in Sahagún, Hidalgo, Mexico. The project of distribution of plant and infrastructure for this new assembly line, made use of the Systematic Layout Planning (SLP) methodology as well as design tools such as AutoCAD and Dialux, in order to project the facilities in 2D and 3D.

For Li & Zhong (2003), Virtual Reality (VR) is a third-dimensional environment generated by computer, which is then rendered in real time according to the needs of the user. Likewise, an interactive visual tool for the planning and revision of the Layouts by the operators of the machines and the designer would be the most appropriate. This is where the RV has the potential to add value by including the operator in the planning stage.

Ting Yang, Bing & Shan (2008), affirm that the Plant Layout is an important factor that enhances the competitiveness of a company and its products. Between 20% and 50% of the operating cost is used in the flow of materials, however, a good Layout can save between 10% and 30% of this cost.

The planning and design of this plant layout for the production of a dry meat product, arose from the need of a livestock company, to take advantage of some cuts of fresh meat which have in their inventory, do not have enough commercial movement and are stuck in storage losing their shelf life. The production process was carried out with the purpose of increase the quantity of a product that has been manufactured and requires a greater production capacity to meet the demand of potential customers.

2. OBJECTIVE

To plan and design a plant layout for the production process of a dry meat product in the facilities of a livestock company in the northern region of the state of Sinaloa.

3. METHODOLOGY

1. Analysis of the current spaces that will be used for the production process in the company, as well as the facilities that have these spaces (electrical installations, drinking water, drainage and physical facilities, such as walls, floors, ceilings among others).
2. Review of historical records of surplus inventories in cuts of fresh meat, this with the purpose of defining the production capacities of the processing plant.
3. Definition of the production process for the preparation of this product, taking into account the specifications and requirements of the regulations NOM-001-STPS-1999, NOM-213-SSA1-2002 and NOM-008-ZOO-1994 applied to this type of processes.
4. Investigation of the dimensions and capacities of the equipment to be used in the production process.
5. Elaboration of the plant distribution, with the SLP method.
6. Design the 2D and 3D (Layout) of the plant.

4. RESULTS

4.1 Layout

4.1 3D Model: This Layout projection, you can visualize the design in virtual reality. They emphasize the importance of the use of virtual reality when designing a plant distribution. Below is the 3D model in Figure 2.

5. DISCUSSION/CONCLUSIONS

This project provides a solution proposal for the need to install a new line to produce dry meat, applying the SLP methodology, we obtained an effective plant distribution complying with its basic principles and thus achieve the objectives that were raised for this draft. Design software such as AutoCAD and SketChup were used. To design the infrastructure, the requirements and specifications of the Mexican regulations for this type of facility were analyzed, complying with regard to safety and hygiene at work, specifications of the facilities, etc. The flexibility of the installations and distribution of the plant was achieved, so that when it is required, changes to the process and machinery can be made at the lowest cost and in a short time

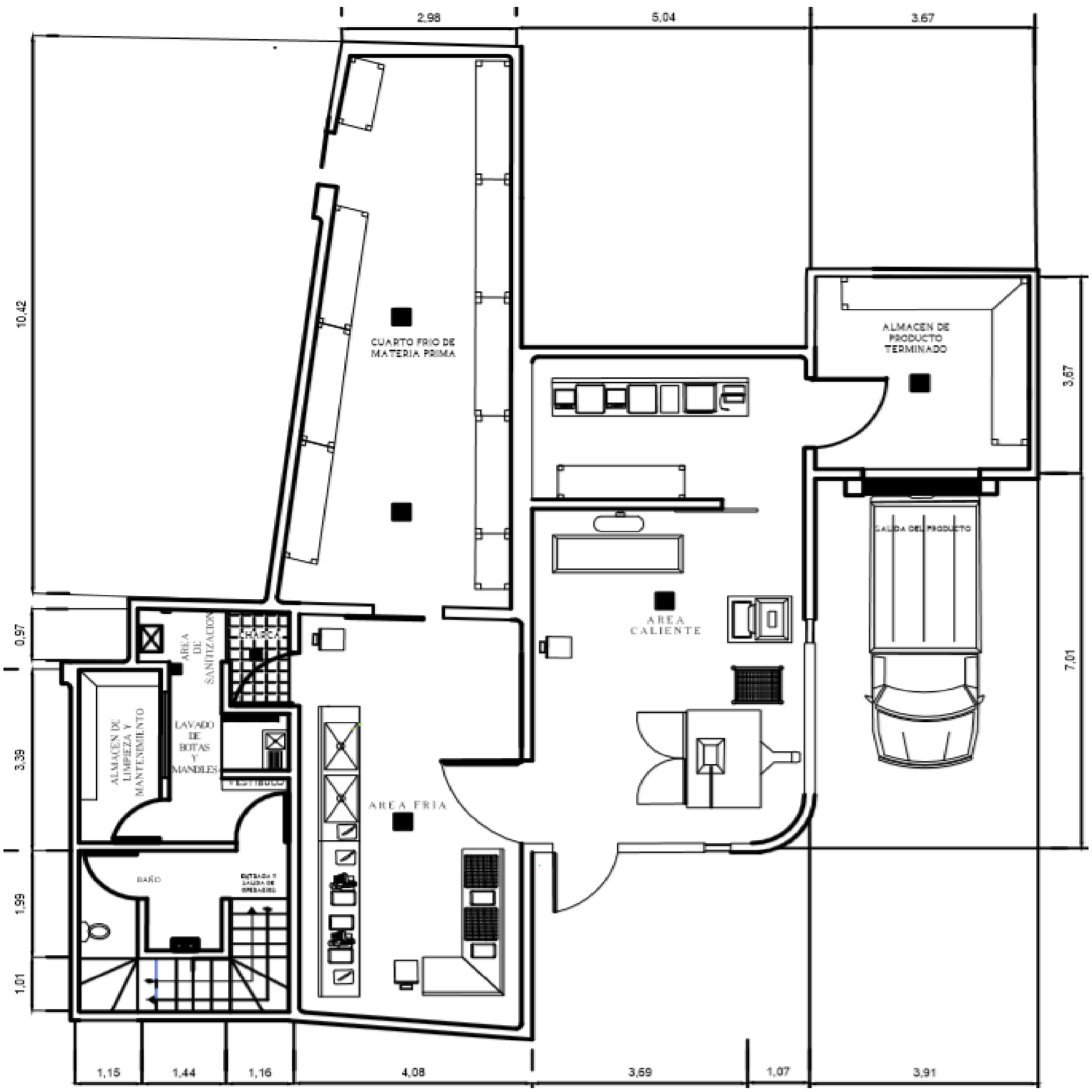

Figure 1. Proposed layout of the processing plant.

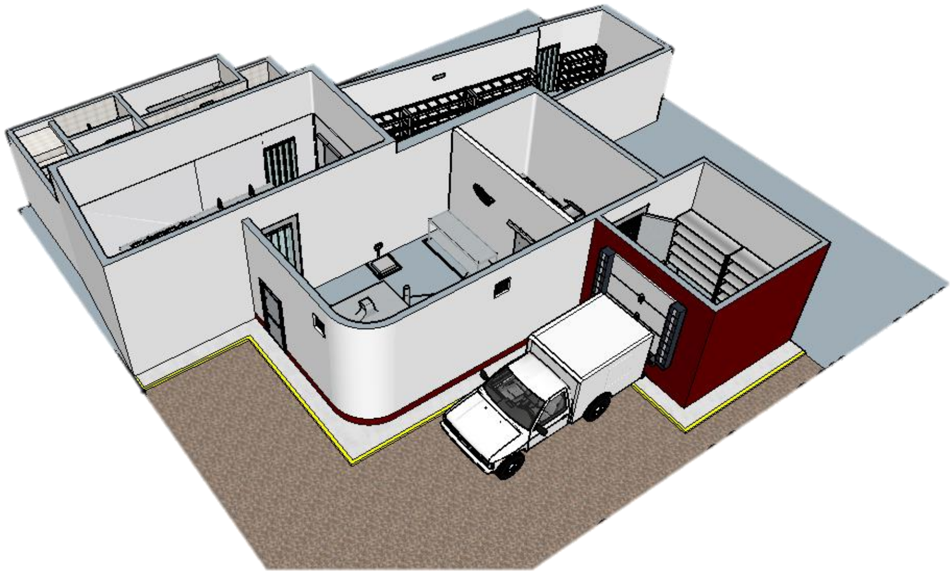

Figure 2. 3D model, processing plant.

4.2.1. Áreas of the production process

Figure 3. Bathroom view, maintenance and cleaning warehouse, sanitation area.

4.2.2. Cold Room

4.2.3.

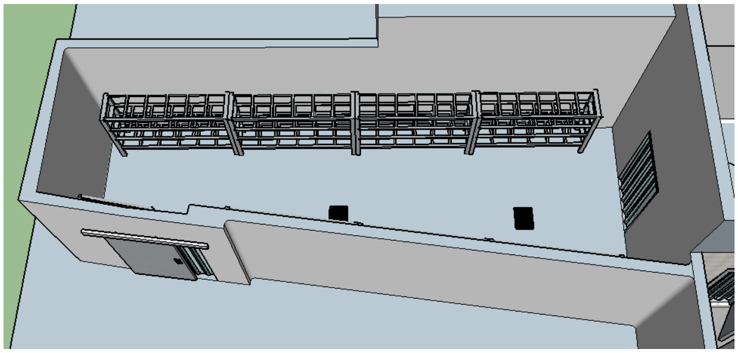

Figure 4. Cold room view.

4.2.3. Cold Área

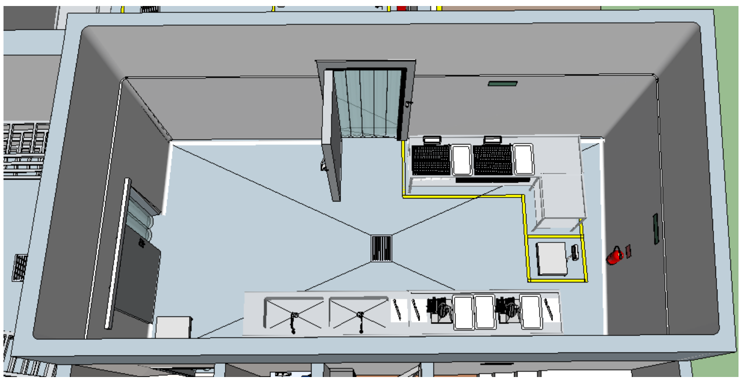

Figure 5. Cold área view.

4.2.4 Hot Área

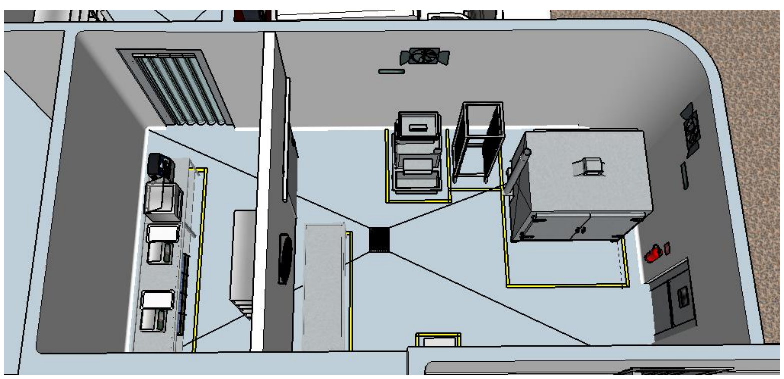

Figure 6. Hot área view.

4.2.5 Finished product warehouse

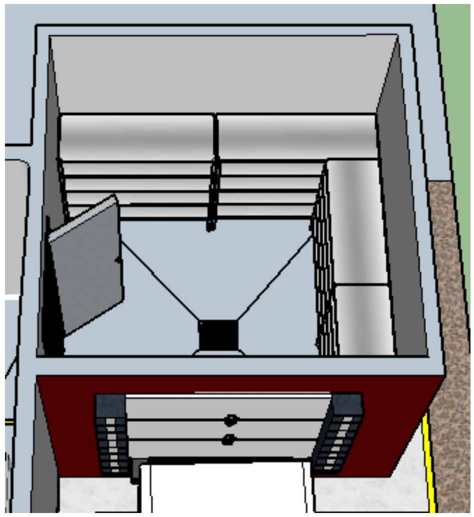

Figure 7. Finished product warehouse view.

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ERGONOMIC ANALYSIS OF THE WATERMELON CUTTING PROCESS IN THE EXPERIMENTAL FIELD OF THE INSTITUTO TECNOLOGICO SUPERIOR DE GUASAVE

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Resumen: El estado de Sinaloa es reconocido como uno de los principales productores de alimento en México. La agricultura es la actividad más representativa de nuestra entidad. Siendo esta un motor económico del estado ya que genera una fuente de empleos y divisas derivadas de las exportaciones agroalimentarias (CODESIN, 2019).

Estos trabajos del sector agrícola son complejos y diversos, y el trabajador confunde sus condiciones de vida y de trabajo, lo que implica que se enfrenta día a día innumerables riesgos para la salud. Meyer (1997) señala a la agricultura como los trabajos más difíciles con un alto nivel de trastorno de trauma acumulado y lesiones en trabajadores.

En el campo experimental del Instituto Tecnológico Superior de Guasave, se producen hortalizas, y granos. En esta temporada se sembró Sandia, y particularmente en el proceso de corte de sandía generando riesgos de salud, posturas no neutrales como inclinado, y en cuclillas. Con esta investigación se buscó analizar las operaciones, procesos, y condiciones labores para detectar desorden de trauma acumulativo de los trabajadores. Se aplicó Método Rula y cuestionario general a 3 trabajadores

Palabras clave: Desorden de trauma acumulativo, corte de sandía, lesiones musculoesqueléticas

Relevancia para la ergonomía: La ergonomía es la interacción entre los seres humanos y otros elementos de un sistema. Este estudio aporta información que contribuye a la mejora de las condiciones de trabajo del sector agrícola.

Abstract: The state of Sinaloa is recognized as one of the main food producers in Mexico. Agriculture is the most representative activity of our entity. This being an economic engine of the state since it generates a source of jobs and foreign currency derived from agro-food exports (CODESIN, 2019).

These jobs in the agricultural sector are complex and diverse, and the worker confuses their living and working conditions, which means that they face innumerable health risks every day. Meyer (1997) points to agriculture as the most difficult jobs with a high level of accumulated trauma disorder and worker injuries.

In the experimental field of the Higher Instituto Tecnologico Superior de Guasave, vegetables and grains are produced. In this season, Sandia was planted, and particularly in the watermelon cutting process, generating health risks, non-neutral postures such as leaning, and squatting. With this research, we sought to analyze the operations, processes, and working conditions to detect the cumulative trauma disorder of workers. Rula Method and general questionnaire applied to 3 workers

Keywords: Cumulative trauma disorder, watermelon cut, musculoskeletal injuries

Relevance to Ergonomics Ergonomics is the interaction between human beings and other elements of a system. This study provides information that contributes to the improvement of working conditions in the agricultural sector.

1. INTRODUCTION

Mexico has a great variety of climates and soils, which favor the production of watermelon cultivation in different regions and seasons, the main states producing watermelon are: Jalisco, Sinaloa, Sonora, Chihuahua and Nayarit (Núñez, et al., 2010, SIAP, 2018). The national average yields in temporary are of 10.5 ton-ha-1, while in irrigation they are of 23.3 ton-ha-1, where different production systems are used, from the most traditional to those highly technified, through drip irrigation, mulching, fertigation, hanging espaliers and permanent programs of mineral nutrition and sanitary protection (Rinconi, 2014). At present, Mexico is the 12th world producer of watermelon with 946, 458 tons of watermelon, however it is considered as the largest exporter in the world (SIAP, 2017).

In the Mexican export of fruits, the flow of watermelon generates the seventh largest amount of foreign currency, and also mobilizes the third largest volume; in the 2012-2017 period an average annual increase of 21 thousand tons was recorded. Sinaloa is located within the main producing entities nationwide of watermelon cultivation, this is due to the improvement in harvesting techniques, which has enabled a greater national production of the fruit; 11% increase in 2017 compared to the previous year (SIAP, 2018).

"Ergonomics is the scientific discipline that deals with the interactions between human beings and other elements of a system, as well as, the profession that applies theory, principles, data and methods to design in order to optimize the well-being of the human being and the result global system ". (EIA, 2000).

The trial was carried out in the Experimental Field of the Higher Technological Institute of Guasave (ITSG), which has a sandy loam soil. Planting density was established from 2000 plants per hectare at a distance of 80 cm between plant and plant. There are 36 beds, the separation between bed and bed is 3 m, and the length of each bed is 80 m, the watermelon plant that was evaluated in the experiment is the mara variety with an average weight between 10 and 12 kg.

In this field, the ergonomic analysis of the watermelon cutting process will help to identify the cumulative trauma disorder and the working conditions that the operators have to perform the tasks.

2. OBJECTIVE

Analyze the ergonomic conditions of the watermelon cutting process in the experimental field of the Higher Technological Institute of Guasave

3. METHODOLOGY

The methodology that was applied to analyze the watermelon cutting process operations the following; The research subjects were 3 people who work in the experimental field. They were given a questionnaire with general data, in order to obtain more information about their physical condition when they performed their tasks. The application of the Rula Method, with the objective of achieving the evaluation of the operator's postures during the fulfillment of their tasks, since this method will allow us to evaluate the existence of risk factors that may cause injuries to the upper limbs of the body including non-neutral postures, repetition of movements, static activity and application of muscular skeletal system forces.

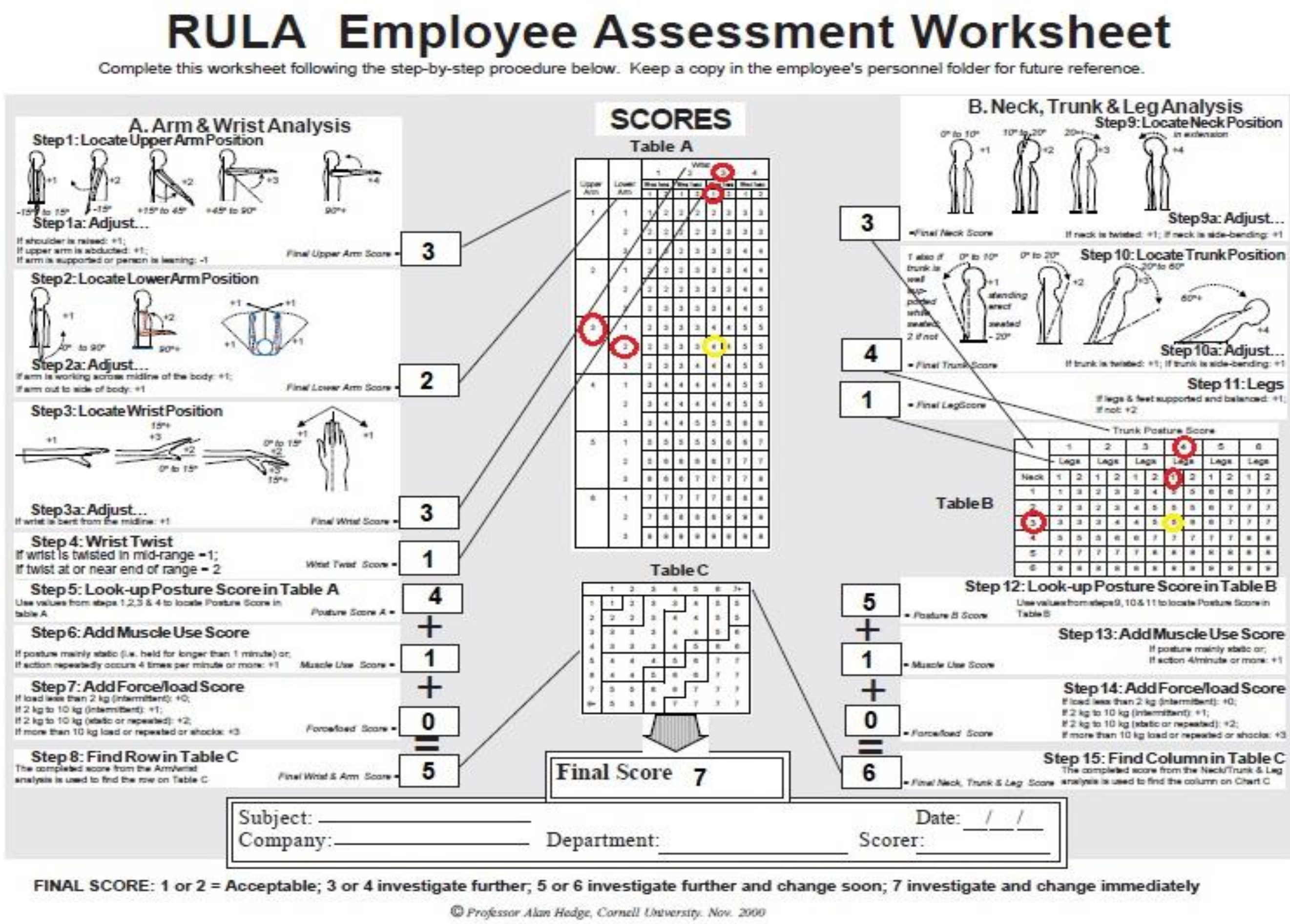
Three phases were considered during the study: the first consists in touring the facilities to visually detect the process operations that can lead to muscle fatigue or musculoskeletal injuries.

The second phase focused on making videos of operations of the watermelon cutting process.

The third phase is an analysis carried out by the video edition, where the evaluation is done through the RULA method, in which the injuries or illnesses during effort, are evaluated highlighting those activities that can impose excessive demands on the muscles and tendons, which are derived from three factors that the method considers: effort, duration and frequency.

4. RESULTS

We analyzed three operators corresponding to the male sex of 24 and 55 years of age, which have a working day of 4-8 hours (this is variable according to daily production), operators at the beginning of the day have no symptoms of pain or discomfort, at the end of the working day the first operator of 55 years at the end of the day shows discomfort in the head and middle back, as well as pain in the lower back, the second operator of 45 years at the end of the day shows the high pain rates in the shoulder, middle back and lower back, which has repercussions for your health. The third operator of 19 years at the end of the day shows high rates of pain in the middle shoulder and low sword.



5. DISCUSSION/CONCLUSIONS

A sketch of the ergonomic conditions presented by the watermelon cutting process of the ITSG experimental field is presented. In this investigation 3 postures not suitable for the operations of the cutting process were detected. At the end of the day a survey was applied to the workers about the working conditions. He was asked the parts of the body that increased discomfort or pain generated his work activity, 100% of workers said they present discomfort in the neck, shoulders, middle and lower back, as well as a bit of fatigue when performing tasks.

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ERGONOMIC ANALYSIS OF THE PROCESS OF ELABORATION OF BREAD, IN GUAMÚCHIL SINALOA, TO IDENTIFY CUMULATIVE TRAUMA DISORDER IN WORKERS

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Resumen: El presente proyecto de investigación se llevó a cabo en una empresa dedicada a la elaboración de pan en la ciudad de Guamúchil Sinaloa. Las operaciones del área de producción se analizaron para identificar los trastornos traumáticos acumulativos que los trabajadores presentan al realizar las operaciones correspondientes. El análisis consiste en la detección de las condiciones físicas de trabajo y el cumplimiento de los principios ergonómicos, así como la aplicación de métodos de evaluación ergonómicos en las diferentes estaciones de trabajo. Ya que hay problemas de tiempo de inactividad, rotación de personal y problemas de manejo manual de materiales.

Palabras clave: Análisis ergonómico, DTA, Método Rula.

Contribución a la Ergonomia: La ergonomía es una parte fundamental para la elaboración de esta investigación, ya que con las técnicas de prevención de riesgos laborales, se evitan y resuelven los problemas de traumas acumulativos en los trabajadores

Summary: The present research project was carried out in a company dedicated to making bread in the City of Guamúchil Sinaloa. The operations of the production area were analyzed to identify the cumulative trauma disorders that workers present when performing the corresponding operations. The analysis consists of the detection of the physical conditions of work and compliance with ergonomic principles as well as the application of ergonomic evaluation methods in the different work stations. Since there are problems of downtime, staff turnover and problems of manual handling of materials.

Keywords: Ergonomic analysis, DTA, Rula Method.

Contribution to Ergonomics: Ergonomics is a fundamental part for the elaboration of this research since with prevention techniques of occupational risks, problems of cumulative trauma disorder in workers are prevented and solved.

1. INTRODUCTION

Ergonomics is the discipline that studies how people, machines and the environment communicate with each other, acting with each other or some of its elements, to optimize the criteria of efficacy, safety, comfort and satisfaction, according to Pereda (1993). In the city of Guamúchil, Sinaloa, there are companies dedicated to the production of bread generating tasks developed with health risks and a high level of workload in non-neutral positions, such as inclined, arms in incorrect positions, movement of materials without protection with inadequate loads, with this research we sought to analyze the operations, processes and working conditions in the elaboration of bread to detect cumulative trauma disorders to the workers and give them a solution to it.

I n Mexico, the number of risks and injuries has increased in the production sector in companies where bread production is carried out. Among the most outstanding activities are the high loads in wineries or warehouses and inappropriate positions in areas of production or maldistribution of production area, presenting labor problems in the process and muscle injuries in the operator and low productivity. According to data from the Mexican Social Security Institute (2017), 5579 cases were registered due to occupational hazards in bread production, which leads to subsidizing 161,791 days of disability per year. They perform various activities in the process adding work hours of 8 to 10 hours a day under inadequate working conditions, causing cumulative trauma disorder and thermal stress, which damages the physical condition of the worker day by day. To date there are no ergonomic studies in the country of the process of making bread, which provides a proposal to improve work and increase productivity but above all the quality of life of the worker.

2. GOALS

Ergonomic analysis of the bread making process, in Guamúchil Sinaloa, to identify cumulative trauma disorder in workers.

Specific objectives

• Perform the current diagnosis of the work stations.

• Identify Mexican Official Standards, ergonomic principles, and safety conditions that apply to work stations.

• Apply ergonomic assessment methods to identify cumulative trauma disorders.

3.METHOD

The structure of the guiding research of this project is established in three stages, which was carried out in 12 weeks:

The first consists in making a current diagnosis of the work stations of the company, where the workers and their physical characteristics are identified: sex, height, age, identify the work areas and the people who work in each one of them, as well as make the diagrams of operations, identification of days and products to be prepared.

In the second part, the Official Mexican Standards, ergonomic principles, and safety conditions that apply to the work stations were identified, to validate whether or not it complies with the regulations.

The third part of the project is to apply ergonomic evaluation methods Rula Method, Corlett & Bishop Method, to detect cumulative trauma disorders.

4.RESULTS

The research was applied in the bakery company dividing into two areas: production area and decoration area. Applying the following tools: General questionnaire, Identification of Mexican official standards, ergonomic principles, RULA method and Corlett Bishop Method.

In the research project, since missing ergonomic mats in all areas of production and decoration of cakes were found, it is suggested the rearrangement of machinery and transport carts of loaves so that employees have better fluidity when transporting material from one area to another. A cumulative trauma disorder was identified in workers at two workstations: low back, high back and shoulders, legs and arms.

Production area

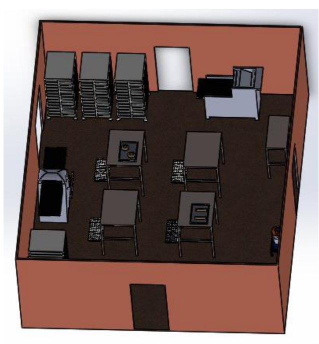


Figure 1. Production area.

Figure 2. Production area

Work stress test

Figura 3. Work stress table

Without Stress (26)	You are in alarm phase, try to identify the factor or factors that cause you stress to be able to take care of them in a preventive way.

Table 1. Official Mexican Standards.

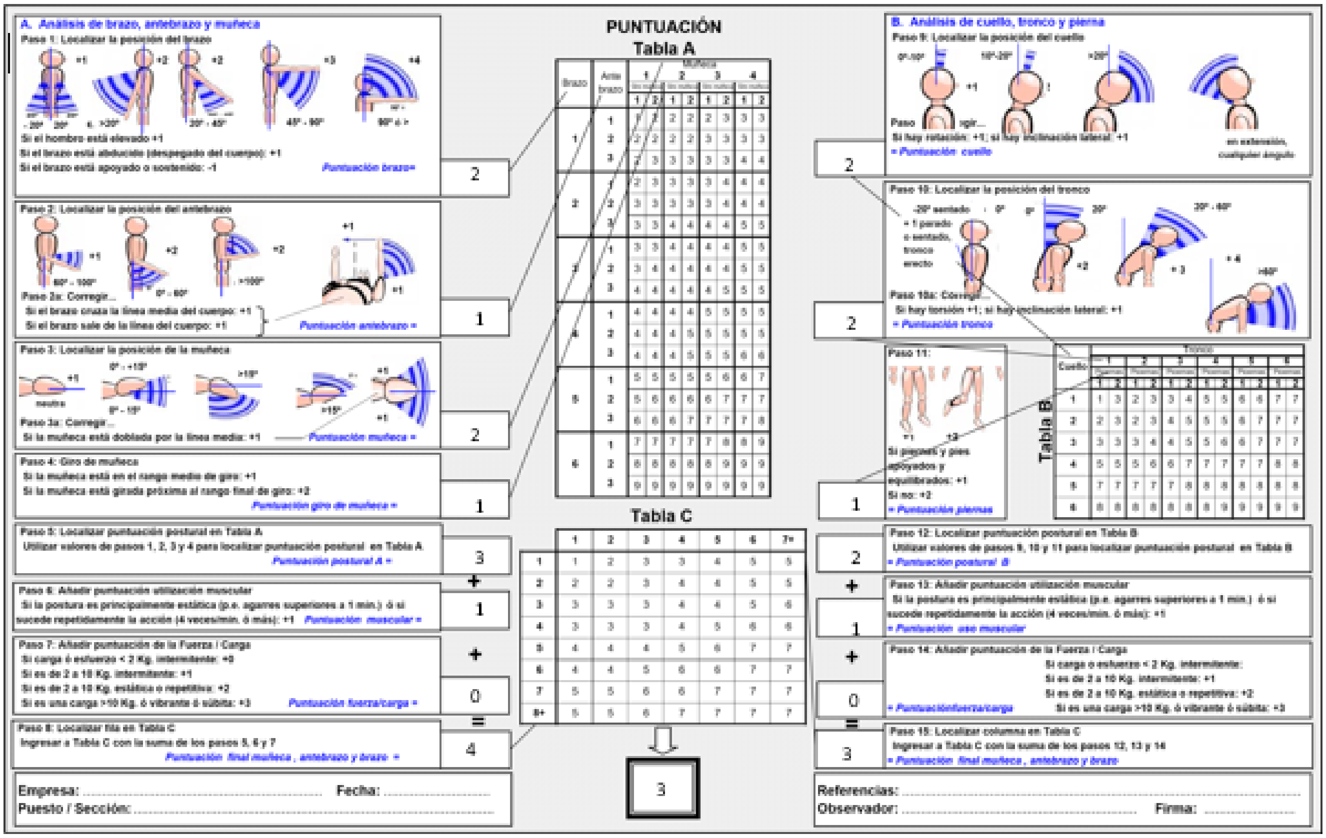
Official Mexican standards

Physicals conditions	**Rules**	**Points to consider**
Illumination	NOM-025-STPS-2008	In the company if the standard NOM-025-STPS-2008 is complied with, considering that it is a closed area for which it is necessary to have controlled lighting to carry out an adequate job, which is why a level of 200 luxes is required for more work precise and detailed using laboratory equipment, as well to be able to move comfortably or give necessary movement to any material with which you are working with. The lighting is measured with the luxometer..
Noice	NOM-011-STPS-2011	The norm NOM-011-STPS-2011 if it is fulfilled in the company in the bakery company since the noise is one of the factors that cause stress, headaches, and even if the noise is very strong the employee will be able to get sick and production will almost not yield.
Temperature	NOM-015-STPS-2001	In the bakery company; the norm NOM-015-STPS-2001 if it is fulfilled since it is of the utmost importance that the employees work in an environment where the temperature is regulated in such a way that it falls within the acceptable range of the individual, which if the employee is within a regulated or acceptable temperature up to help us maximize productivity
Humidity	NOM-116-SSA1-1994	The norm NOM-024-STPS-2001 does not comply with the bread company since it is an area where it is closed and the humidity can be transmitted through the natural air, which all areas of the bakery are closed areas which that have no entrance of open air.
Ventilation	NOM-016-STPS-1993	The norm NOM-016-STPS-1993 of the ventilation if it is fulfilled in the company, since the ventilation is of extreme importance in the employee to be in a pleasant atmosphere. Ventilation has two major requirements regarding the employee. • Provide the necessary oxygen for the maintenance of life. • To reduce the environmental contamination that exists within the company, such as body odors, excess heat, fumes, vapors, etc.
Vibration	NOM-024-STPS-2001	The standard NOM-024-STPS-2001 does not comply with the bread company since it is a bakery and the employee is not subjected to any area where there vibration. You are in alarm phase, try to identify the factor or factors that cause you stress to be able to take care of them in a preventive way.

Table 3. Ergonomic principles.
Ergonomic principles.

PRINCIPLES	APPLY YES/NO	AREA	OBSERVATIONS
Use the height of the elbow as a reference	NO	production	The tables do not have the proper height, the workers exert a force or pressure on the back. Use the height of the elbow as a reference that they lean to perform the operation, because the table is low.
Find the right position for each job	NO	production	In the operation of the blender machines do not have the right height for the employee, which has to strain your back to bend and lift.
Have spaces and access	No	Production and storage	The space is small and all the tools are very crowded, and even when you move the cart with the production you have to move some things so you can have a good time.
Improve work organization	NO	production	Because the company in the production area does not present organization in things and in the work area.

RULA method



PUNTUACIÓN FINAL: 1 ó 2: Aceptable; 3 ó 4: Ampliar el estudio; 5 ó 6: Ampliar el estudio y modificar pronto; 7: estudiar y modificar inmediatamente

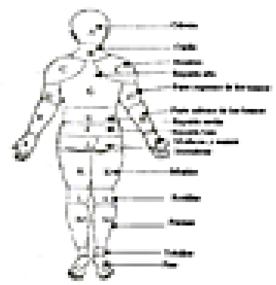
Figure 3. RULA method application

Método Corlett Bishop.

Mapa de molestias para las diferentes partes del cuerpo.

Marque con una cruz las partes del cuerpo donde sienta alguna molestia o dolor y numérelas en orden ascendente según su grado de molestia o dolor.

Vista de una persona de espalda



M=Molestia

D=Dolor

(Corlett & Bishop, 1976)

Observaciones:____

	ENTRADA							SALIDA						
A	D							D						
B	M							D						
C	M							M						
D	M							M						
E	m							M						
F	M							M						
G	M							M						
H	M							M						
I	M							M						
J	M							M						
K	M							M						
L	M							M						
M	M							D						
N	M							M						
O	D							D						

Figure 4. Work stress test results

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Labor fatigue

1. Name: José Martin López
2. Sex: Male
3. How many days a week do you work?

- 2-4 days
- 5-6 days
- 7 days

4. Do you study besides working?

- YES
- DO NOT

5. Do you feel tired when you work?

- YES
- DO NOT

6. How old are you?

28 years

7. Do you feel that you have become ill from overwork?

- YES
- DO NOT

8. What consequences do you think you have had due to work?

- Fatigue
- Work accidents
- Mental fatigue
- None of the above

9. How many hours do you work a day? 8 hours
10. What is your schedule? 6:30 a.m.-2: 30 p.m.
11. Are you fed to come to work?

- YES
- DO NOT

12. What means of transport do you use? Personal automobile
13. How long does it take to get to work? 15 minutes

5. CONCLUSIONS

Through the study, an outline of the ergonomic conditions was developed in a company of the Cd. De Guamúchil, Sin., Where many areas of opportunity were found within the company, mainly the production area, with non-compliance with the regulations of the STPS based on the physical conditions of the work stations. Through the methods of ergonomic evaluation, the disorders of cumulative trauma were identified.

Contribution to Ergonomics:
It is a proposal of ergonomic design for the improvement of working conditions and the detection of Cumulative Trauma Disorder in order to develop a proposal for the redesign of work stations.

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REDESIGN OF WORK STATIONS IN THE PROCESS OF ELABORATING BREAD TO REDUCE THE SKEPTICAL MUSCLE INJURY OF THE WORKERS

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Resumen: La empresa panadera, en la ciudad de Guasave Sinaloa, se basa en métodos ergonómicos para rediseñar el área de producción con base a los resultados del análisis elaborado, de ésta manera se le brinda al trabajador una buena estación de trabajo, evitando o disminuyendo lesiones músculo esqueléticas. Se analizan las actividades de manipulación de carga, movimientos repetitivos dentro del proceso, posturas que fueron analizadas mediante los métodos; Rapid Entire Body Assessment (REBA), Corlett and Bishop, Fatiga Laboral, Normas oficiales mexicanas, determinando como aplicar cada una de éstas NOM´S, para contribuir al productividad y seguridad en la empresa y los trabajadores. Diariamente los trabajadores realizan cargas de 40 kilogramos cinco veces al día, desde almacén hasta la mezcladora,con una distancia de 6 metros aprox. Mediante el estudio de la ''NOM-006-STPS-2014, manejo y almacenamiento de materiales, "Condiciones de Seguridad y Salud en el trabajo'' se establece que el peso máximo recomendado es de 25 kilogramos cuando la actividad se repite varias veces por el mismo operario, asimismo, cuando la actividad es elaborada por trabajadores entrenados y con un rango de edad aceptable, la carga tolerada aumenta a 40 kilogramos. Sin embargo, se detectaron errores en la forma de agarre debido a la obstrucción de objetos en almacén por el mal acomodo de los materiales; enfocándose específicamente al agarre, éste resultaba erróneo por la mala posición que el trabajador adoptaba, debido a que los costales se encuentran a una altura muy baja respecto al suelo.

Se propuso reacomodar el almacén, clasificando los materiales por prioridad. Como lo disponen en los principios ergonómicos, todo espacio laboral donde se utilicen mesas de trabajo, éstas deben de estar a la altura del codo del trabajador. Por la actividad que se realiza en el establecimiento, y porque es un procedimiento artesanal, no se aplica el principio ergonómico, por motivo de operación de amasado los trabajadores necesitan apoyar su cuerpo contra la masa. Los trabajadores no presentan desorden de trauma acumulativo (DTA), sin embargo, muestran molestias en pies muñecas.

Palabras clave: Lesiones musculo esqueléticas, Método REBA, Análisis ergonómicos.

Relevancia para la ergonomía: Es una propuesta de diseño ergonómico para la mejora de condiciones de trabajo. Reduciendo las Lesiones Musculo esqueléticas y la detección de Desorden de Trauma Acumulativo.

Abstract: The bakery company, in the city of Guasave Sinaloa, is based on ergonomic methods to redesign the production area based on the results of the analysis, in this way the worker is given a good workstation, avoiding or reducing muscle injuries. skeletal The cargo handling activities are analyzed, repetitive movements within the process, postures that were analyzed by the methods; Rapid Entire Body Assessment (REBA), Corlett and Bishop, Labor Fatigue, Official Mexican Standards, determining how to apply each of these NOM'S, to contribute to productivity and safety in the company and workers. Every day, workers carry loads of 40 kilograms five times a day, from storage to the mixer, with a distance of 6 meters approx. By studying the " NOM-006-STPS-2014, handling and storage of materials, "Health and Safety at Work Conditions " states that the maximum recommended weight is 25 kilograms when the activity is repeated several times by the same operator, also, when the activity is elaborated by trained workers and with an acceptable age range, the tolerated load increases to 40 kilograms. However, errors were detected in the grip due to the obstruction of objects in storage due to the poor arrangement of the materials; Focusing specifically on the grip, this was wrong because of the bad position that the worker adopted, because the sacks are at a very low height from the ground.

It was proposed to rearrange the warehouse, classifying the materials by priority. As they have in the ergonomic principles, any work space where work tables are used, these must be at the elbow of the worker. Due to the activity carried out in the establishment, and because it is an artisanal procedure, the ergonomic principle is not applied, because of the kneading operation the workers need to support their body against the mass. Workers do not exhibit cumulative trauma disorder (DTA), however, they show discomfort in doll feet.

Keywords: Musculoskeletal injuries, REBA method, ergonomic analysis

Relevance to Ergonomics: It is a proposal of ergonomic design for the improvement of working conditions. Reducing Musculoskeletal Injuries and the Detection of Cumulative Trauma Disorder.

1. INTRODUCTION

Ergonomics is the field of multidisciplinary knowledge that studies the characteristics, needs, abilities and abilities of human beings, analyzing those aspects that affect the design of products or production processes (Ergonomics, 2019). It seeks to maximize safety, efficiency and comfort by coupling the operator's demands, their capabilities (Oborne, 2012). Bakeries are a part of the labor sector, whose trade is almost as active as the human being and still have not lost importance in the market, since it unites families and Mexican society (Riva, s.f.). Throughout time, greater importance has been given to the prevention of accidents and illnesses that are associated with work, through the implementation of laws and institutions focused on the improvement of working environment conditions. There are standards focused on workers such as those imposed by the Ministry of Labor and Social Welfare, which are responsible for the regulation and administration of labor relations.

In this company dedicated to the preparation of bread, in the city of Guasave Sinaloa, we analyzed how is the production process and the physical conditions in which the establishment is located. In this way, a redesign was specifically proposed in the production area due to the non-compliance with the safety standards in the design of the facilities, which caused slight musculoskeletal injuries in the company's workers, based on what is established by regulation 001 STPS and chapters 7 and 9 of Fred. E Meyers.

In Mexico, the number of occupational risks and injuries has increased in workers in the area of food preparation. According to data from the Mexican Social Security Institute (2017), in Sinaloa a total of 521,137 cases of workers at work risk and 593 cases of work accidents in kitchens such as; sprains, tears and work fatigue, caused by poor posture in your work station, as well as the lack of safety and health equipment necessary to carry out the relevant operations in production. Which causes musculoskeletal injuries damaging the physical conditions of the worker. There are few ergonomic studies conducted on this problem which can contribute to the improvement of productivity and quality of life of workers in the bakery industry in the state of Sinaloa.

2. OBJECTIVE

Redesign the work stations in the bread making process to reduce the musculoskeletal injuries of the workers.

3. METHODOLOGY

The research structure of this project is established in 5 stages:

1.- Carry out a diagnosis through journeys to identify the current situation of the work stations of the company. Figure 1 shows how the workstation is located in the production area.

2.- Documentary research of the Official Mexican Standards of the STPS that mark the physical conditions of the work stations.

3.- Application of ergonomic principles in work stations to determine the key needs for design proposal.

4.- Application of ergonomic evaluation methods such as: REBA method, Corlett & Bishop method to identify musculoskeletal injuries.

5.- Proposal to redesign work stations to reduce the number of musculoskeletal injuries and problems.

4. RESULTS

In the analysis carried out in the company several areas of opportunity were obtained such as not having spaces and access, the uncomfortable environment within the company, lack of posters and controls to differentiate and identify the different areas, ergonomic mats. Application of the Official Mexican Standards as, NOM-002-STPS-2010 Safety Conditions- Prevention against fires in the work centers, NOM-006-STPS-2014 Handling and storage of materials, NOM-016-STPS-2010 Concerning ventilation.

Figure 1. Workstation

The NOM-002-STPS-2010 Safety Conditions-Prevention and protection against fires in the workplace, was vital since there is only one extinguisher in the production area. It does not count on security signals, from evacuation route, danger in electric zones and extinguishers, contingency plans and simulations. It is recommended to add an extinguisher in the sales area. Include signs of evacuation route, electrical danger and fire extinguishers. The workers carry loads of 40 kilograms 5 times a day, from warehouse to the mixer, with a distance of 6 meters.

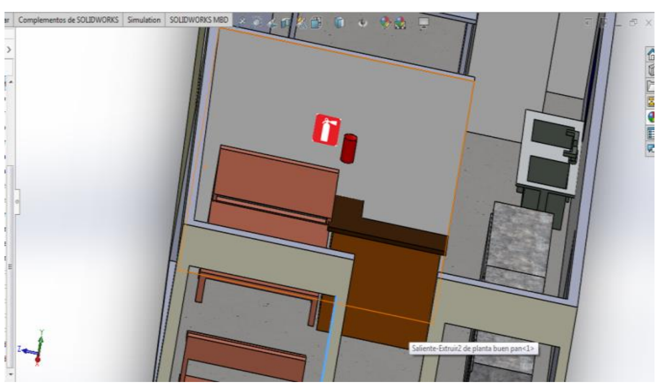

Figure 2. Fire extinguisher proposa

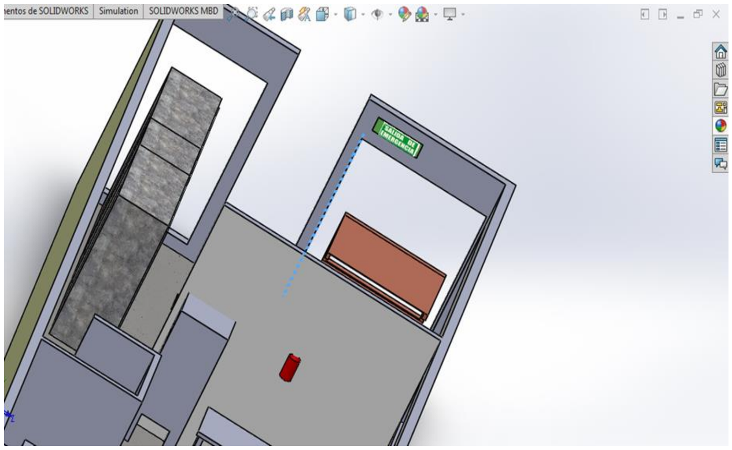

Figure 3. Evacuation route proposal

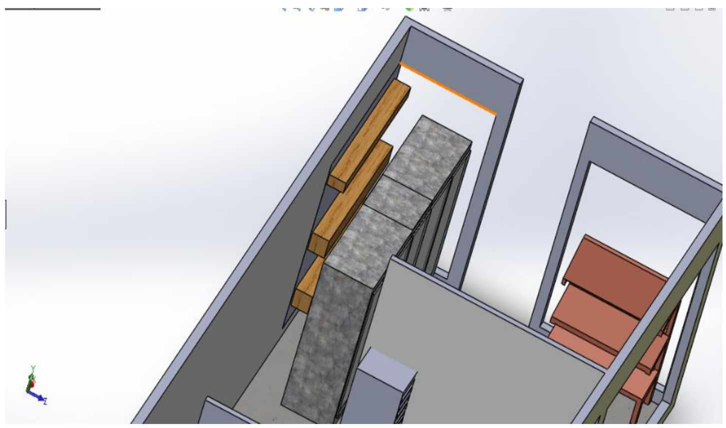

Figure 4. Warehouse proposal

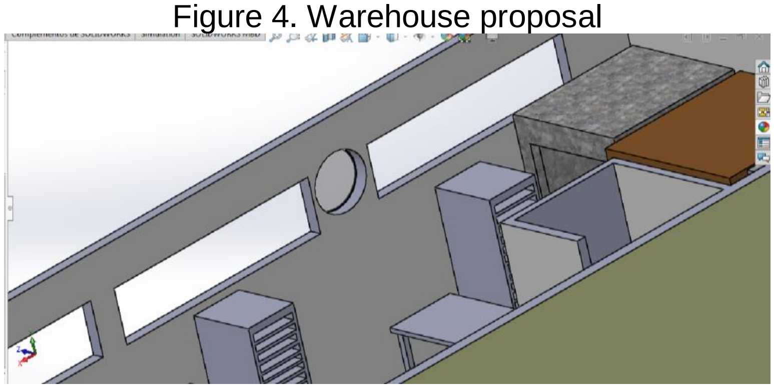

Figure 5. Ventilation proposal

The NOM-006-STPS-2014, Management and storage of materials states that the maximum recommended weight is 25 kilograms when the activity is repeated several times by the same operator. Likewise, the activity is elaborated by workers with an age range of 21 to 45 years, the tolerated load increases to 40 kilograms. However, errors were detected in the way the cargo was gripped due to the obstruction of objects in the corridors due to poor organization of materials inside the warehouse; because of the bad position adopted by the worker, because the sacks are at a very low height stuck to the ground.

The ergonomic evaluation methods (REBA and Corlett and Bishop) were applied. The REBA method registers a score of 9, indicating that a change to the work station is required soon.

The Corlett and Bishop method was applied. The discomfort that occurs in workers is in the neck, shoulders, middle back, feet and wrists and hands. Of the 5 work stations 2 production stations (bread making) have skeletal muscle injuries due to the long standing time, the workers that present these injuries are 5 that are in those areas of a total of 11 workers that work in the company. As well as inappropriate positions were identified within the production process. This served to make a proposal for the redesign of work stations.

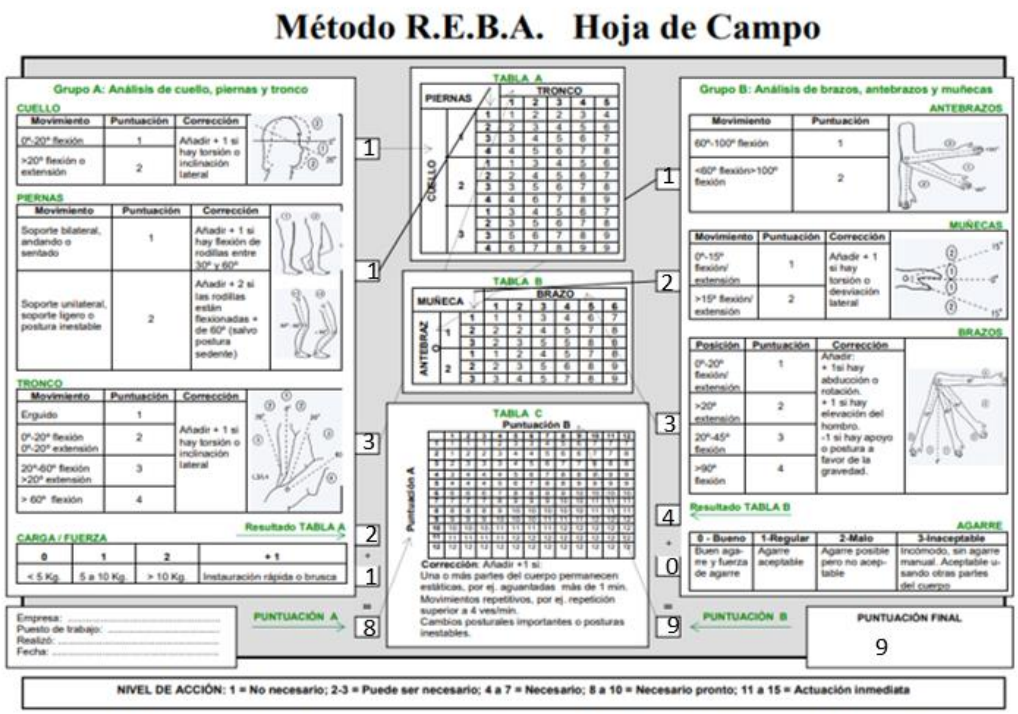

Figure 6. Ergonomic evaluation method REBA

5. DISCUSSION/CONCLUSIONS

Through the study, many areas of opportunity were identified within the company, mainly the production area, where non-compliance with the regulations of the STPS was detected based on the physical conditions of the work stations, as well as the non-compliance of some ergonomic principles. The lack of spaces in the corridors and the storage of materials, lack of posters, use of protection and ergonomic mats. Through the methods of ergonomic evaluation, slight musculoskeletal injuries were detected and the key needs for the redesign of work stations were identified. Presenting to the company a redesign proposal to meet all needs that were registered.

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Assessment of the Performance of Work Activities.

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Resumen. Las molestias en manos y muñecas han sido una de las quejas más constantes entre las personas que laboran tecleando en computadoras, debido a que este es un trabajo estático y repetitivo que afecta a los miembros superiores del cuerpo por el trabajo prolongado. Por esta razón se pretende llevar a cabo un estudio para reducir los riesgos ergonómicos para los trabajadores. La investigación tiene como objetivo determinar el desempeño de trabajadores al hacer uso como herramienta de apoyo la computadora, analizando su rendimiento en base a sus medidas antropométricas y comprobar la posición óptima para el teclado.
El trabajo realizado en oficinas se estima que puede ser evaluado en base a las medidas antropométricas de las personas en relación con su desempeño durante una actividad manual. Actividades comunes como la captura de información en una computadora, puede servir como parámetro para evaluar una función cotidiana en base a las medidas corporales de las personas.

Palabras clave: Desempeño profesional, variables antropométricas, valoración de colocación de manos.

Abstract. The discomfort in hands and wrists have been one of the most constant complaints among people who work typing on computers, because this is a static and repetitive work that affects the upper limbs of the body for prolonged work. For this reason it is intended to carry out a study to reduce ergonomic risks for workers. The objective of the research is to determine the performance of workers when using the computer as a support tool, analyzing their performance based on their anthropometric measurements and checking the optimal position for the keyboard.

The work done in offices is estimated that can be evaluated based on the anthropometric measures of people in relation to their performance during a manual activity. Common activities such as the capture of information in a computer, can serve as a parameter to evaluate a daily function based on the body measurements of people.

Key words: Professional performance, anthropometric variables, assessment of hand placement.

1 INTRODUCTION.

In the work done in offices, employees are exposed to a high ergonomic risk to their health. When sitting for a long time in front of the computer they can acquire skeletal muscle disorders caused by repetitive stress (Poochada and Chaiklieng, 2015). This results in a large and unnecessary expense for the company because it is forced to pay medical expenses and compensation to employees (Fagan and Hodgson, 2017). That is why it is important to implement a project that helps reduce the risks of employees acquiring injuries. You should also train the staff on the correct way to use your work equipment so that they are aware of the injuries they can get.

2 OBJECTIVES

The objective of this study is to measure the effect of posture on the wrist and forearm when using a computer keyboard and how anthropometric factors can influence its performance.

3 Limitations

The study will only represent people without previous muscular disorders, therefore the risks that the work entails for workers with previous illnesses or injuries cannot be defined. In addition, it is possible that the results do not completely coincide with previous studies due to the conditions of the volunteers when performing the test and this only covers the basic positions of the wrist when using the keyboard.

4 METHODOLOGY

The study will be carried out with a group of 12 student volunteers from the Technological Institute of Hermosillo. They take their anthropometric measurements. There are three sessions in which the volunteers will write a text on the computer during a period of 30 minutes during three non-consecutive days. The experiment is going to be done in this way so that the volunteers have a rest and that this can show in a more precise way the productivity that they had with each one of the positions that are used with the wrist when using the keyboard.

Each participant must carry his / her personal computer to perform the experiment, the first day the neutral posture is used, two days after the experiment with flexed posture, this with a backrest that has been placed under the computer to achieve a 30 degree angle . The same will be done for the extended posture, only that the backrest was placed on the opposite side of the computer to achieve the desired inclination.

Three wrist postures are used: neutral, flexed and extended. The work done in the three positions is compared according to their anthropometric measurements and is described with a regression model.

5 Results

A linear regression model is used in each of the positions of the experiment. For the neutral, flexed and extended positions, the following factors are taken into account which directly determine the performance of the participants: weight, left hand thickness, right and left long hand, long left middle finger, left thumb length, width of the thumb left, right and left wrist width and right shoulder-elbow length as shown in figures 1, 2 and 3:

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3.18938	100.00%	99.96%	83.95%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	3721.4	46.1	80.74	0.008	
Weight (Kg)	0.859	0.328	2.62	0.232	18.82
Hand thickness LH	678.6	14.3	47.52	0.013	32.21
Long hand RH	-587.2	14.0	-42.00	0.015	276.97
Long hand LH	216.3	15.4	14.06	0.045	385.03
Long middle finger LH	220.3	11.2	19.76	0.032	67.59
Thumb length LH	13.73	3.12	4.39	0.142	18.72
Thumb width LH	300.52	9.11	32.99	0.019	5.62
Wrist width RH	-228.4	27.9	-8.20	0.077	302.18
Wrist width LH	-314.3	33.5	-9.37	0.068	359.43

Figure 1: Neutral position analysis.

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.17517	100.00%	100.00%	99.64%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	2409.04	9.78	246.22	0.003	
Weight (Kg)	4.838	0.129	37.60	0.017	21.36
Hand thickness LH	1687.0	11.0	152.77	0.004	141.86
Long middle finger LH	-572.09	3.27	-174.93	0.004	42.82
Hand width LH	275.66	5.50	50.12	0.013	105.95
Thumb width LH	-279.77	6.75	-41.47	0.015	22.71
Width middle finger RH	1881.6	15.6	120.88	0.005	109.22

Width middle finger LH	-1976.9	14.1	-140.15	0.005	115.62
Wrist width LH	-1151.28	9.39	-122.65	0.005	207.34
Arm-back length RH	17.75	1.11	16.02	0.040	812.69
Arm-back length LH	10.08	1.02	9.93	0.064	640.40

Figure 2: Flexed position analysis.

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.715951	100.00%	100.00%	99.74%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	4054.42	6.55	619.17	0.001	
Weight (Kg)	1.4477	0.0707	20.47	0.031	17.37
Long middle finger RH	-68.68	1.26	-54.48	0.012	13.45
Thumb length LH	-149.494	0.602	-248.41	0.003	13.78
Thumb width LH	216.98	1.38	157.34	0.004	2.56
Wrist width RH	62.99	6.09	10.34	0.061	286.39
Wrist width LH	-141.24	9.22	-15.31	0.042	539.49
Wrist thickness RH	473.19	2.88	164.03	0.004	24.62
Arm length RH	87.436	0.292	298.94	0.002	92.09
Arm length LH	-192.909	0.330	-583.94	0.001	122.32
Arm-back length LH	55.690	0.161	346.44	0.002	43.27

Figure 3: Extended position analysis.

6 CONCLUSIONS

When carrying out the forward linear regression analysis applied with the anthropometric data, we obtain a prediction of more than 90% in each position. Therefore, it can be concluded that anthropometric measurements can directly determine a person's performance in computer work.

Although the extended position shows a better performance, it may not be the most convenient to use it due to the discomfort and fatigue that people might have. The analysis of fatigue is planned to be determined in a future thesis study.

The results of this document can be very useful when applying them in the office work industry, with this you can determine the performance of the workers based on their anthropometric measurements and know if they may have a musculoskeletal disorder. It is still necessary to determine the fatigue that each one of the positions can have in the person, which possibly requires another thesis study. The present, for the moment only results in the performance of volunteers based on their measurements.

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PROPOSAL OF A GUIDE TO SELECT METHODS OF ERGONOMIC ASSESSMENT FOR REPETITIVE WORK IN THE MANUFACTURING INDUSTRY IN MEXICO

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Resumen. Este documento presenta la situación particular de la industria manufacturera en México, un sector de la economía que proporciona cifras importantes para la economía y que genera un número importante de empleos, y la relevancia de la ergonomía en la atención médica de los trabajadores, en particular los trastornos musculoesqueléticos laborales. En los últimos años ha habido un aumento en el número de estos casos. Además, las nuevas regulaciones legales que requieren que las compañías identifiquen y evalúen los Factores de Riesgo de Ergonomía y es necesario tomar medidas para minimizar el riesgo de exposición a un desorden musculoesqueletico. Este articulo presenta una revisión de los factores de riesgo ergonómico y los desórdenes musculoesqueletico descritos en la literatura, así como la propuesta de una guía metodológica para seleccionar los Métodos de Evaluación Ergonómicos (MEE) con mayor aplicación para la industria manufacturera, distinguiendo dos actividades principales; Trabajo repetitivo y manejo manual de cargas. Para cada uno de estos, se sugieren los MEE con la aplicación más simple en dos niveles; El MEE recomendado y en un segundo nivel los MEE alternativos para complementar la evaluación. La guía se presenta gráficamente y se proporciona una breve descripción de cada método y su referencia científica.

Palabras clave: Trabajo, Trastornos musculoesqueléticos, Factores de riesgo Ergonomicos, Métodos de evaluación ergonómica

Abstract. This paper presents the particular situation on the manufacturing industry in Mexico, a sector of the economy that provides important figures for the economy and that generates an important number of jobs, and the relevance of ergonomics in the health care of workers, in particular the Work Muscle Skeletal Dísorders (WMSD). In recent years there has been an increase in the number these cases. In addition, the new legal regulations that require companies to identify and evaluate Ergonomics Risk Factors (ERF) have taken effect and it is needed take actions to minimize the risk of exposure to a WMSD. The paper presents a review of the ERF and the WMSD described in the literature as well as the proposal of a methodological guide to select the Ergonomic Assessment Methods (EAM) with greater application for the manufacturing industry, distinguishing two main activities; repetitive work and manual handling of loads. For each of these, the EAMs with the simplest application in two levels are suggested; the recommended EAM and at a second level the alternative EAMs to complement the evaluation. The guide is presented graphically and a brief description of each method and its scientific reference is provided.

Keywords: Work Muscle Skeletal Disorders · Ergonomics Risk Factors
Ergonomic Assessment Methods

1 INTRODUCTION

Work has been a means for society to access certain levels of well-being. The industry and in particular the manufacturing industry in Mexico are of great importance for the economy of the country, it is estimated that 1.5 of the gross domestic product (GDP) is generated due to this industry (Instituto Nacional de Geografia, 2017). In this sector of the economy, the automotive industry (AI) is of great importance, according to the Mexican Association of the Automotive Industry ((AMIA), 2017), the country is the seventh producer of automobiles worldwide and generates more than seven hundred thousand jobs; At an international level, according to the International Organization of Automobile Manufacturers (The International Organitation of Motor Vehicle Manufacturs (OICA), 2017). In addition to the AI, there are other types of industries that make an important contribution to the economy. In the Sector Diagnosis (Promexico Diagnostico Sectorial, 2018), the country is highlighted as the main exporter of flat screen televisions and the fourth exporter of computers and microphones and loudspeakers, just to name a few.

Continuous improvement and make more profitable production systems has increasing production rates associated with the needs of optimize the process, even human resources, could lead to the intensification of work, in several surveys it is perceived and reported by workers, in the United States, a study on working conditions (Maestas, Powell, & Wenger, 2018), 40% of respondents answered that at least half of the work schedule, they performed activities with demand for an accelerated work rhythm and with the pressure of time to complete their activity. In Spain, in a similar study (Pinila, Almodovar, Galiana, Hervas, & Zimmerman, 2018), it was found that 33% of workers must work always or almost always at high speed and 35% must meet tight deadlines with the same frequency. In Europe, the percentage in general reported by the workers coincides (Parent-Thirion, et al.), and they mention as the index of labor intensification the combination, among others, of the following indicators; working at speed and to tight deadlines and not having enough time to do the job. The demand for production of goods and the demands of the speed up of work and the deadlines to comply with the work may be related to the presence of Work-Related Musculoskeletal Disorders (WMDs).

It is important to mention that in Mexico, the federal authority on occupational health makes it mandatory to identify the worker's exposure to WMSD risks and to carry out control actions to mitigate that risk.

2 WORK-RELATED MUSCULOSKELETAL DISORDERS (WMSD)

According to the information of the International Labor Organization (International Labour Organization, 2017), work-related musculoskeletal disorders (WMSD) continue being a global concern, mentioning that the cost of work-related diseases in the European Union it is estimated at least on 150 billion euros per year, in France, the government estimates a cost between 1.3 and 1.9 billion euros per year, in Korea, the WMSD represent .7% of GDP. In England, the Health and Safety Executive (HSE, 2017), estimates 8.9 million lost days at work due to WMSD.

In Mexico, according to data from the Mexican Institute of Social Security (INSTITUTO MEXICANO DEL SEGURO SOCIAL, 2017), an institution that registers and attends to health at work, reports an annual increase in WMSD greater than 20%, in 2016, 4,607 WMSD were reported. As a consequence of industrial economic activity, it can be assumed that the number of cases diagnosed as WMSD has gradually increased. It is estimated that the loss of work days caused by the WMSD is approximately 120 days, considering the reported cases can be estimated than an amount greater than 550 thousand days lost per year. The results show in general the women most susceptible to suffer some MSDS, being more evident the difference in Carpal Tunnel Syndrome, De Quervain's Tenosynovitis, while in men the Dorsopathies and Arthrosis are more recurrent. In the affectation by gender, WMSD on distal upper extremities affects more to women while in men, the affection is in the lower back. WMSD are considered occupational diseases, and they occur when the worker is exposed to certain occupational risk factors.

3 THE RISK FACTORS ASSOCIATED WITH THE MSDS

Risk factors associated with MSDs, are also known as ergonomic risk factors (ERF), although some inaccuracy in the term can be highlighted, it is common that this expression is used, they are varied and the studies mention the combination of these as the most likely cause of a MSDs.

Simoneau et al. (Simoneau, St-Vincent, & Chicoine, 2017), describe as modulators ERF; the intensity effort, frequency and repetition of awkward postures and, time of the sustained efforts when a work activity is developed, as risk enhancers to develop a MSDs. The following are recognized as some of the ERF at work related MSDs:

- The forced postures;
- Effort and strength;
- The repetition and invariability of the work;
- Static muscle work;
- Exposure to certain physical aggressors such as vibration;
- Organizational factors such as the pace of work and recovery times.

Additionally, they can be considered as ERF unrelated to work;

- Age;
- Unpaid work;
- Extra work regularly in informality;

• The propensity to degenerative diseases;
• Recreational activities such as sports.

The repetitive work is still present as an activity of workers today, it could be assumed that in XXI Century, working conditions should have improved by attenuating the ERF in the design of work, however data show another reality; in countries with more advanced economies, repetitive work prevails and occupies a preponderant place in the perception of workers; Maestas et al. (Maestas, Powell, & Wenger, 2018), presents the results of the survey on working conditions in America 2015, and highlights the opinion of 74.8% of respondents where repetitive work is mentioned, Pinillas et al. (Pinila, Almodovar, Galiana, Hervas, & Zimmerman, 2018), with data from 2015, found that 73% of workers in industries mentioned doing repetitive work. 63% of the workers who answered the European survey on working conditions, on Parent-Thirion (Parent-Thirion, y otros, 2018), is mentioned that doing repetitive work is at least 25% of the working day.

Static muscle work is also considered a risk factor, it is described as a dangerous posture held for a certain time, usually in seconds, and it limits the flow of blood to the shoulder muscle group accelerating the presence of local muscle fatigue. In Kodak (Changalur, Rodgers, & Bernard, 2003), it is recommended to perform ergonomic research when a sustained effort in the shoulder exceeds 5 s in duration.

Simoneau et al. (Simoneau, St-Vincent, & Chicoine, 2017) mention vibration and contacts with surfaces or objects as potential ERF, Bernard (Bernard, 1997), also refers to vibration as a risk factor to WMSD in the lower back. Organizational factors such as the relationship between workload and recovery time or factors such as the hurry to comply with a work objective or the work schedule or rhythm, recently have appeared as potential ERF.

Few evidence was found on the WMSD relationship with the permanence of a work activity, in the document of the Health Council of the Netherlands (Netherlands., 2017), it is mentioned that Carpal Tunnel Syndrome is present in workers with more than 20 years of seniority in a job, it also refers to the effects of lateral epicondylitis in women when they perform the same activity more than 75% of the working day.

Repetitive work is a basic activity of work and a risk factor in combination with other ERF, the other activity of equal importance in the analysis of work is the manual handling of loads (MMH) and the ERF associated with greater recurrence are the awkward postures and the efforts or application of force to mobilize some type of load causing potential affectations in the lower back.

In Colombini et al. (Colombini, Occhipinti, Alvarez-Casado, & Waters, 2013), there are distinguish three types of sub-activities in the MMH :

• Lifting or lowering objects weighing more than 3 kg.
• Carrying a load and
• Push or pull a load.

In the survey on working conditions in America 2015, Maestas et al. (Maestas, Powell, & Wenger, 2018), 45.1% of the respondents mention that they carry heavy loads as part of their work. In Pinillas et al. (Pinila, Almodovar, Galiana, Hervas, & Zimmerman, 2018), they found that 44% of workers in industries mentioned carrying or moving heavy loads. Meanwhile, 34% of workers who responded to the European survey on working conditions, Parent-Thirion (Parent-Thirion, y otros, 2018), mentioned moving or moving loads at least 25% of the working day. Even when mechanized technology is available for cargo handling, it is still a relevant percentage of workers who perform this activity.

4 THE PROCESS OF IDENTIfiCATION AND EVALUATION OF THE ERF

The intervention process of occupational ergonomics includes identification and assessment of the risk of a TME due to work, usually the evaluation is done through some ergonomic assessment method (EAM). A wide variety of ergonomic assessment methods are available, however, there is no method that includes all the risk factors according to the main work activities.

In the previous paragraphs, the definitions were mentioned and the importance of the main work activities in the industry was highlighted; repetitive work and manual handling of loads. The prevalence of MSD related to these work activities is highlighted.

Identification of the ERF, and the measures, control and mitigation of the ergonomic risk must be part of the process of occupational ergonomics, that is to say, it does not have an end in function of time, it must be constant in the workplace.

Some considerations should be made prior to the ergonomic process; It is advisable to start from the identification of the ERF in the workstations, this entails the knowl-edge of the ERF. It is useful to develop a checklist that includes all the potential ERF, it is also pertinent to consider the information coming from the medical services regarding the consultations related to the symptoms of the MSDs and to follow up the cases that have been diagnosed with. It is advisable to make notes and record the entire initial state of the ergonomic process on an electronic sheet, highlighting the jobs that are considered for the evaluation process with ergonomic methods.

It is necessary to ensure, at the time of performing the ergonomic assessment, that the incorrect work practices should not be evaluated, as well as making sure that the approved work method is followed. It is just as important to make sure to evaluate the properly trained worker to perform the work activity.

It is pertinent to have the most information available, for example;

- The time and motion studies;
- Production standards;
- The process description sheets;
- The weight of materials, tools, and containers;
- Dimensions of the workplace, height of work surfaces, location and dimensions of containers and tools;
- Distances traveled, when carrying loads;
- It is good to have available video recordings of the workstations being evaluated, preferably several work cycles;
- Length of the working day and scheduled breaks;
- If there is a job rotation plan, it is necessary to know it;

• It is important to make observations about other aspects, for example, if there is supports on the wrists, use of bands, ribbons on the fingers, gestures after doing the work activity;
• It is important to give notice to those involved in the management of the production process and, where appropriate, to the representatives of worker's union.

4.1 ERGONOMICS ASSESSMENT METHODS (EAM)

Refer to the risk without making an evaluation is speculation. The practice of ergonomics changed favorably when the EAM was used. A widely variety of ergonomic assessment methods are available: In Stanton et al. (Stanton, Hedge, Brookhuis, Salas, & Hendrick, 2006), Marras and Karwowski (Marras & Karwowski, 2006), Malchaire (Malchaire, Cock, & Vergratch, 2011), Stack et al. (Stack, Ostrom, & Wilhelmensen, 2016), among others, information can be obtained about the different EAM. David (G.C., 2005) and Garg and Kapellush (Garg & Kapelush, 2017), present comparisons among some EAM. The EAM of greatest use is distinguished between ergonomists and depending on various working conditions. The use of the EAM is recommended to be carried out by properly trained personnel.

5 PROPOSAL OF A GUIDE TO SELECT OF EAM

For the focus of this work, the proposal EAM depends on it use in general, first at all is the assessment of repetitive tasks, then the assessments of manual materials handling.

The offer of methods is extended and can be considered as tools, according to each situation an EAM is used. The guide proposal is considering the two major activities; repetitive work and manual handling of loads. It is considered repetitive work when the work activity cycles are short, from 4 to 30 s per cycle, the pattern of movements in the muscle groups is repeated and more than 4 h are worked per day in the same activity. If the shift exceeds 8 h of work, a special consideration must be made. For the MMH, the main type of activity to select the EAM would be considered.

For repetitive work, it is proposed to use the ART Tool (HSE, ART TOOL Health and Safety Executive, 2017) as a basic tool, including in the evaluation almost all the risk factors and muscle groups of the upper extremities, including the back. It does not evaluate the lower extremities however, in the data on the WMSD, the number of failed cases in that segment of the body is not significant. The evaluation time is shorter than for the other methods and is relatively simple to understand and apply it works in the field and allows to observe more details.

It offers the possibility of including the extended shift greater than 8 h, a condition that is increasingly present in the manufacturing industry. If it is necessary to evaluate the duration of the sustained efforts and if it is required only for the elbow segment at hand the Strain Index (Garg & Kapelush, 2017) can be considered a second method, but if it is necessary to assess the sustained effort on the shoulder or back, a second Method can be the Muscular Fatigue Analysis (Changalur, Rodgers, & Bernard, 2003), (Stanton, Hedge, Brookhuis, Salas, & Hendrick, 2006)], it also has the advantage of driving in a more concrete way the search for solutions for high risk valuations of WMSD. Strain Index and HAL do not consider the type of grip on the fingers, a situation that is included in ART Tool and MFA. If the need is the postural assessment, RULA (McAtamney & Corlet, 1993) and REBA (Hignett & McAtamney, 2000) are viable alternatives.

For the MMH the proposal of EAM is more concrete; to evaluate lifting, lowering or transporting loads the MAC Tool (Health and Safety Executive, 2017), has some advantages, it is not limited to a symmetrical grip on the hands, it is easier to use, involves fewer calculations and includes more variables. It is of greater scope when considering two types of activity and with more options. The NIOSH lifting equation (NIOSH, 2017), is the most used tool on lifting or lowering tasks, but it is restricted by the symmetrical position on the hands.

The Liberty Mutual Tables (The Liberty mutual, 2017), also could be used to assess lifting or lowering a load, but just show the percent of population capable to safety do the job and it is restricted to some data on the basic variables of the activity.

For the activities of pushing the suggestion is to use the RAPP Tool (Health and Safety Executive. , 2017), it does not have a reference for the level of intervention, however, it consider the weight of the equipment used to be pushed or pulled and the weight of the load, and depending on it, there are the limits on weight for a safety movement, it also include the other factors influencing in pushing or pulling tasks. The RAPP tool also considers push or pull loads without the use of equipment. The Liberty Mutual Tables (The Liberty mutual, 2017), also could be used to assess pushing or pulling a load, but just show the percent of population capable to safety do the job and it is also restricted to some data on the basic variables of the activity.

The following figure shows the guide to use the EAM (Fig. 1).

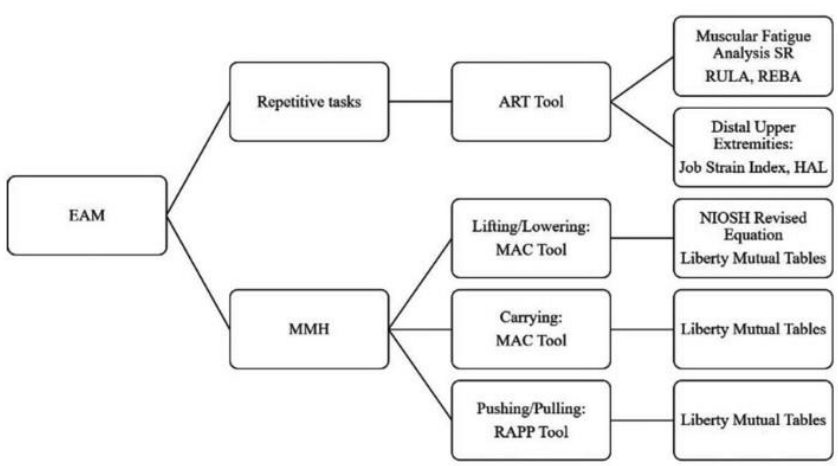

Fig. 1. Proposal Guide to EAM. Source; Own elaboration, 2018

6 CONCLUSION

The WMSD is still a health problem at work, the risk factors are present in the work activity and it is necessary to measure the risk in order to attend to it, assign a value or show the need to act to reduce or avoid the risk, fundamental for the advancement of occupational ergonomics. The AEM are an excellent tool to quantify the risk and a large number of options are already available, which is why this proposed selection guide for EAM according to the basic work activity can be very helpful.

Companies continue move forward and governments have the obligation to establish the relevant legal frameworks, but they can also generate guidelines for EAM that make it easy the inspection and prevention of occupational diseases, this guide can be an auxiliary in the process. For the ergonomist, it can shorten the time for the assessment and thus have more time to search for improvements and solutions in working conditions.

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ERGONOMIC EVALUATION OF AN ELECTRICAL HARNESSES ASSEMBLY LINE IN LOS MOCHIS, SINALOA

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Resumen: En el presente documento se expone de manera detallada la investigación sobre los factores ergonómicos a los que están expuestos los trabajadores de una línea de ensamble en una compañía manufacturera de sistemas eléctricos, la medición de estos mediante la aplicación de la herramienta Brief and Best con el objetivo de plantear propuestas orientadas a reducir o eliminar riesgos de trabajo que permitan cumplir con la normativa establecida por el Instituto Mexicano del Seguro Social, incrementen la productividad y promuevan el bienestar del trabajador.

Palabras clave: Evaluación ergonómica, Salud ocupacional, Factores de riesgo.

Relevancia para la ergonomía: El presente artículo pretende promover las buenas prácticas ergonómicas en el área industrial, e incentivar a las empresas a mejorar el ambiente en donde se desarrolla el trabajador, además de fomentar una cultura de prevención de riesgos a la salud, higiene y seguridad.

Abstract: On the following paper, it´s exposed a detailed research about the ergonomic factors that workers of an assembly line of a control and electrical system manufacturing company are exposed to, as well as the measurements of those by the application of brief & best method, in order to develop improvement proposals for this ergonomic conditions looking forward to minimize or erase risks factors that allow us to stand by the normativity stablished by Instituto Mexicano del Seguro Social, to increase productivity and promote the worker´s welfare.
Keywords: Ergonomic evaluation, Ocupational health, Risk factors.

Relevance to ergonomics: This article aims to promote good ergonomic practices in the industrial area, and encourage companies to improve the environment where the worker develops, in addition to promoting a culture of risk health prevention, hygiene and safety.

1. INTRODUCTION

Given the great competitiveness of the pressent market it is essential to maintain the level of production in the most efficient way possible, most of the times the economic factor is the one of greatest interest to the managers of the industries, however, it is necessary to understand that the most important part of our operation is the human factor, and as such, the right amount of attention must be given, avoiding that the worker suffers unnecessary postures and later presents musculoskeletal disorders as a cause derived from work.

Over the last two decades of the twentieth century, maquiladoras have acquired enormous importance for the Mexican economy (Contreras Oscar et al., 2005). They emerged in 1965 as a marginal activity in the context of a policy of protection of the national market, these were transformed to become the basis of the industrial development in the northern region of Mexico.

Between 2012 and 2105, the number of workers affiliated with the Mexican Social Security Institute (IMSS) who reported a work-related illness increased by 147%, according to the Report on Statistical Reports of that organization.

Based on the importance it represents for the country and the statistics analyzed, has been determined the necesity to carry out an ergonomic analysis in the line of work using the brief and best tool to measure the level of risk of the activities carried out by the operators, with the purpose of diminishing said factors or eliminating them.

2. OBJECTIVE

General objective: Evaluate the impact of activities that represent health risks to workers of an electrical harnesses assembly line and then develop improvement proposals that contribute to reduce or eliminate the risks.

Specific objectives:

- To Identify risk factors in the work areas that structure the production line.
- To perform an ergonomic evaluation by applying the brief and best method in selected stations.
- To generate proposals that allow the worker to perform efficiently, productively and safely.

3. METHODOLOGY

1.1 Stage 1

Preliminary data analysis.

In this stage we studied antecedents of the area in question, such as the activities carried out in the assembly line and the work areas that configure it.

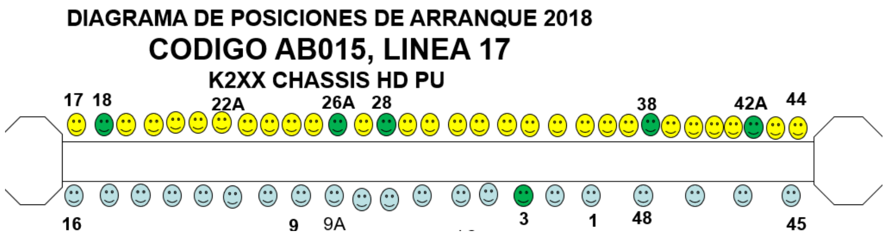

Figure 1. Distribution of AB015 line workstations.

1.2 Stage 2

Define priority projects.

The determination of the stations that underwent the study was done through methodological triangulation, which is defined as the combination of multiple methods in a study of the same object to address the different perspectives of the phenomenon being investigated (Crowman, 1993), by which, by observing the area of opportunity, together with the application of the questionnaire of ergonomic risk factors and damages, and the analysis of the historical data of the company, it was determined which are the priority stations and that demonstrated to have greater area of opportunity.

1.3 Stage 3

Diagnostic visits

Once the areas that made up the field study were determined, the visits to the plant represented a key stage to identify, in a general way and through observation, the different elements that influenced the performance of the workers, as well as to locate possible latent risk factors in the workstations.

Studies and videos

Following the methodology of data collection in field studies (Fernández, 2010) the video filmed contains a minimum of 3 to 5 work cycles, in order to be considered valid for the study performed. In addition to documenting the cycle time, it was necessary to photograph the work area and the general distribution of the workstation.

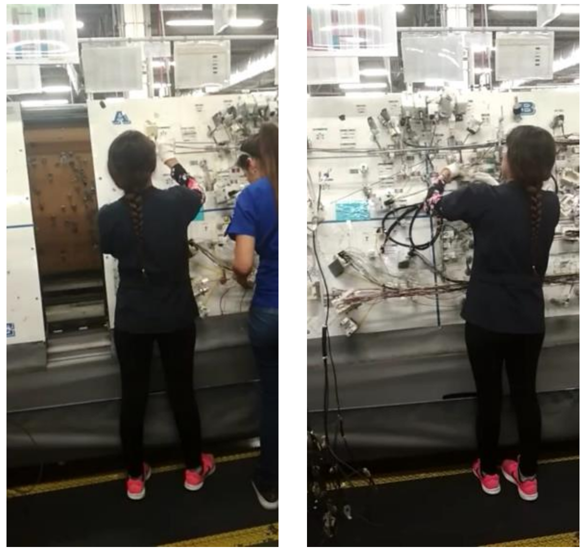

Figure 2. Workstation 14. Distribution of work area.

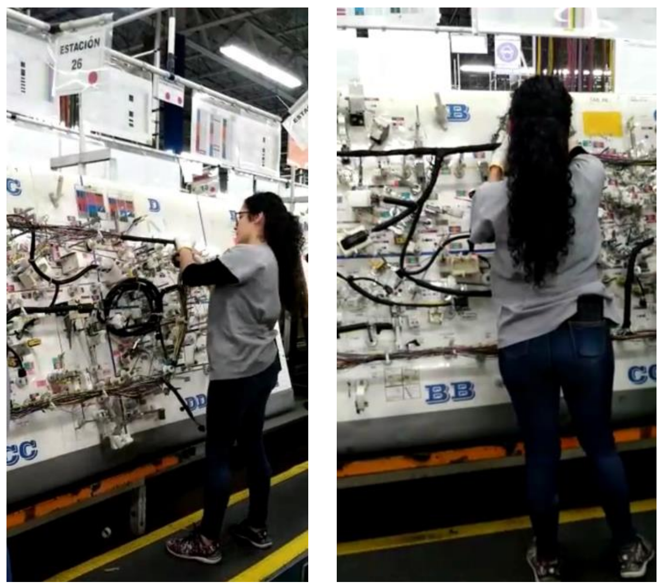

Figure. 3 Workstation 26. Distribution of work area.

1.4 Stage 4

Study and work measurement

Worker's measurements were taken to analyze the activities of the workstation and relevant information entrances were taken such as process diagrams, cycle times and activities carried out, provided by the department of methods engineering of the plant.

1.5 Stage 5

Analysis and evaluation

Based on previous analysis of the severity, frequency and recorded data of the injuries that occured in these work stations, the ergonomic conditions to which operators of stations 14 and 26 of line AB015 are exposed were evaluated.

1.6 Stage 6

Control, improvement and recommendations

By analyzing the results obtained, the need for the application of corrective actions is established, as well as controls to reduce risks.

The application of these proposals is up to the company and a decision-making process can be created to determine the order in which the implementation of these is convenient.

Table 1. Results of method´s application in station 14.

WORKSTATION 14				
Number of activity	Description	Estimated time	Task risk Index	Priority
1	Check part number to build.	2 seconds.	1.2	Low
2	Take splice 1750 according to option	3 seconds.	4.4	Low
3	Undo White coil and assembly the point	3 seconds.	4.0	Low
4	take fastener splice and large terminal tip assembly	6.5 seconds.	11.2	Medium
5	Undo 4-wire coil routing and assembly.	4 seconds.	8	Low
6	Route splice to support.	4 seconds.	8	Low
7	Undo 4-wire coil routing and assembly.	10 seconds.	25.6	Medium
8	Close prl pushing lever.	1 seconds.	6.8	Low
9	Undo 1750 splice coil tip with yellow seal and assemble.	5 seconds.	8.4	Medium
10	Take fastener twisted rutee by p.d.bb2, p.d.bb26, r.p.p bb31 and assemble in bracket 20.	9 seconds.	13.6	Medium
11	Remove holder connector, close plr and place in v.pin.	4 seconds.	7.6	Low

Table 2. Results of method´s application in station 26.

WORKSTATION 26				
Number of activity	Description	Estimated time	Task risk Index	Priority
1	Check part number to build and build according to the method.	2 seconds.	1.2	Low
2	Take cloth tape and perform solid wrapping by marking output in p.d. a32, in p.d.a 20 and p.d.b38.	26 seconds.	52	Very High
3	Cut tape with razor 2r01240cp.	2 seconds.	7.6	Low
4	Take polyducts and assemble.	4.2 seconds.	8 .0	Low
5	Take polyducts and assemble.	4.2 seconds.	8.0	Low

4. RESULTS

Improvement proposals:

Limit the vertical height of the boards to avoid pronounced flexions of the arms and back.

At the manufacturing level, it is recommended to divide workers based on the anthropometric measures they present and thus locate them in jobs suitable for their physical composition, so that they do not do muscles flexing or unnecessary movements.

It is suggested to establish various administrative and engineering controls, among which the correction of positions and redesign of work areas, for the benefit of workers' health, stand out.

5. CONCLUSIONS

The research carried out shows that the characteristics of the activities that are currently carried out within the manufacturing company represent a health risk to the operators, for which proposals aimed at modifying them were made.

It has been proven that carrying out short-term modifications in the execution of work, through specific techniques and methods, allows the industry to improve the ergonomic conditions in which the worker performs.

The objectives set out in the research were met through the development of this and it is important to specify that the implementation of the proposed improvement proposals is for the consideration of the administrative staff of the company, however, the benefit that they generate is sustained.

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STUDY OF THE MENTAL LOAD FOR THE DEFINITION OF STRATEGIES THAT CONTRIBUTE TO THE IMPROVEMENT OF TRAJECTORY INDICATORS IN AN EDUCATIONAL INSTITUTION

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Resumen: Hoy en día, el estrés derivado de una alta carga mental, es una de las enfermedades con mayor incidencia en el país. El objetivo del presente estudio es medir la carga mental en estudiantes de Ingeniería Industrial con el fin de establecer estrategias que permitan mejorar su rendimiento académico, ayudando a evitar el retraso del estudiante. El Método consistió en la determinación del tamaño de la muestra a estudiar y en la adaptación y posterior aplicación del instrumento basado en el método TLX de la NASA. Una vez obtenida la información, se realizó el análisis e interpretación y, finalmente, se generaron las acciones de mejora. Entre los resultados más significativos se encuentra que: el 61% de las participantes mujeres tienen un alto nivel de carga mental, siendo la dimensión predominante la frustración; El 54% de los participantes masculinos maneja una carga mental alta, con la dimensión predominante como el rendimiento, y; Los estudiantes del segundo semestre son aquellos con la mayor carga mental que tiene el desempeño como el área predominante. Las estrategias propuestas son: enseñanza en el desarrollo de factores de protección, técnicas de afrontamiento, estrategias de aprendizaje, desarrollo de habilidades para planificar el estudio y proporcionar información oportuna. En conclusión, generar acciones para combatir la carga mental, contribuye a la reducción de indicadores como el retraso y el abandono escolar, lo que sin duda favorece la educación académica de los estudiantes universitarios.

Palabras clave: Trayectoria, Estudiante, Carga mental, Estrategias.

Abstract: Nowadays, the stress derived from a high mental load, is one of the diseases with greater incidence in the country. The present study's objective is to measure the mental load on students of Industrial Engineering with the purpose of establishing strategies that allow the improvement of their academic performance, helping to avoid student lag. The Method consisted in the determination of the sample's size to be studied and in the adaptation and subsequent application of the instrument based on the NASA TLX method. Once the information was obtained, the analysis and interpretation was carried out and, finally, the improvement actions were generated. Among the most significant results is that: 61% of female participants have a high level of mental load, with the predominant dimension being frustration; 54% of the male participants handle a high mental load, with the predominant dimension being the performance, and; the students of second semester are those with the greater mental load having performance as the predominating area. The strategies proposed are: teaching in protective factors development, coping techniques, learning strategies, the development of skills in planning the study and providing timely information. In conclusion, generating actions to combat the mental load, contributes to the reduction of indicators such as lag and school dropout which undoubtedly favors the academic education of university students.

Keywords: Trajectory, Student, Mental load, Strategies

1. INTRODUCTION

Dropout or student desertion are the terms that have been adopted to name a variety of situations identified in the educational process of the student with a common denominator, detention or interruption of initiated studies before finalizing them (Cabrera, Bethencourt, Álvarez and González, 2006). According to the Organization for Cooperation and Economic Development (OCDE) Mexico shares with Turkey the first place in the abandonment of university students, with only 38% of the young people attending the University coming to graduate (García, 2015).

According to data from the National Institute of Statistics and Geography (INEGI) in Mexico only eight out of every hundred students conclude a college career, the main reason is the lack of economic resources. To this is added the lack of vocation, academic background, family difficulties, community environment, as well as the lack of capacity from the universities to retain students (Universia México, 2013). The undersecretary of Higher Education of the Ministry of Public Education explained that it is during the first year that there is the highest number of dropouts, so it is in the first year of the university students in which the government must intervene (García , 2015).

There are methodologies applied to the time of desertion, which allows a follow up from the beginning of the academic process until the event of desertion occurs and relate it to the complete set of factors that theoretically can influence the time of permanence of a student in the institution (Suarez and Díaz, 2014). Among the determinants that they find are: individual, age, gender, marital status, extra academic issues; Academics, such as exam results, dissatisfaction, study methods; Institutional, support through scholarships, political environment; and Socioeconomic, work situations and level of education of the parents.

According to the National Association of Universities and Institutions of Higher Education (ANUIES, 2001), graduation is the percentage of students who have accumulated 100 percent of credits in the time established by the curriculum of the institution to which they belong. Having a favorable egress depends on the dropout, lag or failure which are explained by a wide variety of factors attributed both to the student and its context as to institutional factors, so there is no cause or factor that determines it. In the same way, the factors that explain the dropout are not the same as those that explain lag, failing or poor school performance (García and Barrón, 2011).

Some of the stressors linked to the indicators described above are: the biannual academic load represented by assignments, broad content of courses, exams, final projects and other psychosocial factors in the family and / or personal environment that lead the student to a state of demotivation, cognitive fatigue and physical fatigue before the generated mental load (Freuderberger cited by Salanova, 2005). In recent studies, university students reported having moderately suffered from feelings of anxiety, depression and irritability (Meda, Santos, Lara, Verdugo, Palomera and Valdez, 2008). Faced with this situation, we have the following question: *What will the stragtegies be that, based on the measurement of the mental load, contribute to the decrease of the student lag indicator in a higher education institution?*

2. OBJECTIVE

Establish strategies that allow the improvement of the mental load and the student lag indicator in an educational institution.

3. METHODOLOGY

The subject under study covers the students of second, fourth, sixth and eighth semester of the educational program of Industrial and Systems Engineering in ITSON Guaymas' campus. The applied methodology will be an adaptation of the steps suggested by Hernández (2010). Which are shown below:

Determine the sample size to be studied: To do it, the statistical calculator of samples for market research will be used, working with a confidence of 94 percent and a 6 percent error.

Collect data: This was done by applying the NASA TLX method instrument to the students described as the subject under study. The task to be analyzed will be those activities that are related to the academic field corresponding to the enrollment semester. For the application, the participants were first explained what each one of the dimensions that make up the method consists of.

Analyze and interpret data: A Microsoft Excel database was used to capture the information collected. Once this is done, the statistical analysis will be carried out to determine the percentages of incidence of the different variables and to interpret the results obtained through graphs, with the intention of determining the main reasons for the mental load on the students. Generate improvement strategies: Here the strategies to be followed to counteract the effects of mental load were planned.

4. RESULTS

In this section the main results obtained during the investigation are presented. As an initial phase, once the statistical calculator was used with a 94% confidence level, an error of 6% and 384 as the total number of students enrolled, it was obtained that the number of students to be surveyed is 53 of the second semester, 37 of the fourth semester, 44 of sixth semester and 33 of eighth semester. The next step was the characterization of the sample whose relevant data are listed below:

- 22.5% of the students are enrolled in 8 subjects, 15.4% are enrolled in 11 subjects and 13% are enrolled in 9, 10 and 7.
- Regarding marital status, the respondents were 97% single, 2.4% married and 1.2% in free union.
- 67.5% of the students surveyed are dedicated to their studies only while 32.5% work and study.

For a better appreciation, the information was stratified considering the sex of the surveyed, the age, semester and dimensions. The results of the study are described below.

1.- Presence of dimensions by gender.

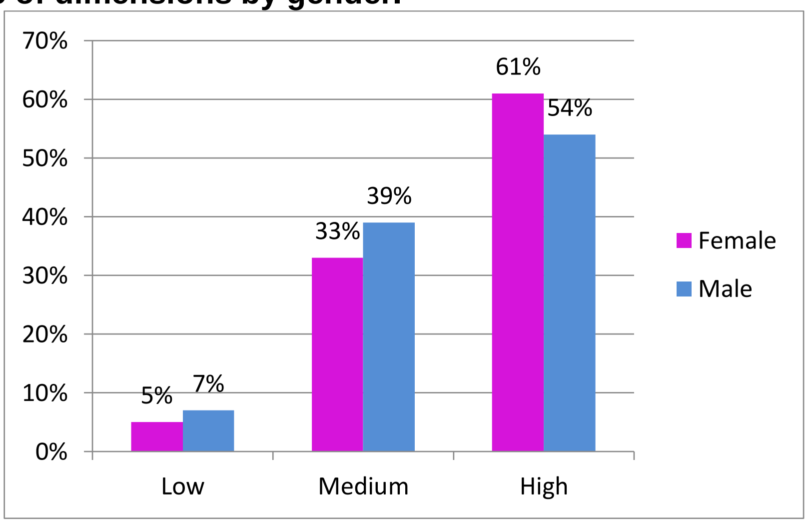

Figure 1 Presence of dimensions by gender**.**

According to the results obtained in the NASA TLX method, 61% of female students have a high mental load and 33% have a medium level. In the case of the male students, 54% have a high mental load and 38% have a medium level. This suggests that female students tend to be more prone to feeling stress and suffer from symptoms of the disease, coinciding with previous studies where it was established that women's brains are more sensitive to the action of a hormone that orchestrates the response of the organism in the face of stress, that is, the female neurons are more prone than the male neurons to react and trigger the stress process (Sanz, nd).

3. Presence of dimensions by age.

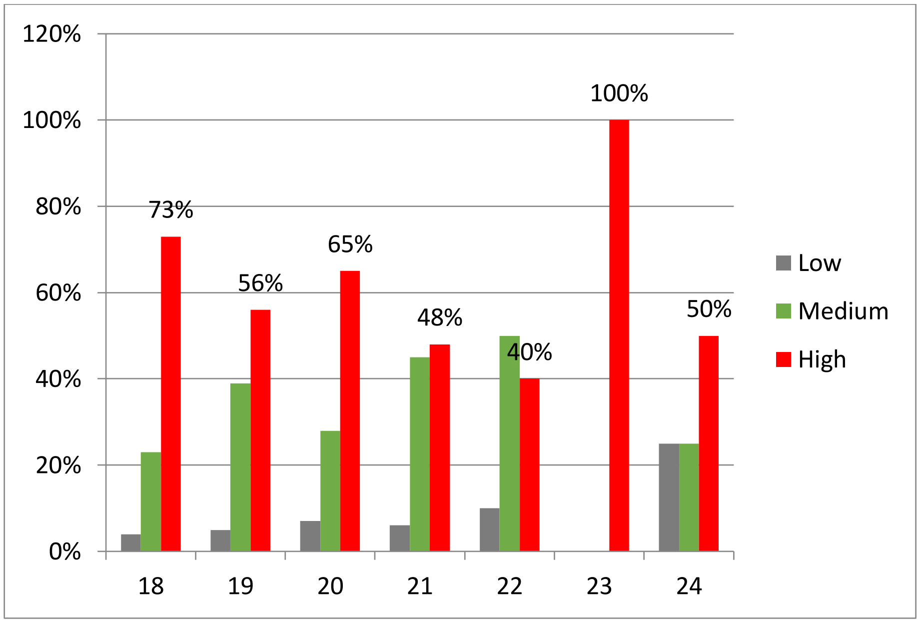

Figure 2. Presence of dimensions by age.

From the previous figure we have that 100% of the 23-year-old students surveyed have a high mental load, followed by the students of 18 years with 73%, those of 20 years with 65%, those of 19 years with a 56%, 21-year-olds with 49%, 22-year-olds with 40% and finally 24-year-olds with 25%.

4. Presence of dimensions by gender and age.

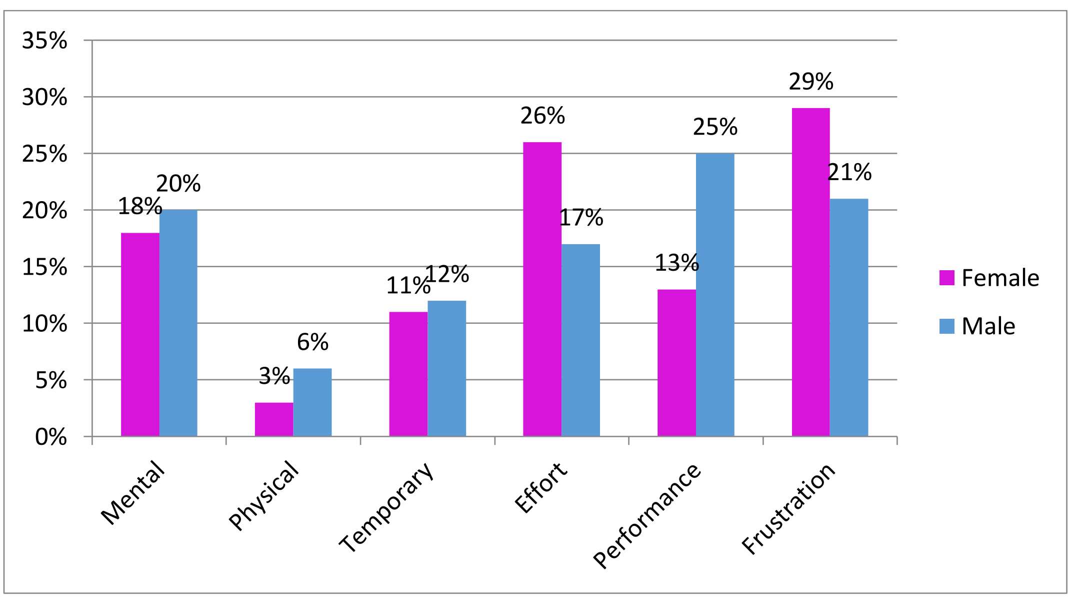

Figure 3. Presence of dimensions by gender and age.

The dimensions with greater presence for male students are: performance with 25%, frustration 21% and mental load 20%. In the case of female students are frustration with 29%, effort 26% and mental load with 18% the dimensions with greater presence.

When exploring the dimensions mentioned before by age, it was identified that the students: 18 and 21 years of age present frustration, 22-year-olds frustration and mental burden, 20 and 23 years effort, and 19-year-olds performance.

5. Presence of dimensions per semester.

The dimensions that are mostly presented per semester are: in second performance, in fourth and sixth mental load and in eighth the frustration. 61% of students enrolled in the second semester have a high mental load, followed by 50% of students in the sixth semester, 49% of students in eighth grade and only 13% of students in the fourth semester.

6. Improvement strategies.

In order to fight the mental load and therefore the lag, strategies were generated separated by students of initial, intermediate and final semesters, which appear below:

S1. Teach the student through the tutorial program to develop protective factors to help safeguard their mental health. The protective factors are the personal characteristics and elements of the environment, or the perception that is had about them, capable of decreasing the negative effects of stress (Zaldivar, 2002).

S2. Teach coping techniques. Cohen (1999) argues that coping is aimed at preventing, slowing, avoiding or controlling tension and stress.

S3. Develop skills in study planning and learning strategies.

S4. Provide information about the study plans and the psychoeducational characteristics that are required, such as administrative procedures.

S5 Give an orientation in time and form in relation to the degree alternatives, administrative procedures, advisors, research projects.

S6. Provide training, prior to the end of the degree, on how to prepare a curriculum vitae and elements of a job interview.

S7. Accompany the student during his / her final semester of the career in both academic (advisory) and administrative (tutoring).

5. DISCUSSION/ CONCLUSIONS

As a conclusion, the Objective has been met by establishing strategies that allow the improvement of the mental load and the student lag indicator in an educational institution. With regard to the resulatdpos, it can be said that these do not differ much from that stipulated by Cano (2008), who comments that initiating the study of a professional career can be a source of stress that haunts psychological well-being, health and can result in academic achievement. In the same way, Polo, Hernández and Poza (1996) concluded that psychological well-being is disadvantaged in the presence of the stress produced in first-year students in the belief that there will be a greater amount of workload and a lack of time. to fulfill its academic activities. Also in a study conducted on anxiety and sources of academic stress in students of careers in health (nursing and medical technology) where it was found that the main sources of stress are academic overload, lack of time to fulfill academic obligations and Conducting an exam (Castillo, Chacón y Díaz, 2016). The carrying out of this type of studies has information on the different dimensions in which work must be carried out to minimize this burden (mental load, physical load, temporary demand, frustration, performance and effort) allowing thus generating programs aimed at reducing the backlog and the prevention of health problems, both physical and mental.

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PHYSICAL ERGONOMICS: CONDITIONS THAT AFFECTS THE INFORMAL WORKER FROM THE CURRENTLY COLOMBIAN TRADE

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Resumen: Objetivo: Analizar las condiciones del dominio de la ergonomía física para establecer la relevancia de sus interacciones, logrando optimizar los elementos de protección y minimizando el riesgo. Método: Estudio descriptivo del análisis de contenido de la categoría, búsqueda de documentos de investigación que introdujeron el trabajo físico ergonómico e informal. Resultados: con esta investigación fue posible determinar que no hay más información sobre la ergonomía física en el sector informal y el sector de comercio en Colombia. Conclusiones: Los trabajadores informales en Colombia no tienen las condiciones ergonómicas óptimas para el desarrollo de su actividad laboral, además, no existe un sistema de seguridad y salud en el trabajo que pueda garantizar el bienestar y las buenas prácticas laborales.

Palabras clave: Ergonomía / fisiología / trastornos musculoesqueléticos / biomecánica / sector informal

Relevancia para la ergonomía: Esta investigación documental permite caracterizar las variables de análisis, desde la ergonomía física de acuerdo con el desarrollo del trabajo informal, donde se encuentran algunos factores involucrados como el tipo de gesto, la postura mantenida y prolongada, el movimiento repetitivo y otras variables que generalmente están involucradas. En el trabajo diario (empresa y trabajador). Entonces, cuando no hay información, permite caracterizar esta actividad humana, calificar y cuantificar el riesgo en su desarrollo, logrando una mayor comprensión de la ergonomía en la comprensión de la interacción entre la máquina humana y el espacio físico.

Abstract: Objective: Analyze the conditions from the domain of physical ergonomics to establish relevance from their interactions, achieving optimize protective elements and minimizing risk. Method: Descriptive study of category's content analysis, search of investigative documents that introduced the physical ergonomic and informal work. Results: With this investigation it was possible to determine that there is no more information on the regarding to the physical ergonomic in the informal sector and the commerce sector in Colombia. Conclusions: Informal workers in Colombia do not have the optimal ergonomic conditions for the development of their work activity, in addition, there is no safety and health system at work that could guarantees the well-being and good work practice.

Key words: Ergonomics / physiology / musculoskeletal disorders / biomechanics / informal sector

Relevance for ergonomics: This documentary research let characterize the analysis variables, from the physic ergonomics according to the development of the informal work, where are some involved factors as the gesture type, maintained and prolonged posture, repetitive movement and other variables which are generally involved in the diary work (company and worker). So, when there is no information, it let characterize this human activity, qualify and quantify the risk in its development, getting more to the ergonomics in the understanding of the interaction between human-machine and the physical space.

1. INTRODUCTION

The exercise of labor as proper activity of the human requires through its process of bodily and mental conditions that request to the person an important demand of his time and body waste. It is why during the execution of this person carries out various activities that, if performed in an inappropriate way, generate alteration in the various bodily functions, That is, if the worker during his working day does not carry out his activities seeking bodily comfort this triggers permanent or temporary musculoskeletal injuries that limit the performance of the work practice. One of the topics of injuries is the biomechanic, where we evaluate all the characteristics of human movement that if those are complemented with the physiological and anthropometric factor, it allows the ideal characterization of the work gesture, this ensuring that the worker performs the appropriate activity according to the ergonomic characteristics of the workplace given by the body component of each individual.

This is why in Colombia it is important to understand that the informal workers should be involved in occupational safety and health programs due to that it does not work to have the whole country working if a large part of these workers do not have adequate health guarantees which ensure the citizen welfare of the entire population.

2. OBJECTIVES

2.1 General objective: analyze the conditions from the view of the physical ergonomics, in order to establish the relevance since its interactions, achieving optimize protective elements and reducing the risk.

2.2 Specific objectives:

- Collect research studies regarding to the conditions from the physical ergonomics dominium in the commerce sector.

- Identify biomechanical and anthropometrics physiological factors which affect the population and then let it act.
- Establish interactions of the variable, analyzing its level impact

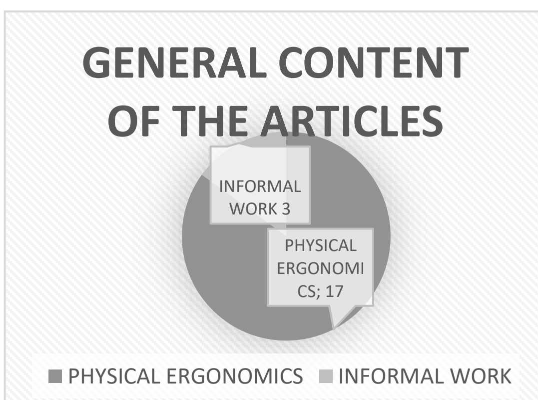
3. METHODOLOGY

- Chronological delineation: A time window was created for the search of articles from 2000 to 2018. This window was established because during this time several investigations were published with key results for research.
- Conceptual delineation: The search was carried out with specific terms such as physical ergonomic, informal worker, trade sector, physiological, biomechanical and anthropometric that allows a greater and bigger approach in research. These terms are the pillars because they clearly support the hypothesis given by the researchers.

4. RESULTS

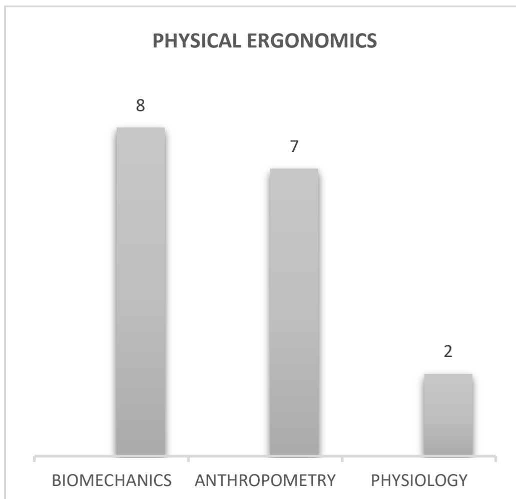
During the development of the research, a search was made of various researches that would allow the development of this document, during this search several publications were obtained whose fundamental basis is informal work and physical ergonomics from categories of analysis (physiology, biomechanics and anthropometry), the articles found were chosen according to inclusion and exclusion criteria established in the research, obtaining 20 documents that contributed to the development of this work.

Graphic 1 shows that within the 20 articles found, 15% refer to informal work where its definition, characterization parameters and statistics are contextualized at the national level in the various sectors and cities, 85% refers to ergonomics physics from its different conditions such as anthropometry, biomechanics and physiology.



Graphic 1. Description of the content of the articles

Graphic 2 the description by subject of the 17 articles related to the physical ergonomics is made, the articles related to the biomechanics present in their content information related to ranges of corporal movements, corporal postures, repetitive movements and physical factors of the development of the work in the human being , the anthropometry described in the articles describes the importance of the jobs from its correct analysis prioritizing all the corporal factors of the human being to grant him a job suitable to his labor need and physical conditions, finally the articles related to the physiology describe the bodily factors characteristic of the work gesture that generate work overload, physical wear and tear that involve the specific mechanisms of cause and effect of any physical activity.



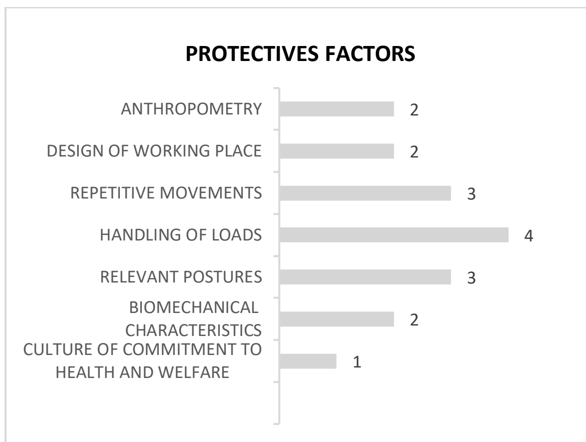
Graphic 2. Contextualization of the content.

The risk factors (graphic 3)are those that during the development of this activity increases the probability of suffering some type of alteration or injury in any situation or body area, as expressed in the graph are 7 the main factors that generate in the informal sector alteration in their well-being and quality of life, thus allowing their work practice to be limited, in the first instance the factors of biomechanical type generate in the worker greater consequences of musculoskeletal type being the postures bodily injuries have the greatest impact on the work.

There are several factors that allow the worker to increase their productivity and improve their physical well-being, in the graph they relate some of them found in the analysis of the articles that correlate the correct application of these factors with the quality of life and work of the person (graphic 4).

The development or inclusion of these factors generate variables of welfare or risk in the worker that is why it is essential that every worker has healthy work practices, thus guaranteeing their physical and productive well-being where their work activity is not affected

Graphic 3. Risk factors in informal workers in the commerce sector.



Graphic 4. Protective factors in informal workers in the commerce sector

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5. DISCUSSION

In Colombia, a number of formal labour activities are carried out where a contract of employment is concluded or is signed between the employer and the employee where certain requirements and obligations for each party during the duration of the contract; on the other hand there is the informal labour activity in which there is no contract signed between the parties concerned or the work is simply performed independently, Luna (2014) refers in his article that in Colombia there is a great tendency to increase precarious employment, informality and underemployment thus leading to a decline in employment and working conditions for most workers, which has an impact on a proportional decrease in the income of the working population, Intensification and densification of the work carried out with negative repercussions on health.

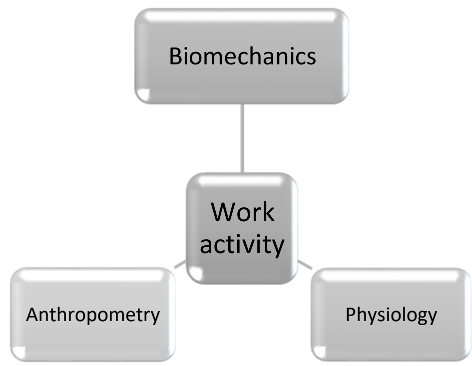
According to Ballesteros (2012) Informal work or informal economy can be taken from different perspectives, the definition of informal economy can be taken from the structuralist school (it groups unpaid family workers, self-employed persons, unprofessional or technical workers, domestic servants, employees and employers of private sector enterprises up to ten workers) such as the institutionalist school, which is based on labour and institutional legality with guarantees of social security in health, pension affiliation and employment contracts, according to it, it is understood that informal workers do not have adequate health and safety conditions so that during the performance of their work there are no situations that alter their personal and family welfare.

Ergonomics is defined by the International Ergonomics Association as described in the Gomes document (2014) as "the body of scientific knowledge applied to adapt work, systems, products and environments to the person’s physical abilities and limitations". Among the areas of study we find the domain of physical ergonomics which is established as the one related to physical activity, which includes anatomical aspects, physiological characteristics, anthropometric characteristics and biomechanical factors of the human being in the working practice, where the postures, efforts and movements carried out during the development of the activity.

In the text described by Piedrahita (2014) ergonomics is described as inter and multidisciplinary science with different approaches that depend to a great extent on the approach and what we expect from it, understanding it, ergonomics allows the studies to be developed in an open way thus looking for pertinent results that guarantee the new knowledge and the solution of the problems presented by the workers during their work activities; It is therefore true that if jobs do not have the appropriate structural conditions and analysis to ensure that the activity and the labor gesture developed is the appropriate one can generate that the worker would be exposed to some factors that alter his condition and physical well-being.

During the performance of any work activity, there are various modifications or physiological alterations based on the development of the bodily metabolic needs of the human being in which the good habits are covered foodstuffs, rest and hydration which allows the proper adaptation of the body to the muscular and/or physical effort. Inadequate performance of activity generates body overexertions that increase energy expenditure and increase muscle fatigue thus generating feeling of tiredness that are reflected in musculoskeletal type injuries Zapata (2017) consider that muscle-skeletal injuries have a huge and increasing impact worldwide, from the perspective of productivity and economy of the industry, those are the main cause of pain and disability; Work overload is mainly caused by postural alterations during work activity that trigger various bodily disturbances such as pain, discomfort, movement limitation, among other characteristics representing disability and diminishing working capacity.

The work activity is complemented by activities of biomechanical and physiological type, that means that in the performance of the activity is involved internal and external bodily components as the energetic regulations, physical and mental changes it is why during the performance of any task the person must perform bodily movements within the normal comfort ranges since certain positions and/or movements generate higher body overload (see Figure 1.) this is why performing movements that are not within normal anatomical boundaries, can lead to musculoskeletal injuries, for this reason it is important that the performance of the work gesture would be appropriate and that the place where the activity described as the job is performed is the correct according to each type of productive activity, in this spaces we have to keep in mind the appropriate conditions of the environment, physical structure, among other variables taken in mind according to the anthropometry of the worker, so that this space does not trigger further complications.



Graphic 5. Determinants of work activity
Source: Elaborated by the authors

Informal work has different characteristics during its development, due to that the person who performs this activity generally performs it empirically and by necessity of subsistence, therefore it is observed that during the working day the worker performs his practice in an inergonomic way where the most of his movements are carried out outside the normal work plans which imply that all his movements must be within normal joint ranges, also because they do not have a correct job, their place of work is usually limited to developing on the ground or in elements or places that do not have the anthropometric characteristics necessary for each worker thus generating increased body fatigue, acquisition of forced bodily postures that alter the physical condition of work.

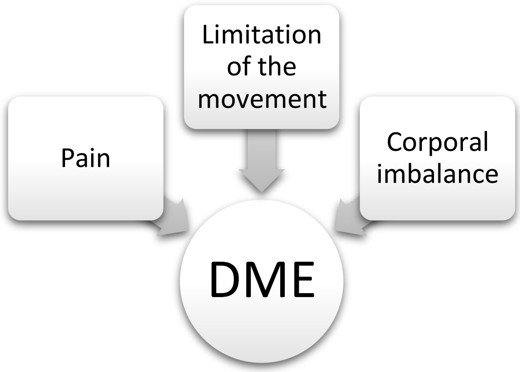
One of the greatest challenges of ergonomics has been the study of man’s interaction with physical requirements (posture, strength, movement) as set out in Vernaza’s text (2005) "When these requirements exceed the responsiveness of the individual or there is no adequate biological recovery of the tissues, this effort may be associated with the presence of muscle-skeletal lesions related to work."

Its study concludes that the happening of musculoskeletal lesions are associated with biomechanical risk factors (posture, strength, and movement) contributing to the scientific evidence presented by Kumar on the presumption that all occupational musculoskeletal injuries are of biomechanical origin.

The research conducted by Ordoñez (2016) describes that "Muscle-skeletal disorders (MSDs) are caused by laborious work involving prolonged, maintained and forced postures, with little chance of change, outside comfortable angles or in imbalance, with unstable or vibratory support bases, by lifting and manipulating loads and repeated movements" thus relating musculoskeletal disorders with the conditions of the physical type ergonomics where these characteristics are found that effectively generate that type of injury by not performing the work activities correctly. On the other hand, in this same document, modulating factors of an organizational type are listed that can enhance or minimize the risk of musculoskeletal injuries such as "working hours, rest time and its distribution, kinds of control, variety of work and remuneration, as well as individual conditions such the age and gender" it is why it is important to understand that in labour practice there must be rigorous controls to ensure the welfare of all workers in general regardless of the workplace.

Musculoskeletal injuries or disorders can be triggered in any region. Nevertheless, depending on the work activity developed there are some areas of the body where discomfort or injury is most likely from overload employment. Muñoz (2012) refers in their document that the pain of the spine represents a complex problem in its origin and in its consequences, it is as well as individual factors, ergonomic factors of the job and premature retirement from work, thus leading to decreases in productivity and failures in the system of management of safety and health at work since sometimes these alterations are not generated only by the work activity or the working environment but by unhealthy life habits that cause bodily disturbances.

The compilation of skeletal muscle disorders and biomechanical risk factors must be performed (see Figure 2.) as it is found in Montalvo's document (2015) in which questionnaires and risk rating were carried out according to the physical activity of the worker. The results of this study reported that 73.9% of the people were part of the health area, 49.5% of the people manifested muscle aches being the back and the upper limbs the parts of the body the most affected, which concludes that back and hand pain-wrist are significantly associated with the risk of physical load in the health area considering that these professionals must develop different positions or maneuvers to meet the patient's requirement or needs. This is why it is necessary to do a special emphasis on the proper application of ergonomics in all work areas to decrease the incidence of skeletal muscle disorders.



Graphic 6. Characteristics of musculoskeletal disorders
Source: Elaborated by the authors

In a general level the whole population at some point in its life presents musculoskeletal problems that are not only derived from work practice but from its daily life, women have higher prevalence in musculoskeletal injuries as Rodriguez concludes (2015). In the study carried out on people from the administrative area of a University in Bogotá, Colombia, where analysis was carried out according to the methods of evaluation of physical ergonomics and showing that women had a higher prevalence of symptomatology in the neck and shoulders in reference to men analyzed, these figures can be related to the general activities carried out by women in their home and that in the Colombian population the average of women is lower than the average of men, finding anthropometric difficulty for job designs.

Musculoskeletal disorders generate various alterations that range from the quality of life of the affected workers and the productivity in their workplace, the best way of eliminating or diminishing it is giving the worker good ergonomic conditions that include their job and work environment, as mentioned during the document and corroborated in the publication by Cotè (2013). When there are no healthy conditions in jobs or places of work there are failures in the processes that harm the productivity and therefore the quality of life of workers. Managing working conditions is a fundamental part of any sector of work because if this process is not carried out, there are consequences such as increases in costs, unnecessary payments, in conclusion, it could be avoided, thus affecting the sustainability of the companies, as it is understood in his research Oviedo (2016). In every company or entity the administrative area enjoy a very important role due to that this area processes and all the possible solutions before the needs of the workers are raised, implemented and supervised, this is reflected in the results of the investigation de Dixon (2009) where they emphasize that the protocols or systems that provide guarantees to workers to avoid musculoskeletal problems or alterations of an ergonomic nature are largely due to the commitment of senior management and the individual efforts of management personnel to intervene in support of prevention programs that include health and safety at work.

It is necessary to understand that every institution, entity or company must provide safe working conditions where the worker has the necessary tools to carry out their work in the healthiest possible way. The environment or work environment is an essential part of the proper development of work activity since if it is within the ergonomic or anthropometric characteristics intended for the worker, he can perform his activity in the best way, which is why Ardila, et to the. (2013) state in their document that the definitions of a healthy work environment have evolved over the last decades, starting from an almost exclusive focus on the physical work environment (traditional occupational health and safety scheme, which considers the physical, chemical risks, biological and biomechanical) to include habits of healthy lifestyles, psychosocial factors and all that determinant that can have a profound effect on employee health and labor productivity levels.

In the work’s sectors, the employee is exposed to a number of risks inherent to the work practice, regardless of whether the work is of a formal or informal type, one must have control over the factors or characteristics that cause the complications. Many of these workers do not have knowledge about the performance of their work practice adequately because some of them acquire knowledge empirically or because their place of work is not appropriate, it is not normal for academic institutions to be taught to student and professional future as biomechanically positioned to develop their activity and this lack of teaching is reflected in the work practice where the worker generates several injuries and / or illnesses due to the improper performance of his work practice added to the lack of work stations duly analyzed according to the company's requirement and the anthropometric conditions of the worker as established in the Isper document (2018).

In several industrial sectors such as agriculture there are higher prevalence rates per year as corroborated in the document described by Barrero (2014) which states that these workers have a high occurrence of musculoskeletal diseases. In this article they emphasize the way in which the magnitude of the problem, its causes and possible solutions are understood. They propose to improve the ergonomic conditions of the working population of this sector of the industry, decreasing the presence of bodily alterations that affect the work practice, the study was carried out in 2007 in which the Ergonomics Study Center of the Department of Industrial engineer. Whose overall objective of the work is the prevention of diseases based on past projects which focused on the evaluation of the ergonomic conditions of the work, the characterization of the working population and the development, implementation and testing of solutions. Developing an effective way of prevention with the proper application of ergonomics in the industrial sector and reducing the incidence of skeletal muscle diseases in its workers.

Another important area of formal work is the cinematographic area from where the biomechanical risk assessment is carried out behind the cinema screens. As expressed in Vitela's paper (2015) show how in recent years Ergonomics has aroused more interest in the study of musculoskeletal disorders and manual handling of material, the main objective of the project was to redesign the work area , from the ergonomic point of view where it was recorded in the results that these workers have a high risk of presenting work accidents or occupational diseases due to bad practices and for not taking into account ergonomics or risk control measures in each task perform.

Another significant area of work is the area of aesthetics where some workers acquire their remuneration for the work generated in the day to day, some of these workers do not have the social benefits given by the employer and their work may not be constant but requires body wear to remain in a sitting position prolonged maneuver as done by the manicurists who must adapt to the patient's body conditions adapting their workplace to the needy to perform their work according to the need of the client, in their activity these workers they must constantly lean, rotate the body, reach the objects many times out of the normal working plane, thus generating various bodily alterations in both upper and lower trains that, due to the complexity of their workplace, cause disorders at the musculoskeletal level, this was determined through the valuation by the Rula method described in the article by Garcia (2017).

The role of ergonomics in the change of working conditions has certain perspectives in Latin America as it is mentioned in its document Gomes (2014). The evolution of the industrial society in the last centuries has been demanding of the ergonomics and the engineering of production a joint and continuous effort towards the supply of solutions through concepts, methods, techniques and tools, in order to satisfy the needs of modern societies. Among the needs of the human being is health is for this reason that from the work practice should be guaranteed to the worker the enjoyment of this, due to that in Colombia not all workers can ahieve this benefit because the informal sector is not a fundamental part of the social security system. It is observed that in various commercial activities, workers do not have the right conditions in their workplace, nor perform the biomechanically correct activity can be deduced that many of these people have musculoskeletal disorders that affect their well-being and productivity thus generating limitation and diminution of the labor development.

It is important to generate a culture of prevention in the population. Health and well-being is generated in order to reduce the incidence of musculoskeletal injuries and improve the quality of life of human beings, generating improvements in the conditions of decent and decent work regardless of the informal and formal work sector. Providing timely preventive actions for the performance of safe and timely work. Strategies and / or methods must be generated in a mandatory way that includes the informal working population and ensures that the development of their activity is appropriate, generating a reduction in injuries and repercussions on workers' health, in addition to providing the state with figures real where all the Colombian working population is included in the social security system that allows greater coverage and support.

The analysis of physical ergonomics in informal work, shows the precariousness of information due to the exhaustive search that was carried out, the vacuum of knowledge is disclosed in the informal sector of the population in general, it is for this reason that during the During the course of the research special emphasis was placed on the conditions from the domain of physical ergonomics and its different variables within which is physiology, biomechanics and anthropometry, in order to establish interactions that lead us to improve and strengthen the protective elements in the informal population in Colombia, where it is possible to optimize job designs, raise awareness about the manual handling of loads, repetitive movements, pertinent positions, thus avoiding the presence of forced or anti-gravitational positions during working hours. Which generate the greatest impact at the musculoskeletal level and they are reflected in the increase in injuries.

In Colombia, labor informality is part of the economy of the country where a large part of its population is immersed in it, these workers perform the work practice without any specific control where they are analyzed and indicate if the development of this is done optimally and does not generate repercussions on their health, nor are there policies that include informal workers in their guidelines, thus leaving this working class unprotected and thus generating shortcomings in the national health and safety at work system, taking into account that this system should include to the entire working population, thus guaranteeing the reduction of figures related to accidents and occupational diseases

6. CONCLUSIONS

• Emphasis must be placed on the creation of methods of incorporation into the system and analysis of the worker from his position of work that guarantees the development of his work activity, thus allowing inclusion in the system where the coverage of his entire population is given and allow the mitigation of injuries.
• In Colombia there are no clear guidelines or methods for the development of job analysis, for workers in the informal area.
• Workers try the work practice without any specific control where they have analyzed and indicated if the development of this is done optimally and does not generate repercussions on their health.

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SOLVING WORK ILLNESSES IN PASTRY BY CREATING AN ERGONOMIC PASTRY TABLE

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Resumen: La investigación presenta métodos ergonómicos con resultados precisos. A base de dichos resultados surge la necesidad de diseñar y crear la mesa ergonómica repostera con el objetivo de evitar las lesiones y daños musculo-esqueléticos de los reposteros, la creación del equipo contiene una mesa ajustable con base giratoria e instrumento de alisado eléctrico. Este equipo Ayuda a aumentar la producción.

Se muestra la problemática en base a la acción de preparar y decorar pasteles, en la cual se han encontrado una gran cantidad de personas con lesiones musculo-esqueléticas las cuales a los reposteros de las empresas que se dedican a la producción de pásteles les ha creado como consecuencia una baja producción. Esta investigación relata la forma en cómo se han presentado los daños y como es que a lo largo del tiempo ha afectado de tal forma que hoy en día en cualquier pastelería, restaurant y empresas se encuentra al menos con una persona con este problema. Las técnicas utilizadas que se muestran en la información actual, son recolectadas de personas encontradas con estas lesiones. Por lo tanto la aplicación del estudio de la biomecánica y ergonomía es de gran impacto para la eliminación de las lesiones causadas por la repetitividad y posturas inadecuadas en estas actividades. A base de esta investigación se ha identificado la idea de cómo diseñar una mesa ajustable con base giratoria e instrumento alisador eléctrico que van a cubrir las necesidades en función a la actividad del repostero.

Palabras clave: Bienestar del repostero, movimientos repetitivos, lesiones, incapacidades

Relevancia para la ergonomía: Este equipo está aportando a la ergonomía y a la sociedad un equipo que le facilita al repostero su actividad, reduciendo la fatiga y disminuyendo el esfuerzo, ya que se elaboró a base de la necesidad de eliminar los movimientos repetitivos y posturas inadecuadas de los trabajadores, enfocándose a la salud ocupacional y así poder lograr una mayor comodidad e integridad del repostero.

Es de gran importancia dar a conocer al mercado este equipo, con el objetivo de concientizar a la sociedad en el ámbito de la repostería, para así cambiar la mentalidad y enfoque sobre el cuidado de la salud ocupacional, e informar sobre la utilización que traería el adquirir este equipo beneficiando principalmente a los trabajadores, empresas y establecimientos relacionados con esta actividad comercial.

Abstract: This investigation presents ergonomic methods with precise results. Based on these results arise the need to design and create an ergonomic pastry table with the objective of avoid injuries and skeletal muscle damages on the pastry chefs. The team project include an adjustable table with a rotating base and an electric smoothing instrument, the pastry table also helps to increase the production. The problem is shown based on the action of preparing and decorating the cakes, in which a large number of people with musculoskeletal injuries have been found, which the bakers of the companies that are dedicated to the production of cake have created as a result a low production. This investigation relates the way in which the damages and the consequences have been presented, such as the long term, the time, the present, the bakery, the restaurant and the companies meet at least one person with this problem. The techniques used that are shown in the current information are collected from people with these injuries. Therefore, the application of the study of biomechanics and ergonomics is of great impact for the elimination of injuries caused by repetitiveness and inadequate postures in these activities. A basis of this research has given an idea of how to make an adjustable table with a base of an electrical instrument and a response to the needs depending on the activity of the pastry chef.

Keywords: Pastry chef Wellness, repetitive movements, injuries, disabilities

Relevance to ergonomics:

This team is contributing to the ergonomics, to society, with an innovator product that facilitates the operator's activity, reducing fatigue and eliminating accidents since the product was developed based on the repetitive movements and postures inadequate of the pastry chef, focusing particularly on occupational health and being able to achieve better comfort and integrity.

It is very important to announce and inform the market about this product, to change the mentality and focus more on occupational health care, and to inform about the advantages of acquiring this equipment by benefiting mainly the operators or pastry chefs, companies, enterprises, and establishments related to this kind of commercial activity.

1. INTRODUCTION

The research presents ergonomic methods with precise results. Based on these results arises the need to design and create the ergonomic pastry table with the aim of eliminating injuries and musculoskeletal damage of the pastry chef who make cakes, the creation of the equipment contains an adjustable table with rotating base and smoothing instrument electric, so also increase production.

2. PROBLEM

In the preparation of cakes taking only the smoothing operation, you will find an alarming number of workers with different musculoskeletal injuries, such as injuries to the back, shoulder and hands of workers who perform this function. There are two ways of making cakes, artisanal and industrial, both are plaintiffs and more and more problems arise with respect to this activity because of the repetitive movements that take place during long working hours of 8 to 16 hours.

The use of the hands is essential to carry out the corresponding activities in that section of smoothing, due to the routine of an operator with this type of tools, machinery and equipment in their work do not help in reducing the injuries acquired daily, but on the contrary only They damage muscles, nerves, ligaments and tendons injuries that are due to frequent movements. Obtaining over time the lack of interest in carrying out their activities as a baker with a low productivity performance, the alarming thing is that it deteriorates their health without being able to return to normal in mobility.

2.1 THE SPECIFIC PROBLEMS ARE

- ✓ Back, shoulder and hand injury
- ✓ Eye damage
- ✓ Cause arthritis and rheumatism
- ✓ Tiredness of the legs and feet
- ✓ Repetitive movement
- ✓ Stress
- ✓ Disability costs
- ✓ Lower productivity
- ✓ High time in the activity of smoothing the cake

3. OBJETIVE

Design and create an adjustable table with rotating base and electric smoothing instrument for pastry, in order to eliminate repetitive injuries, injuries due to frequent stress, and injuries to muscles, nerves, ligaments and tendons. Based on field studies and investigations, biomechanics and ergonomics of real events.

3.1 THE ESPECÍFIC OBJETIVE ARE

- ✓ Elimínate musculoskeletal injuries.
- ✓ Enhenes productivity.
- ✓ Minimize times in making cakes.

- ✓ Avoid stress in operators.
- ✓ Decrease number of disabilities.
- ✓ Take care of occupational health.
- ✓ Get more production without repetitive movements.
- ✓ Prevent traumatic problems in hands, shoulders, arms and back.

4. METODOLOGY

The adjustable table with revolving base and electric smoothing instrument is a prototype that is based on basic and applied research since it is focused on anthropometric studies, occupational biomechanics, work study and ergonomics. Checking repetitive movements and inappropriate postures with the OCRA check list method. It also has a focus on quantitative research since the measures are verified according to the previous study of the needs of the people.

The adjustable table with rotating base and smoothing instrument, a field statistical research was carried out in different pastry shop small and medium-sized, in order to know in what percentage the smoothing of the cake is demanded as well as its repetitive movements and inadequate postures, with a diagram that causes In effect, all the factors that cause repetitive movements are observed. A result was obtained and the great impact that the ergonomic pastry table has, since there is no equipment that includes all the functions obtained from different appliances in the bakery.

5. FIGURES AND TABLES

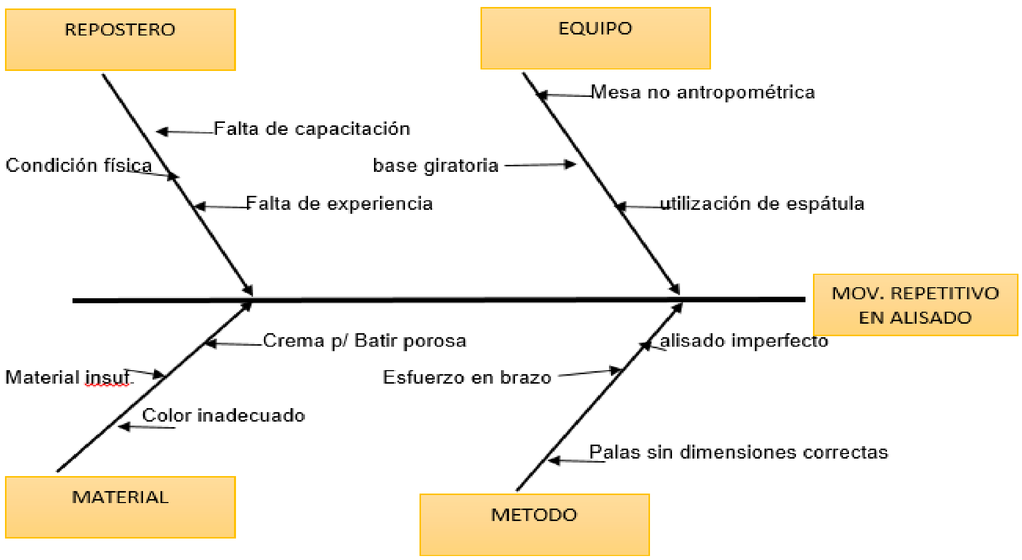

Figure 1. Cause-effect diagram applied to pastry

Table 1. Application of OCRA Check List method to a bakery

Checklist OCRA		Ficha: Resultados	
Empresa:	**Pasteles Lulu**	Fecha:	**7 de marzo del 2018**
Sección:	**Pasteleria**	Puesto:	**Repostero**
Descripción:	**Hornear, alisar y decorar pasteles**		

Table 2. OCRA method Check list risk factors

Factores de riesgo por trabajo repetitivo	Dch.	Izd.
Tiempo de recuperación insuficiente:	2	2
Frecuencia de movimientos:	4.5	4.5
Aplicación de fuerza:	12	8
Hombro:	12	12
Codo:	4	0
Muñeca:	8	0
Mano-dedos:	8	8
Estereotipo:	1.5	1.5
Posturas forzadas:	13.5	13.5
Factores de riesgo complementarios:	3	3
Factor Duración:	0.5	0.5

Table 3. Results of the OCRA Check list method

Índice de riesgo y valoración

	Dch.	Izd.
Índice de riesgo:	17.5	15.5
	No aceptable. Nivel medio	**No aceptable. Nivel medio**

Escala de valoración del riesgo:

Checklist	Color	Nivel de riesgo
HASTA 7,5	Verde	Aceptable
7,6 - 11	Amarillo	Muy leve o incierto
11,1 - 14	Rojo suave	No aceptable. Nivel leve
14,1 - 22,5	Rojo fuerte	No aceptable. Nivel medio
≥ 22,5	Morado	No aceptable. Nivel alto

6. RESULTS

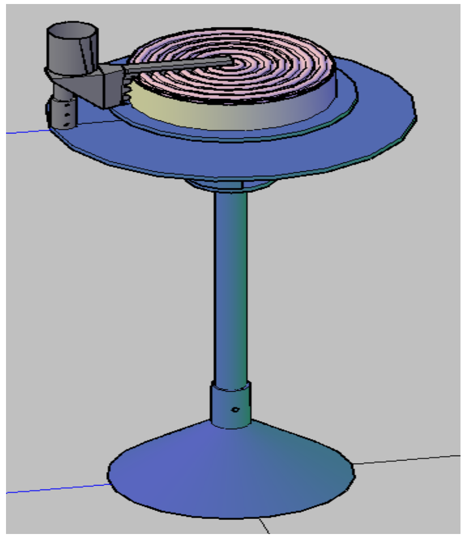

Figure 1. AutoCAD program, Isometric view of the ergonomic pastry table

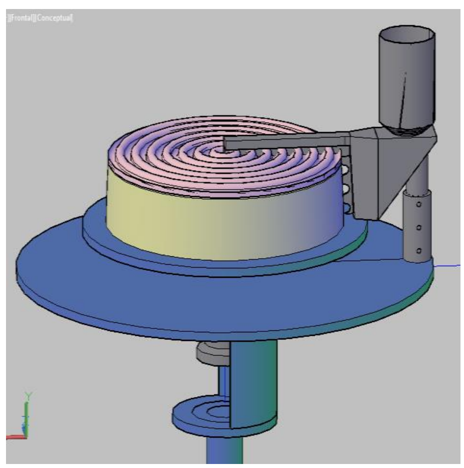

Figure 2. Front view of the ergonomic pastry table

Figure 3. Real isometric view of the ergonomic pastry table

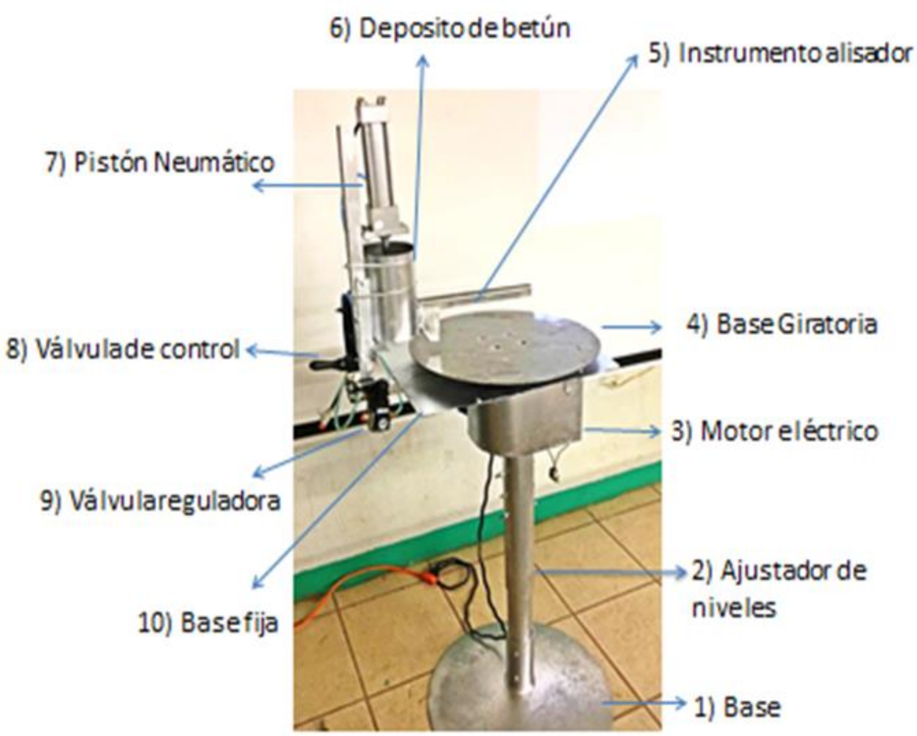

Figure 4. Composition of ergonomic pastry table

7. CONCLUSIONS

This equipment has the benefits of performing the activities of smoothing the cake in a shorter time, the worker who manages the equipment will not make it difficult in any way to smooth the cake since it only has to position it and when to crush a button and have put the cream in the tank, the base will start to rotate and therefore the cake will be smoothed automatically. Completely eliminating musculoskeletal injuries.

With the innovation of the ergonomic pastry table is eliminating all repetitive movement of the hands, since the hands is essential to perform the corresponding activities in the process of smoothing the cake in this way. The lesions, rheumatism, carpal tunnel, tendinitis, among others, are eliminated.

Contribution to Ergonomics: this team is contributing to ergonomics a team that facilitates the operator's activity, reducing fatigue and reducing effort avoiding accidents since this was developed based on the movements and positions of the workers, focusing on the occupational health and thus being able to achieve greater comfort and integrity.

Before the confectioner towards lifting and improper postures when smoothing cakes, now with the ergonomic pastry table you only have to press the button and automatically the equipment smoothies the cake, only the pastry worker deposits the bitumen.

It was found the most optimal way for the confectioners to elaborate their work in such a way that they are in a work area as comfortably as possible and benefiting the pastry company by increasing sales and productivity in a short time.

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ISBN 978-0-578-48915-5

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