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Prefacio

La Sociedad de Ergonomistas de México A.C. (SEMAC), como parte relevante de su actividad e interés en la difusión, promoción y apoyo a la ergonomía, ha organizado desde 1999 y de forma anual, su Congreso Internacional de Ergonomía. En Abril de 2011, Mexicali, B.C. nos abre sus brazos para recibir el XIII Congreso Internacional de Ergonomía, con la participación de ergonomistas profesionales e interesados en esta área.

La Ergonomía como un activo en empresas competitivas encierra en un solo círculo, por un lado a ergonomistas que la practican y por el otro a todo cúmulo de protagonistas de las mas variadas ciencias que en conjunto forman el "todo" de esta importante ciencia de la Ergonomía.

Las empresas competitivas, constituidas por personal competitivo, cada día dan más espacio a la práctica de la Ergonomía ya que además de lograr tareas mas confortables y saludables, logra un valor agregado que se da en la misma inversión realizada y en el regreso de su inversión muchas veces en un plazo mas corto del esperado.

El análisis del trabajo aunado a la corrección del mismo a través del proceso de mejora contínua es una puerta abierta al éxito que cualquier empresa seria puede lograr ...

Nuestro Congreso ... tu oportunidad

Los editores, árbitros y comité académico, a nombre de la Sociedad de Ergonomistas de México, A.C., agradecemos a los autores de los trabajos aquí presentados su esfuerzo, e interés por participar y compartir su trabajo y conocimientos en el XIII Congreso Internacional de Ergonomía de SEMAC. También agradecemos a los participantes y asistentes, provenientes de muy diversos lugares y formaciones, así como a todo el equipo de organización de este congreso, 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.

SOCIEDAD DE ERGONOMISTAS DE MÉXICO A.C.

“Trabajo para optimizar el trabajo”

Mexicali, B.C. Abril de 2011

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Children´s Anthropometric measures ages in elementary school from Caborca, Sonora, Mexico.

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RESUMEN

De los recursos con que cuenta la sociedad, el hombre quizá sea el más valioso, debido a que éste es el que impulsa y hace avanzar la sociedad, la económica, la política y la tecnología, es por eso que nace la inquietud de desarrollar una investigación con lo cual se establecerán medidas predeterminadas que deben usarse en el diseño del mobiliario adecuado para ciertos rangos de edades.

En base a la definición del problema se considera que es necesario realizar este estudio ya que si no se toma en cuenta las dimensiones antropométricas, los niños pueden presentar problemas como daños físicos, bajo desempeño, entre otros, mismos que con el tiempo pueden afectar en su desarrollo.

Con el estudio se busca obtener información sobre las medidas antropométricas de la población infantil en edad escolar primaria de la región de Caborca, Sonora. El propósito del presente trabajo es establecer tablas de dimensiones antropométricas en donde se determine el 5%, 50% y 95% percentil para los niños de las escuelas primarias de primero a sexto grado de ambos sexos residentes en H. Caborca, Sonora, México.

Una vez establecidos los percentiles, se podrán diseñar áreas de juego, estudio (trabajo), descanso, diversión o incluso el diseño de vestimenta, sin embargo otros puntos a tomar en cuenta son:

- Determinar áreas de desarrollo y su influencia en la salud del los niños.
- Mejorar la calidad de vida de los niños.
- Reducir el riesgo de enfermedades a largo plazo.
- Mejorar su desempeño, estado anímico y de salud.

El proyecto se limita a ocho escuelas donde se medirán a sesenta alumnos por cada una de ellas, desde primero a sexto grado en nivel primaria. Se registraron 22 medidas antropométricas.

Para la obtención de datos se tomaron al azar ocho escuelas de la Ciudad de Caborca Sonora, de estas se consideraron a cinco niños y cinco niñas de cada grado de primero a sexto, el tamaño de la muestra se tomo de formas aleatoria, para la realización de este estudio se necesito la participación de dos personas, mientas una tomaba las medidas, la otra anotaba los datos en la carta antropométrica.

Durante la recolección de datos en cada escuela se facilitó un aula acondicionada, donde existe buena iluminación, bajo nivel de ruido, ventilación adecuada, amplitud, muebles apropiados y absoluta privacidad, en la cual se acomodan los instrumentos de medición y se procede a la toma de medidas, los alumnos pasan uno a uno para ser medidos.

Las medidas se realizan y expresan en unidades del sistema métrico decimal, seleccionándose sólo aquellas que realmente van ayudar a cumplir los propósitos.

Una vez obtenida la muestra de cuatrocientos ochenta niños, los datos fueron capturados en una tabla de Microsoft Excel, se hicieron los cálculos de los datos de cada una de las medidas dando como resultado el máximo, mínimo y la media.

Teniendo como conclusión la importancia del registro de las medidas de los niños de las escuelas primarias, ya que con ello tendremos la seguridad de crear espacios adecuados para que desarrollen las actividades correspondientes y disminuir las posibilidades de lesiones por malas posturas o daños por traumatismo acumulado.

Palabras claves: Medidas Antropométricas, Antropometría y Ergonomía.

ABSTRACT

Of the resources available to society, man is the most valuable, because this is the motor that advances social, economic, political and technological, that's why we created the concern to develop an investigation will be introduced to predetermined measures to be used in furniture design appropriate for certain age ranges.

Based on the definition of the problem is considered necessary to perform this study because if you do not take into account the anthropometric dimensions, children can have problems with physical injury, poor performance, among other things, that over time they can affect their development.

The study is to obtain information on anthropometric measurements of children of primary school age in the region of Caborca, Sonora.

The purpose of this study is to establish anthropometric dimension tables used to determine the 5%, 50% and 95% percentile for primary school children in first through sixth grade of both sexes living in H. Caborca, Sonora, Mexico.

Once established percentiles, can be designed playgrounds, study (work), relaxation, entertainment or even clothing design, however, other points to consider are:

- Identify areas of development and its influence on the health of children.

- Improve the quality of life of children.
- Reduce the risk of long term illnesses.
- Improve your performance, mood and health.

The project is limited to eight schools where sixty students will be measured by each of them, from first to sixth grade in elementary school. 22 anthropometric measurements were recorded.

For data collection were randomly selected eight schools in the city of Caborca Sonora, these were considered in five boys and five girls from each grade one through six, the size of the sample was taken at random to perform This study requires the participation of two people, lie one took the measures, the scoring of anthropometric data in the letter.

During data collection in each school provided a conditioned classroom, where there is good lighting, low noise, ventilation, space, appropriate furnishings and absolute privacy, which fit the measurement instruments and proceeds to take measures, students spend one by one to be measured.

The measurements are made and expressed in metric units, selecting only those that will actually help accomplish the goals.

Once the sample of four hundred eighty children was captured data into a table in Microsoft Excel, calculations were made of data from each of the measures resulting in the maximum, minimum and average.

Bearing in conclusion the importance of registration of the measures of elementary school children, as this will create safety to develop adequate space for activities and reduce the chances of injury from poor posture or cumulative trauma injury.

Keywords: Anthropometric Measurements, Anthropometry and Ergonomics.

INTRODUCTION.

Education of children is a commitment that every civilized nation takes. Educate future generations requires a considerable investment. Despite this, efforts should be made to make education the more people will become a benefic for economic and social development of humanity.

So that effort be less and not incurs additional costs for not taken it some precautions dimensions about children is important to consider the design and the anatomical structure of individuals to understand and develop those areas that involve human performance.

Recent studies such as (Andreasi, Michelin, Rinaldi, & Burini, 2010) where he analyzed the association between physical fitness and health-related anthropometric and demographic indicators of children in three elementary schools in Botucatu, Brazil, as well that (Brown, Gotshalk, Katzmarzyk, & Allen, 2011) which compared the measures of adiposity in two cohorts of school children in the area of Hilo in Hawaii and measures related to parental reports of ethnicity, family income and the level of primary education or that of (Kovárová, Vignerová, Bláha, & Osancová, 2002) studied the prevalence of obesity in which the evaluation was done by cross sectional method in elementary schools in all regions of the Czech Republic with children from 7 to 11 years, the survey covered a total of 3,362 children (1,668 girls and 1,694 children) 12 anthropometric dimensions were taken, the outcome was the proportion of obese children of both sexes in the Czech Republic (children with IMC values above the 97th percentile of reference population) increased. These studies are an example of the importance of the use of ergonomics in the performance and prevention of diseases of children.

With all the technological advances that have occurred, you can have a better life. Studies have been conducted in several areas; one of them is the anthropometry, with which to determine the dimensions of the human body. In this area There are some studies in developed countries as in the case of (Habibi, Asaadi, & Hosseini, 2011) that examined the adequacy of school furniture for students of elementary schools Iranian participants aged between 7 and 12 years, it also in the same line is (Castellucci, 2010) who studied furniture design school assembly of the students where the main objective of the study was to register anthropometric, considered the main anthropometric dimensions of Portuguese students of elementary school.

Countries like the U.S., Canada, Japan, Chile, Brazil, Colombia, European Community, for mention some, they have anthropometric graphics representative of the population. The statistics tables are traditionally used in Mexico, only made reference to "Latin American people" where they include all the countries of Central and South America.

Panagiotopoulou (2003) conducted a study with the purpose of comparing the student's size of elementary school, with the dimensions of Desks to determine if the dimensions of the furniture is well designed and see if they promote good posture sitting considering the dimensions of children.

Jung (2005) developed a prototype of an adjustable chair for educational institutions, in which assesses their suitability according to international standards. His research began with simple mechanisms for height adjustment of chair legs and backrest height and seat depth.

In Mexico there are some anthropometric reference tables such as percentiles female population referred by (Avila 2001), percentile female population referred by (Liu 1999), percentile female population referred by (Lavender 2002), Anthropometric referenced letters design a the working population in Caborca, Sonora, Mexico from (Vasquez, Guzman, & Vega, 2010).

None of the above studies refer to children in elementary schools (Gonzalez, 2004) who analyzes the elementary school classrooms from the perspective of ergonomics, work is concentrated on a desk for education institutions prevail in the State of Sonora, suitable for the type of activities carried out, allowing the body to have good posture, with the aim of reducing the risk of injury and improve the teaching-learning process.

MATERIALS AND METHODS

For the development of the research team used the following:

- Three anthropometer model 01140, 01290 and 01291 marks Lafayette.
- One stadimeter marks Seca.
- One analog scale marks Seca.
- Two measuring tape marks Powerlock Stanley.
- Two flexible tapes.
- One chair designed with a height adjustment system.
- One computer to recording information.

The methodology for taking the measures was as follows:

To obtain the information has taken randomly selected eight schools from Caborca Sonora City, these were considered in five boys and five girls from each grade one through six, the size of the sample was taken at random to perform. This study requires the participation of two people, while one was taking other measures to record the details in the anthropometric letter.

During the data collection in each school provided a conditioned classroom, where there is good lighting, low noise, ventilation, space, appropriate furnishings and absolute privacy, which accommodate the measurement instruments and proceeds to take measures, the students pass one by one to be measured.

The 22 measures are shown in Table 1 are those reported for the case study of this work, according to the definitions used in similar anthropometric examinations conducted by the National Aeronautics and Space Administration (NASA 1978).

Table 1 Measures recorded in this study

Code	Name of the measure
N920	Weight
N805	Stature
N328	Standing eye height to
N23	Standing shoulder height
N949	Standing waist height
N80	Arm length from the wall
N122	Standing shoulder width
N223	Standing chest width
N931	Waist circumference stands
N178	Standing hip circumference
N758	Seat height sitting at the head
N330	Seat height sitting in the eye
N25	Seat height sitting shoulder
N312	Seat height to seated elbow to 90
N856	Sitting thigh-high
N2FGM	Height of sitting down
N4FGM	Seat height from floor to sit
N200	Back of the knee to the back of chair
N194	Length from knee to back of chair
N678	Height from floor to knee back
N529	Height from floor to knee
N381	Length from elbow to middle finger

ANALYSIS OF RESULTS

The results of research carried out in each of the measurements are shown in tables or records anthropometric population of Caborca Sonora elementary schools as follows:

Table 2 through 7 shows the total data information from first year to sixth grade girls; of 8 to 13 males. The tables show the calculation of the percentiles 5, 50 and 95%, and the maximum and minimum measurements. The calculations were analyzed in an Excel spreadsheet. The calculation is given weight in kilograms; the other measures are in centimeters.

Table 2 Results of the study on girls in 1st grade girls.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	19.9	25.6	41.4	15.2	52.6
N805	Stature	113.9	125.0	134.1	112.0	136.0
N328	Standing eye height to	103.7	112.0	122.1	101.0	126.0
N23	Standing shoulder height	93.4	100.0	109.1	92.0	112.0
N949	Standing waist height	69.9	77.0	85.8	68.0	89.0
N80	Arm length from the wall	53.0	59.0	67.2	50.0	70.0
N122	Standing shoulder width	26.3	29.2	32.8	23.5	36.5
N223	Standing chest width	17.1	19.2	23.2	16.0	26.7
N931	Waist circumference stands	53.6	60.0	70.5	25.0	84.0
N178	Standing hip circumference	62.0	70.0	83.1	57.0	95.0
N758	Seat height sitting at the head	60.0	66.0	71.2	57.0	74.0
N330	Seat height sitting in the eye	49.9	55.0	61.2	47.0	63.0
N25	Seat height sitting shoulder	37.9	42.5	47.2	36.0	49.0
N312	Seat height to seated elbow to 90	11.9	16.0	20.1	11.0	21.0
N856	Sitting thigh-high	5.9	8.0	10.1	5.0	14.0
N2FGM	Height of sitting down	95.8	102.0	109.1	89.0	110.0
N4FGM	Seat height from floor to sit	33.5	37.0	37.1	31.5	38.0
N200	Back of the knee to the back of chair	30.0	33.5	37.6	30.0	39.0
N194	Length from knee to back of chair	37.0	41.0	46.0	35.0	48.0
N678	Height from floor to knee back	30.9	35.0	36.6	29.0	38.0
N529	Height from floor to knee	38.0	42.0	44.5	37.5	45.0
N381	Length from elbow to middle finger	29.0	32.0	35.0	28.0	36.0

Table 3 Results obtained from the study on girls in 2nd grade girls.

		Percentiles				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	20.2	28.8	44.6	18.8	50.0
N805	Stature	116.0	128.0	136.5	114.0	142.5
N328	Standing eye height to	104.0	117.5	124.0	104.0	129.0
N23	Standing shoulder height	95.0	106.0	114.0	90.0	116.0
N949	Standing waist height	72.0	80.0	88.0	69.0	91.0
N80	Arm length from the wall	54.0	62.0	75.0	52.5	76.0
N122	Standing shoulder width	27.0	30.0	36.7	25.7	62.3
N223	Standing chest width	17.5	20.5	26.5	15.5	28.5
N931	Waist circumference stands	52.0	63.0	81.0	52.0	85.0
N178	Standing hip circumference	65.0	73.0	88.0	60.0	97.0
N758	Seat height sitting at the head	62.0	68.0	73.0	61.0	79.0
N330	Seat height sitting in the eye	52.0	58.0	62.0	51.0	69.0
N25	Seat height sitting shoulder	39.0	45.0	49.0	37.0	50.0
N312	Seat height to seated elbow to 90	13.0	17.0	20.5	12.5	28.0
N856	Sitting thigh-high	6.5	9.0	12.0	6.0	13.0
N2FGM	Height of sitting down	98.0	105.0	109.0	93.0	110.0
N4FGM	Seat height from floor to sit	33.0	37.0	37.0	31.0	37.0
N200	Back of the knee to the back of chair	31.5	34.5	38.5	30.0	41.0
N194	Length from knee to back of chair	39.0	43.0	48.0	37.0	49.0
N678	Height from floor to knee back	31.0	35.5	38.0	28.0	38.5
N529	Height from floor to knee	36.0	43.0	46.0	34.5	47.5
N381	Length from elbow to middle finger	31.0	34.0	38.0	29.0	40.0

Table 4 Results obtained from the study on girls in 3rd grade girls.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	24.0	31.6	45.6	23.2	73.0
N805	Stature	128.0	134.8	147.0	123.0	158.0
N328	Standing eye height to	115.5	124.0	134.2	113.0	148.0
N23	Standing shoulder height	105.0	111.3	121.7	103.5	134.0
N949	Standing waist height	79.0	86.8	91.0	77.0	106.0
N80	Arm length from the wall	60.8	67.0	72.0	57.0	80.0
N122	Standing shoulder width	28.0	31.9	36.6	26.8	48.0
N223	Standing chest width	18.3	21.6	26.7	17.7	30.4
N931	Waist circumference stands	55.0	64.0	78.2	50.0	92.0
N178	Standing hip circumference	67.0	76.5	89.1	66.0	106.0
N758	Seat height sitting at the head	67.0	71.0	75.1	66.0	80.0
N330	Seat height sitting in the eye	57.0	61.0	66.3	56.0	73.0
N25	Seat height sitting shoulder	43.4	47.0	50.1	40.0	57.0
N312	Seat height to seated elbow to 90	14.0	18.0	21.5	12.0	23.0
N856	Sitting thigh-high	7.0	9.5	13.1	6.5	16.0
N2FGM	Height of sitting down	103.0	108.0	112.7	103.0	123.0
N4FGM	Seat height from floor to sit	36.0	37.0	40.1	36.0	41.5
N200	Back of the knee to the back of chair	33.0	36.0	41.1	31.0	43.0
N194	Length from knee to back of chair	40.0	45.0	52.1	39.0	56.0
N678	Height from floor to knee back	34.9	36.5	41.0	33.0	43.0
N529	Height from floor to knee	36.2	44.0	48.1	16.5	57.0
N381	Length from elbow to middle finger	32.9	36.0	39.0	31.0	44.0

Table 5 Results of the study on girls in 4th grade girls.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	22.7	36.2	58.9	20.0	66.2
N805	Stature	127.9	142.0	153.1	125.0	161.0
N328	Standing eye height to	117.9	131.0	143.1	114.0	149.0
N23	Standing shoulder height	106.0	119.0	130.0	102.5	136.0
N949	Standing waist height	80.0	90.0	99.1	78.0	100.0
N80	Arm length from the wall	61.8	70.0	75.0	58.0	82.0
N122	Standing shoulder width	28.8	32.8	37.4	27.4	38.2
N223	Standing chest width	18.3	22.0	27.5	18.1	31.4
N931	Waist circumference stands	55.8	65.0	83.4	53.0	88.0
N178	Standing hip circumference	66.7	80.0	96.2	64.0	102.0
N758	Seat height sitting at the head	64.0	74.0	82.0	63.0	83.0
N330	Seat height sitting in the eye	54.0	63.0	71.1	32.0	72.0
N25	Seat height sitting shoulder	42.9	49.0	55.1	40.0	57.0
N312	Seat height to seated elbow to 90	14.9	19.0	25.0	13.0	39.5
N856	Sitting thigh-high	7.5	10.0	14.0	7.0	15.0
N2FGM	Height of sitting down	102.9	113.0	122.1	98.0	130.0
N4FGM	Seat height from floor to sit	37.0	39.0	43.0	35.0	46.0
N200	Back of the knee to the back of chair	34.0	39.0	43.6	32.5	45.0
N194	Length from knee to back of chair	43.3	48.0	54.1	39.5	55.0
N678	Height from floor to knee back	35.5	39.0	43.0	33.0	43.5
N529	Height from floor to knee	42.0	47.5	53.8	36.0	56.5
N381	Length from elbow to middle finger	34.0	38.0	41.3	33.5	43.5

Table 6 Results of the study in girls 5th grade girls.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	28.6	42.5	63.3	27.8	87.0
N805	Stature	136.0	146.0	156.2	135.0	170.0
N328	Standing eye height to	126.0	134.0	147.0	125.0	158.0
N23	Standing shoulder height	114.0	122.0	134.1	110.0	146.0
N949	Standing waist height	83.0	93.0	100.1	43.0	113.0
N80	Arm length from the wall	62.0	72.0	80.0	60.0	85.0
N122	Standing shoulder width	30.3	34.2	39.4	29.8	43.0
N223	Standing chest width	20.0	23.0	30.0	18.8	32.3
N931	Waist circumference stands	56.9	69.5	87.2	54.0	95.0
N178	Standing hip circumference	71.0	85.0	103.3	70.0	114.0
N758	Seat height sitting at the head	70.7	75.0	83.0	69.0	83.0
N330	Seat height sitting in the eye	60.0	65.5	72.1	59.0	74.0
N25	Seat height sitting shoulder	46.0	51.0	56.0	45.0	59.0
N312	Seat height to seated elbow to 90	17.0	20.0	24.0	14.0	26.0
N856	Sitting thigh-high	9.0	11.5	15.1	8.0	18.5
N2FGM	Height of sitting down	108.9	117.5	123.1	103.5	130.0
N4FGM	Seat height from floor to sit	37.0	40.8	43.5	37.0	47.0
N200	Back of the knee to the back of chair	35.5	40.8	49.6	33.0	52.5
N194	Length from knee to back of chair	42.5	49.5	59.1	40.0	63.0
N678	Height from floor to knee back	36.9	40.0	45.5	35.0	51.0
N529	Height from floor to knee	44.4	50.0	56.0	41.5	60.0
N381	Length from elbow to middle finger	36.0	39.3	44.3	34.5	51.0

Table 7 Results of the study on girls in 6th grade girls.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	32.4	51.1	72.7	27.4	92.8
N805	Stature	141.0	154.0	161.0	133.0	165.0
N328	Standing eye height to	130.0	143.0	151.0	122.0	155.0
N23	Standing shoulder height	118.0	129.0	135.2	110.0	138.0
N949	Standing waist height	88.0	97.0	103.5	79.0	104.0
N80	Arm length from the wall	69.0	75.0	81.2	67.0	86.0
N122	Standing shoulder width	31.6	36.6	44.5	30.2	45.6
N223	Standing chest width	20.8	24.9	30.4	18.8	32.5
N931	Waist circumference stands	61.9	75.0	94.6	59.0	106.0
N178	Standing hip circumference	75.0	92.5	108.6	75.0	120.0
N758	Seat height sitting at the head	72.9	79.0	84.1	71.0	87.0
N330	Seat height sitting in the eye	63.0	69.0	74.1	62.0	77.0
N25	Seat height sitting shoulder	49.0	54.0	57.0	48.0	58.0
N312	Seat height to seated elbow to 90	17.0	20.5	24.0	16.0	26.0
N856	Sitting thigh-high	9.5	12.5	17.0	8.5	21.0
N2FGM	Height of sitting down	110.0	121.0	125.1	109.0	128.0
N4FGM	Seat height from floor to sit	37.0	41.0	44.0	36.0	45.0
N200	Back of the knee to the back of chair	35.0	43.0	49.1	32.5	51.0
N194	Length from knee to back of chair	44.0	54.0	60.1	41.0	61.0
N678	Height from floor to knee back	38.0	41.0	43.1	34.5	45.0
N529	Height from floor to knee	44.3	51.5	55.5	36.0	56.5
N381	Length from elbow to middle finger	38.0	41.3	43.5	34.0	45.0

Table 8 Results of the study in children in 1st grade boys.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	20.8	24.9	35.6	19.6	41.8
N805	Stature	117.0	124.3	132.1	114.0	135.0
N328	Standing eye height to	104.0	112.0	117.2	102.0	121.0
N23	Standing shoulder height	93.8	100.0	105.1	90.5	109.0
N949	Standing waist height	70.4	75.0	79.5	68.0	83.0
N80	Arm length from the wall	55.0	60.0	64.2	54.0	69.0
N122	Standing shoulder width	26.7	28.8	32.6	25.8	34.3
N223	Standing chest width	18.0	19.5	22.6	16.5	24.1
N931	Waist circumference stands	53.0	58.0	73.6	53.0	85.0
N178	Standing hip circumference	64.0	69.0	85.0	63.0	89.0
N758	Seat height sitting at the head	61.0	66.0	71.1	59.0	72.0
N330	Seat height sitting in the eye	50.0	56.0	60.2	49.5	93.0
N25	Seat height sitting shoulder	39.0	42.0	47.1	37.0	78.0
N312	Seat height to seated elbow to 90	13.0	16.0	21.6	11.0	51.0
N856	Sitting thigh-high	6.0	7.5	10.0	6.0	42.0
N2FGM	Height of sitting down	95.0	103.0	107.0	92.0	109.0
N4FGM	Seat height from floor to sit	33.0	37.0	38.0	32.5	38.0
N200	Back of the knee to the back of chair	30.0	33.1	40.0	29.0	42.0
N194	Length from knee to back of chair	37.0	40.0	47.0	37.0	48.0
N678	Height from floor to knee back	31.0	34.5	37.0	29.5	37.5
N529	Height from floor to knee	38.0	41.5	44.0	36.0	45.0
N381	Length from elbow to middle finger	31.0	33.0	35.1	29.5	43.0

Table 9 Results of the study on children in 2nd grade boys.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	21.0	27.2	47.6	20.0	55.4
N805	Stature	121.8	129.5	140.2	115.0	144.0
N328	Standing eye height to	109.8	119.0	129.0	105.0	132.0
N23	Standing shoulder height	97.8	106.5	117.0	93.5	120.0
N949	Standing waist height	69.9	80.0	88.1	66.0	89.0
N80	Arm length from the wall	57.0	64.0	71.1	55.0	75.0
N122	Standing shoulder width	27.0	30.0	37.2	26.0	37.4
N223	Standing chest width	17.9	19.9	25.5	16.8	26.8
N931	Waist circumference stands	53.5	58.5	81.0	52.0	89.0
N178	Standing hip circumference	63.9	72.0	88.1	61.0	95.0
N758	Seat height sitting at the head	63.0	69.0	73.0	62.0	75.0
N330	Seat height sitting in the eye	53.5	58.3	63.0	53.0	68.5
N25	Seat height sitting shoulder	40.0	44.5	49.1	39.5	51.0
N312	Seat height to seated elbow to 90	14.5	17.0	20.0	14.0	22.0
N856	Sitting thigh-high	6.0	8.0	11.5	6.0	13.0
N2FGM	Height of sitting down	98.0	106.0	110.3	98.0	118.0
N4FGM	Seat height from floor to sit	35.0	37.0	37.0	32.5	41.0
N200	Back of the knee to the back of chair	31.0	34.0	38.0	30.0	42.5
N194	Length from knee to back of chair	39.0	42.8	47.1	37.0	53.0
N678	Height from floor to knee back	32.0	35.5	41.7	28.5	45.0
N529	Height from floor to knee	38.0	42.5	46.1	32.0	49.0
N381	Length from elbow to middle finger	31.5	34.3	38.0	30.0	40.5

Table 10 Results of the study in children 3rd grade boys.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	22.6	31.1	49.2	21.2	70.6
N805	Stature	126.0	138.0	145.1	124.0	149.0
N328	Standing eye height to	114.0	125.5	133.0	111.0	136.0
N23	Standing shoulder height	103.8	113.8	122.5	100.0	123.0
N949	Standing waist height	79.0	84.0	92.1	77.0	93.0
N80	Arm length from the wall	60.0	67.0	78.0	57.0	79.0
N122	Standing shoulder width	27.8	31.4	36.7	27.3	42.5
N223	Standing chest width	18.0	21.0	25.8	17.2	30.3
N931	Waist circumference stands	53.9	63.0	79.5	32.0	101.0
N178	Standing hip circumference	65.0	77.0	94.1	64.0	112.0
N758	Seat height sitting at the head	65.0	71.0	76.1	64.0	80.0
N330	Seat height sitting in the eye	56.0	61.0	67.1	54.0	71.0
N25	Seat height sitting shoulder	41.9	46.0	52.0	39.0	53.0
N312	Seat height to seated elbow to 90	14.0	17.0	21.0	11.5	24.0
N856	Sitting thigh-high	7.0	9.3	12.5	6.5	13.5
N2FGM	Height of sitting down	102.0	109.0	117.1	101.0	119.0
N4FGM	Seat height from floor to sit	36.5	37.0	40.0	36.0	41.5
N200	Back of the knee to the back of chair	32.0	35.5	40.1	30.5	44.5
N194	Length from knee to back of chair	40.0	44.5	50.1	40.0	52.0
N678	Height from floor to knee back	35.0	37.2	42.1	34.5	43.0
N529	Height from floor to knee	39.4	44.8	49.2	37.0	52.0
N381	Length from elbow to middle finger	33.0	36.5	40.0	32.0	41.0

Table 11 Results of the study on children in 4th grade boys.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	27.6	41.7	65.7	24.8	75.4
N805	Stature	132.5	141.5	154.0	130.0	157.0
N328	Standing eye height to	121.0	130.0	145.0	120.0	146.0
N23	Standing shoulder height	109.0	119.0	132.0	107.0	135.5
N949	Standing waist height	81.4	88.0	97.0	79.0	99.0
N80	Arm length from the wall	64.9	71.0	80.0	61.0	86.0
N122	Standing shoulder width	30.0	33.8	40.5	23.5	41.0
N223	Standing chest width	19.2	22.9	29.5	18.8	31.2
N931	Waist circumference stands	58.0	75.5	90.2	55.0	98.0
N178	Standing hip circumference	69.0	84.0	102.1	67.0	108.0
N758	Seat height sitting at the head	70.0	74.0	79.1	69.0	80.0
N330	Seat height sitting in the eye	60.0	64.0	69.5	59.0	71.0
N25	Seat height sitting shoulder	45.0	49.0	56.0	44.0	57.0
N312	Seat height to seated elbow to 90	14.0	18.0	24.1	13.0	27.0
N856	Sitting thigh-high	7.5	10.3	14.5	7.0	16.0
N2FGM	Height of sitting down	107.0	113.5	122.1	105.0	126.0
N4FGM	Seat height from floor to sit	37.0	39.5	43.0	37.0	43.0
N200	Back of the knee to the back of chair	33.0	37.8	43.0	31.0	43.5
N194	Length from knee to back of chair	42.0	47.3	54.1	41.5	56.0
N678	Height from floor to knee back	35.4	38.8	43.0	34.0	43.5
N529	Height from floor to knee	44.0	47.5	54.0	43.0	55.0
N381	Length from elbow to middle finger	35.0	38.5	42.0	34.0	43.0

Table 12 Results of the study in children 5th grade boys.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	29.2	41.6	73.2	27.4	82.8
N805	Stature	135.5	146.0	158.0	133.0	164.0
N328	Standing eye height to	124.0	134.0	147.0	123.0	152.0
N23	Standing shoulder height	111.5	122.0	134.0	110.5	140.0
N949	Standing waist height	83.5	91.0	100.0	80.0	102.0
N80	Arm length from the wall	67.0	72.0	81.0	64.0	83.0
N122	Standing shoulder width	31.0	34.7	40.5	30.6	42.0
N223	Standing chest width	20.0	23.0	32.0	19.2	34.5
N931	Waist circumference stands	60.0	72.0	102.0	58.0	105.0
N178	Standing hip circumference	70.0	85.0	106.0	69.0	113.0
N758	Seat height sitting at the head	70.0	75.5	82.0	69.0	83.0
N330	Seat height sitting in the eye	59.0	66.0	71.0	58.0	73.5
N25	Seat height sitting shoulder	46.0	50.0	55.0	44.0	56.0
N312	Seat height to seated elbow to 90	15.0	19.0	24.5	13.5	25.0
N856	Sitting thigh-high	8.0	11.0	15.0	7.5	16.5
N2FGM	Height of sitting down	109.0	116.0	126.0	106.0	128.0
N4FGM	Seat height from floor to sit	38.0	40.0	44.5	37.3	44.5
N200	Back of the knee to the back of chair	35.0	38.5	44.0	33.5	45.0
N194	Length from knee to back of chair	43.5	49.0	55.5	43.0	57.0
N678	Height from floor to knee back	36.0	39.5	45.0	35.5	49.5
N529	Height from floor to knee	44.5	49.0	56.5	38.5	57.0
N381	Length from elbow to middle finger	36.5	39.0	44.0	36.0	44.0

Table 13 Results of the study in children 6th grade boys.

		Percentile				
Code	**Name of the measure**	**5%**	**50%**	**95%**	**Minimum**	**Maximum**
N920	Weight	36.4	48.0	76.3	30.6	90.4
N805	Stature	141.9	151.5	167.1	140.0	173.6
N328	Standing eye height to	131.9	141.5	156.2	130.0	164.0
N23	Standing shoulder height	120.0	127.8	140.0	119.0	144.0
N949	Standing waist height	88.0	94.0	104.1	78.5	109.5
N80	Arm length from the wall	70.0	77.0	83.1	69.0	92.0
N122	Standing shoulder width	32.6	36.5	41.4	31.4	43.3
N223	Standing chest width	21.5	23.9	31.4	20.0	33.6
N931	Waist circumference stands	60.9	73.0	104.1	58.0	106.0
N178	Standing hip circumference	76.0	87.5	109.1	70.0	116.0
N758	Seat height sitting at the head	71.0	78.0	86.1	70.0	89.0
N330	Seat height sitting in the eye	62.0	68.0	76.1	62.0	78.0
N25	Seat height sitting shoulder	48.0	52.8	58.1	47.0	61.0
N312	Seat height to seated elbow to 90	16.0	20.0	25.0	15.0	27.0
N856	Sitting thigh-high	9.0	12.8	17.0	8.0	19.0
N2FGM	Height of sitting down	112.0	117.5	131.1	107.0	134.0
N4FGM	Seat height from floor to sit	37.5	41.3	46.6	36.0	48.0
N200	Back of the knee to the back of chair	35.0	40.5	47.5	33.0	56.0
N194	Length from knee to back of chair	45.4	50.3	57.1	43.0	59.0
N678	Height from floor to knee back	38.0	41.5	46.9	35.0	54.0
N529	Height from floor to knee	47.0	51.8	56.0	44.0	59.0
N381	Length from elbow to middle finger	38.5	42.0	47.1	38.0	48.0

CONCLUSIONS AND RECOMMENDATIONS.

Currently, tools and techniques used are increasing in sophistication and accuracy. The computer has made it possible to record and process data information for immediate results in the form of clear graphics and simulations. Anthropometry has many practical uses, and some of them beginners. For example, is used to assess nutritional status, growth monitoring of children, assist the design of work environments and everyday objects, etc.

The resulting values from this study are of fundamental importance for the design elements that should be used by children in these age groups, such as furniture for schools, parks, transportation items, sports equipment, toys, clothing and so any element with which the children should live.

In Mexico there are not enough studies of child anthropometry, compared to other countries where if you have been given more importance to this sector, which is why research has focused on the child population in elementary schools from H. Caborca, Sonora.

With these records may initiate what could be the study of children at a national level as said Daniel Vergara Lope, which recommended that studies be conducted with the Mexican population, because they are imported products and equipment that did not be able to fit dimensions of Mexicans.

The data information provided in this work could be taken as a basis for further studies, which used to see changes in the physical development of infants. There are variations in weight, size of children of similar age and design for workstations, we refer them to places where children develop their daily activities. These studies set the stage for forming a database containing the dimensions of children of elementary schools in Sonora.

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WORKSTATION FOR STUDENTS OF INDUSTRIAL DESIGN UAEM

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RESUMEN

Habiéndose concluido las dos primeras etapas del proyecto de investigación titulado "Puesto de trabajo áulico para el discente de diseño industrial", con registro ante la Secretaría de Investigación y Estudios Avanzados de la Universidad Autónoma del Estado de México (UAEM) folio 2510/2007U, que en conjunto permitieron obtener la información antropométrica necesaria para diseñar el objeto en cuestión, fue posible realizar la etapa creativa y de experimentación. Al respecto de esta última fase, todo el trabajo fue realizado tomando como referencia el método de diseño establecido por Bernd Löbach, alcanzándose a diseñar un mobiliario pertinente para los estudiantes de diseño industrial de la UAEM, el cual permite realizar actividades teóricas y prácticas de la formación, en una posición sedente sana.

Palabras clave: Diseño industrial, Mobiliario, Postura sana.

ABSTRACT

Having completed the first two stages of the research project entitled "Aulic workstation for industrial design students", registered at the Secretaría de Investigación y Estudios Avanzados de la Universidad Autónoma del Estado de México (UAEM) Folio 2510 / 2007U, which altogether allowed us to get the anthropometric information needed to design the object in question was possible to make the creative and experimental stage. As regards to this last stage, all the work was done by reference to the design method introduced by Bernd Löbach, reaching a furniture design appropriated for industrial design students at UAEM, which allows a theoretical and practical activity for training in a healthy sitting position.

Keywords: industrial design, furniture, healthy posture.

INTRODUCTION

Way back in ancient Greece, specifically in the act of the old school of Aristotle, the teaching process brings to mind the image of that teacher who shared his knowledge while walking outdoors accompanied by a small group of disciples. And where necessary to make the act of sitting by the teacher, his companions gathered around him, sitting where and how they could.

Over time, during the nineteenth century, the concept of school was consolidated, it was now time to seek to provide students a learning process through homogeneous groups in age, and in the best cases, enclosed spaces where coexist seats and desks that lets you take notes without difficulty generating the walking and do even more ... without mishap.

Today, the classroom, in a simple conceptualization, is defined as the space where the coexistence tables, chairs and desks, routed to a board, which is characterized by which all things being equal, being aligned with each other, and the spacing between them, allow the free movement of teachers and also facilitate dynamic developing in favor of education. Besides this, the tools have changed too, so that pen and paper have given way to specialized tools and laptops.

It is a fact that the pedagogical dynamics has tried to correct, moving from a traditional model to a critical and active type. However, the conduct of this action have hardly turned his eyes to the furniture. Just enough to observe any classroom that is said to belong to a quality school, to confirm that these objects remain almost intact in formal settings, perhaps, to change color or material. And if this is added that, given the growing demand for national education classrooms previously housed 30 students in favorable conditions for teaching and is now expected to accommodate 45 or more, you can set the school furniture is outdated and therefore, could be questioned in a way, the relevance of the teaching process.

From the above, and after multiple discussions among teachers of industrial design at the University Center Zumpango, under the Autonomous University of Mexico State, was the need to design furniture that would make both theoretical and practical activities within a classroom for training students in the graduate education program in industrial design.

DEVELOPMENT

Having identified the main needs coexisted around the furniture in the classrooms of the CU Zumpango industrial design, was established at first objective: to design a courtly job for industrial design students at UAEM. After that, and with the intention that the proposed design not only be functional for the educational area in question is determined to make an anthropometric survey of industrial design students UAEM headquarters located in Toluca, Valle de Chalco and Zumpango course. Activity which produced several anthropometric tables, where it was feasible to identify all critical dimensions to begin designing the job.

Once they had anthropometric parameters, devoted himself to work aimed at the analysis stage of existing products, and interesting design that is, to good solutions, but in all cases, avoiding plagiarism of ideas. So, after obtaining information regarding the shop fittings used by industrial design students, most of the institutions visited, both public and private, it was observed that the misnamed drawing table or drawing tables were all similar, ranging in size from The 120cm long, 90cm wide and 90cm high, counting in all cases to support seated in a height range 60cm, and are commonly known as lab benches.

During this activity, it was observed that the students interact in the drawing boards, they tended to adopt a sitting position where the natural curvature of the spine is lost (Fig. 1), and that without being a professional in orthopedics Certainly cause in the future, a serious injury in bones. Thus, while ratifying the low efficiency of school furniture for drawing, now laid bare more of a problem ... to promote a healthy posture for the design student. So it was necessary to stop on the way to check what's sitting on and what could be called healthy posture.

Figure 1. Posture of an industrial design student.

About the ultimate grounds, must be within the field of industrial design, "say many professionals, " the conceptualization of an article for the sitting of the people has been one of the more difficult is artifacts. To a large extent, both the object used to support the sitting, as the bottom of it, were created for a specific purpose, but which over the years, have served for many other secondary purposes.

Elaborating, the object to which reference is made and that most people identify as a chair or variations of it, came up with the intention of being a symbol of power or hierarchy-recall here the ancient Egyptians thrones, elements that be used in Western civilization, they adopted the role of serving as an object to support multiple sedentary. For its part, the buttocks are mostly formed by the gluteal muscles that have until now, the task of participating in the movement of the human body via a small lever arm. As far as that of Antonio Bustamante (2004), instead of being called buttocks, should be identified as walkers.

In this regard, it is envisioned that the biggest mistake-if you can call it that, is not in the proper design of the chair, but rather in the position that this object will induce, as an individual sitting in all buttocks, being given static use an item that was made for the dynamics.

However, properly analyzing the position an individual adopts when perched on a chair or similar object in its function, it is influenced by five effects:

- *E. Biomechanics: where the position will depend on the relationship that the dimensions of the object vs. complexion and stature of the user.*
- *E. Action: referred to the position will be determined by that object with the individual in front of him during the development of a task.*
- *E. Cultural: establishes that the position will be the result of design style furniture, which in the vast majority has been set thinking more about the use of materials and cost reduction in the functionality and potential user.*
- *E. Humor: mention that the position will be in readiness with the mood of the user.*

- *E. Starring where the position adopted is derived from the social context in which the user is laboring.*

Concerning the design activity itself and based on the method of Bernd Löbach, it first saw the return of fellow studying Modesto Marisol (2009), where´re the anthropometric tables of industrial design students from the campus Toluca, Valle de Chalco and Zumpango. As second generation was proposed designs for two-dimensional and three-dimensional way, arriving at the proposal called ADN001 constructed (Figure 2), which after a study of use (Figure 3) was identified that there was feasible to generate discomfort in the area of the ball joints and a bad foot position, and prevents rapid user access and egress, to occupy too large an area, excessive weight to present and create a negative visual impact on users.

Figure 2. Courtly job called ADN001.

Figure 3. Analysis ADN001.

Being clear about the negative aspects of ADN001 and objective of the project, was determined to separate the structure, so that the graphic support was independent sitting support to thereby speed up user access and egress in an emergency or simply to interact in the classroom. With regard to support sitting, three prototypes (Figures 4, 5 and 6), which were tested with three different body dimensions of students, which identified the average size of elbow support. Similarly, data that was compared with anthropometric study.

Figure 4. Prototype 08-A

Figure 5. Prototype 16-A

Figure 6. Prototype 11-A

Because of adjustments in dimensions and trim, was performed a functional model of graphic support, the same as evidence to a difference of height with current CU drawing board (Figure 7).

Figure 7.
Existing drawing board (left) and functional model (right)

Having determined the dimensions of the support chart and established aspects of style and unity among the components, we proceeded to generate a first prototype called PTA001 (Figure 8), which like its predecessors, was tested during a working session in the Unit Descriptive Geometry learning. The findings suggest that the object met the requirements for the student to interact in both the drawing room as in a traditional classroom (Figure 9 and 10).

Figure 8. Prototype PTA001

Figure 9. Prototype Analysis sitting PTA001

Figure 10. Analysis Prototype standing PTA001

Advantages PTA001 prototype is the deck is 16 gauge steel, something that gives firm support and provides more stability and allow the student has a secure base for cutting activities without affecting the surface and thus generate a low quality of stroke during future sessions. As for the seat, which only provides the necessary support in the area of the iliac, improve seating posture and preventing the user to bow down his spine and developed malformations or musculoskeletal pain. While the height of the graphic support, allowing review of documents or sheets of drawing standing.

CONCLUSIONS

So far above it was possible to confirm that, to design an object intended to maintain a sitting posture is not easy, as this requires constant testing and analysis work. In addition to facing the problem of the pairing order and culture, which derives from being for many years a person accustomed to a concept, and the refore it tends to reject even if the benefits are noticeable when using it.

Finally, commenting that the industrial design, in addition to solving a problem through an object is, and should be a trigger of culture, so it is expected that the allylic job for students UAEM design is a starting point for generating more school furniture, which has a priority to promote healthy posture.

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ERGONOMICS IN THE EVALUATION AND SELECTION OF ADVANCED MANUFACTURING TECHNOLOGY

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Resumen

Este documento presenta un estudio teórico y una revisión de la literatura sobre aspectos importantes en el campo de la Ergonomía implicados en la selección de Tecnología de Manufactura Avanzada (TMA). La industria moderna ha incrementado sus inversiones en esta tecnología, sin embargo; los modelos actuales de planificación, evaluación y justificación de TMA se consideran incompletos ya que los atributos ergonómicos requeridos en los equipos generalmente son obviados o subestimados. Por lo tanto, algunos problemas relacionados con la TMA y la automatización se describen en esta investigación. Así mismo, los atributos ergonómicos que deben tomarse en cuenta en la selección de TMA son expuestos a partir de una revisión de la literatura. Por último un nuevo enfoque ergonómico de evaluación de esta tecnología se describe mediante el Modelo Evaluación de Compatibilidad Ergonómica (MECE) para la selección de TMA desde una perspectiva multiaributo.

Palabras Clave: Ergonomía, Atributos Ergonómicos, Tecnología de Manufactura Avanzada.

Abstract

This paper presents a theoretical study and a literature review of important ergonomic issues on the selection of Advanced Manufacturing Technology (AMT). Due to actual models for planning, evaluation and justification of AMT are found to be incomplete in order that ergonomic attributes of the equipment are obviated or underestimated. In this way, problems related with automation and AMT are exposed in this work. Also the ergonomic attributes that must be considered in the AMT selection are explained from an extensive literature review. Finally an ergonomic compatibility approach is described using the Ergonomic Compatibility Model for the selection of AMT from a multi-attribute perspective.

Key Word: Ergonomics, Ergonomic Compatibility Attributes, Advanced Manufacturing Technology

INTRODUCTION

Advanced Manufacturing Technology (AMT) is regarded as one of the most critical resources of manufacturing companies in the world to achieve competitiveness. The constant and rapid evolution of the AMT has led to the manufacturing sector towards progressively automated processes. Historically, this development was originally led by a technical centered approach, yet the results have not been entirely satisfactory; reason why it has been developed a new human-centered approach, in which the capabilities and limitations of the human being must be integrated and taken into account in the design, as well as the evaluation, selection and implementation of this technology. The ergonomics is the science whose purpose is entirely appropriate for this approach, because it promotes the understanding of the capabilities and limitations, thereby contributing to the design of most human-compatible systems. Actual models for evaluating and selecting AMT are scarce of the ergonomic approach which can includes multiple ergonomic attributes that must be considered to guide a more complete decision on the acquisition of equipment, so it is considered that the ergonomic science and its principles should have a more active intervention on evaluation processes for the selection of AMT. This document presents a review of reflective literature which develops the theme of ergonomics in the selection of AMT. A great opportunity for research in this area is overlooked and therefore this work aims to develop the relevant topics associated with the ergonomics science and its intervention to support the processes of evaluation and selection of this technology in decision making processes.

THE CONCEPT OF ADVANCED MANUFACURING TECHNOLOGY

Although the AMT is for Säften (2007) the collective name given to modern technology integrated to manufacturing, it includes Computer Aided Manufacturing (CAM), Computer Numerical Cotrolled (CNC), and the Flexible Systems for Manufacturing. For Rao (2007), also includes robotics, rapid prototyping, environmentally sustainable technologies, among others. Boyer et al. (2000), classify it according to its areas of application, which are: design, manufacturing and administration. Computer-aided engineering and CAD (Computer Aided Engineering) are examples of the first one; while CAM, robotics, control systems process in real time, FMS and the automated systems of materials handling, are examples of the second one. Finally, the use of internet to support decision-making systems, Material requirements planning and Material Requirements Planning (MRP), are examples of the application for the administration. According to Bayo-Moriones and Díaz (2004), Saraph and Sebastian (1992), this technology has promoted a transcendent change in the competitive strategies of manufacturing companies. Companies are interested in AMT since they can obtain a combination of flexibility, efficiency and quality in such a way that they can minimize significantly, costs and optimize the quality. According to Dean and Snell (1991) the most important feature found is related to its potential to integrate the different stages of the process of manufacturing. As a result, the manufacturing of large volumes of standardized products, or small batches with high quality (Gyan-Baffour, 1994) can be afforded. In summary, AMT is such technology generally related to the use of the computer, which can be integrated in manufacturing operations having a significant impact on the product, process and information aspects of the system.

RELEVANT TOPICS ABOUT ERGONOMICS IN THE SELECTION OF AMT

In this part it is presented a discussion about the relationship between human and AMT and the relevance of human intervention. Also, it is explained that Human Factors and Ergonomics are aspects that have been relegated in actual models for AMT selection and evaluation, consequently there are important health and safety implications related to AMT.

Human and AMT: an interdependent relationship

For Vincent (1999) the technical-centered approach has historically dominated the integration of the AMT within a system where people interact in a dynamic environment with incomplete and uncertain information, in which there are unexpected problems and actions are computer-mediated creating complex socio-technical systems. According to Kesseler (2006) the technical-centered approach describes that systems provide what is technically possible (Automation) without sufficient and adequate attention to the interaction with human beings and because failures are often unexpected, designers have reduced but not eliminated, human intervention. While the human intervention has been reduced or nullified, human beings have been affected in different ways, including the crucial adaptation of workers to new skills. To this end, the physical abilities are now superseded by the cognitive, reducing its capacity and experience in the operations which are now automated, (Mital and Pennathur 2004 and Reason 1990).

For Endsley (1993), Siemieniuch and Sinclair (1995), human skills are still needed, and are even more critical than before, due to a complex man-machine system. These human skills usually are required for management of heterogeneous equipment, multimedia databases with operations in real time, monitoring task, other tasks that require anticipation, judgment, rapid diagnosis, programming, maintenance and adjustment, quality control and rapid intervention in difficult situations. According to Wobbe (1990), when tasks cannot be automated or are complex and require assessment and judgment the human being is able to perform them with relative efficiency. Therefore, human beings and the AMT maintained an interdependent relationship and to achieve a successful implementation of this technology, capabilities and limitations, must be taken into account as an integral part in the recent advanced manufacturing systems. Currently, a new human-centered approach has been created where ergonomics plays a crucial role (Mital and Pennathur, 2004). In this regard, the role of humans is more important than before, particularly by the relevance of the intervention and the high costs related to errors in the man-machine system. In this regard, Wiener and Curry (1980), Moray (1986), Billings (1991), Sarter and Woods (1995) and Kaber (2004), Ramachandran and Naadmuthu (1989), Lee and Salvendy (2006), report serious problems associated with the man-machine system errors and attribute them mainly to the decrease attention about the intervention of the human being in complex systems and automation, where the AMT can be located. They claim that while it was introduced among other reasons to reduce human errors, heavy and repetitive tasks, new forms and more critical error and dangerous situations have ironically resulted as a consequence.

About this discussion, models that assist decision making processes during planning and evaluation phases even on the early stages of AMT design present a lack of attention on ergonomic attributes. In this matter; the interaction of AMT with human is a very interesting and important topic to be attended in the Ergonomics field and research.

The ergonomic approach: a relegated aspect in the selection of AMT

This section contains theoretical evidence that reveals the lack of the ergonomic approach in the selection of AMT. According to Wobbe and Charles (1994), about the functions of planning, selecting and implementing of AMT; traditional economic models are largely used. About the selection function in particular it is mainly executed with the criteria of cost and return on investment, however; in some cases it has been informed about the improper operation of AMT and low productivity.

In these functions, the ergonomic aspect is usually omitted or neglected, and when it comes to be considered, is limited to analysis for reduction of labor costs. Ayres et al. (1983), Majchrzak (1988), Butera (1984), Susman and Dean (1992) notify that in the implementation phase of AMT, ergonomics and human factors issues are usually ignored or relegated having just a reactive approach to the arising problems.

For Talluri and Yoon (2000), the evaluation of AMT is an important problem, because of the elevated and critical of the investments. Also, because the processes and procedures implicated in it are complex and strategic, involving multiple decision variables, moreover, the critical attributes of performance are not known precisely, as well of the preference relations among them; and appropriate models for this purpose are scarce.

Several ergonomic and safety problems are associated with AMT design. In this topic, Karwowski (2006) comments that even when Ergonomics is a design-oriented discipline, the ergonomists do not design systems, but those interactions between humans and the systems-artifacts. He recognizes that ergonomists and the ergonomics discipline must have a more participative role in the design of these systems.

On the other hand, with regard to the planning and selection of AMT, current models for decision making, obviate or relegate the ergonomic aspect. The decision makers are not aware of the relevant ergonomic attributes of AMT therefore, they cannot include them effectively. Also they continuously face the problem of selection among several alternatives and sometimes they do it with incomplete or vague information.

So, we can say that science constitutes the driving force of the growing evolution of AMT and it promotes the emergence of new application of more efficient and cleaner technologies, even free of the human being intervention. However, on its implementation and operation, human factors and ergonomics aspects should be included to enhance systems´ performance.

The health risks associated with the AMT

According to Karwowski (1990,2005), safety and health issues associated with complex manufacturing systems, are critical aspects for their design and operation. In the study of the AMT, other aspects such as human factors, reliability and safety, must be in taken into account in addition to the technical aspects. Human Factors and Ergonomics aspects have been underestimated in the control of injuries and accidents, In accordance to Ayres and Miller (1983), Masterson (1987), Zimolong and Duda (1992) there is insufficient and/or incomplete information related with the health and safety of AMT systems. These aspects have been relegated in their importance and there are difficulties in determining the magnitude and potential impact of the AMT in terms of health and safety. For Nicolaisen (1985), Sugimoto and Kawaguchi (1985), Karwowski et to al. (1988), and Karwowski (2005); the reason for this, is that a high percentage of accidents related with AMT are not registered. Likewise, it is difficult their identification in the available statistics, because they are mixed among the classification of accidents caused by other kind of reasons linked with some other equipment, machine or tool.

Only very few studies were found related with this topic, like the one of Sugimoto (1987) and the Ministry of Labor in Japan, where robots failures have caused hazardous conditions at work resulting in injuries and even fatalities. Most failures of AMT systems take place when programming, cleaning and maintenance tasks are performed; in this way, they have been identified as the main sources of these hazards and risks according to authors like Wilson et. al. (1994, Backström and Harms-Ringdahl (1984), Chan and Courtney (2001) and Jiang and Gainer (1987).In such a way, in accordance with Sugimoto (1987), and Chan and Courtney (2001), there is a generalized misunderstanding of the nature of the automation and AMT; and there are false beliefs about its safety. Therefore, an increased attention on these topics is needed.

Furthermore, it is relevant to denote that most of the available information is in the AMT implementation phase, but has not been considered for the evaluation of AMT on planning and selection phases; which would represent a strategic advantage when selecting technology. In addition to these difficulties, there is a lack of modeling of costs associated with health and safety benefits. These include the works of Oxenburg (1991) and Anderson (1992) who proposed guidelines to reduce these costs. They also propose a model to estimate the return of ergonomic investments. However, there is a lack of procedures to compare alternatives in terms of health and safety to justify such investment.

IMPORTANT ERGONOMIC ATTRIBUTES FOR THE SELECTION OF AMT

Ergonomic attributes for the selection of AMT concern to human´s capabilities and limitations in interaction with this technology, as well as the effects of ergonomic incompatible equipment and the consequences of the error by design. AMT systems are highly complex and requires of considerable amount of cognitive tasks in everyday work. Human beings by nature have limitations; among the most important ones are: their limited working memory, slow performance of cognitive operations, and information retrieval, numerical operations and time and space orientation. These constraints must be taken into account when selecting alternatives of AMT, especially the ones related with monitoring tasks where problems associated with mental workload may carry out considerable downtime affecting production times, Endsley (1993).

On the other hand, Mital and Pennathur (2004) reported that most of automated equipment does not comply with basic guidelines for interface design; engaging inefficiencies on both equipment and human operator. Conversely an efficient interface will reduce the mental workload, eliminate or minimize human errors, will prevent confusion and will reduce the cost of the time consumed by such inefficiency. It can be said that the human being is still the most versatile and flexible element in the manufacturing system. In addition, they point out that it is unlikely that machines can perform functions with variable information in real time; at least in the near future; consequently humans will have an important role in advanced manufacturing environments. In this way the implementation and successful adoption of AMT depends crucially on human intervention, so ergonomics aspects must be included and objectively evaluated during the selection of alternatives of AMT. According to Corlett and Clark (1995), the main interactions between humans and machines can be summarized in Figure 1 showing the major components. Ergonomics is concerned about the study of interfaces and interactions between the human operator and other of its components as well as the effects of such interactions in the performance of the system.

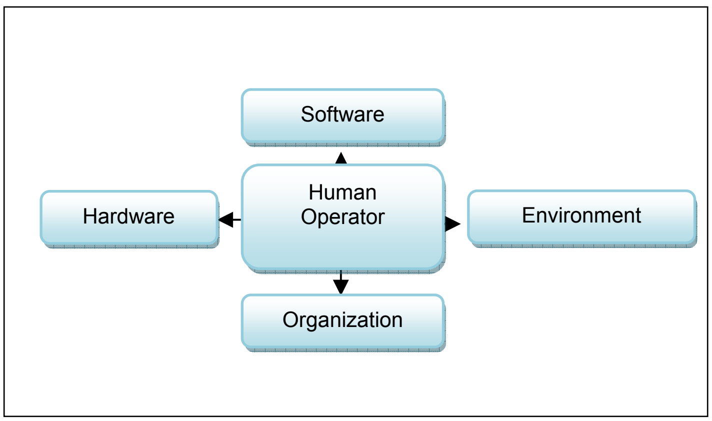

Fig. 1 Interactions in Human-Machine Interface

In this system, the Hardware (physical ergonomics), refers to the machine design intended for improved operation, maintainability, and safety. The software (cognitive ergonomics), refers to the design of visual displays and instructions, labels, symbols, tables, computer and manual programming. The Environment refers to noise, vibration, temperature and lighting emitted by the machine. Finally the Organization element refers to the content of the work, work methods, rate of production, cycle time, pace of work associated with the interaction of the machine and the human being.

Ergonomic Compatibility Attributes for the selection of AMT

In this part, the Ergonomic Compatibility Attributes are described according with the Ergonomic Compatibility Evaluation Model for the selection of AMT proposed by Maldonado (2009). This model is a multi-attribute approach that combines in an innovative way the Axiomatic Design Theory in Ergonomics and the Fuzzy Logic Theory fundamentals to evaluate and compare alternatives of AMT from an ergonomic perspective.

Ergonomic Compatibility (EC) is a construct used in this model and it is defined evoking the concepts of human-system and human-artifact compatibility introduced by Karwowski (1997, 2001, 2005), who offers a comprehensive treatment of compatibility in human factors discipline. It intends to measure in a subjective way, the probability of a design to satisfy ergonomic requirements using the Ergonomic Incompatibility Content (EIC). The EIC is an index obtained by the adaptation of the Information Axiom in the Axiomatic Design Theory. Ergonomic Compatibility attributes are not precisely determined in the literature, also involves the evaluation of multiple quantitative and qualitative aspects, so complexity and vagueness are involved. For Karwowski (2005), advanced technologies with which human interact constitute complex systems that require a high level of integration, he considers that Ergonomic Compatibility Attributes of AMT have to focus in the design integration of the interactions between hardware (computer-based technology), organization (organizational structure), information system, and people (human skills and training).

Maldonado et. al. (2009) presents the set of attributes for Ergonomic Compatibility Evaluation based on an extended literature review and the ergonomic factors proposed by Corlett and Clark (1995). Ergonomic Compatibility Attributes are presented bellow in Figure 2.

The model presents a hierarchical structure with five main attributes and twenty sub attributes. Also, the work of Maldonado et. al. (2010) is recommended for further reading. This scheme is shown below in Figure 3.

- (A11) **Human Skills and Training Compatibility**
  - (A111) Skill Level Compatibility
  - (A112) Training Compatibility
- (A12) **Physical Work Space Compatibility**
  - (A121) Access to Machine and Clearances
  - (A122) Horizontal and Vertical Reaches
  - (A123) Adjustability of Design
  - (A124) Postural Comfort of Design
  - (A125) Physical Work of Design
- (A13) **Usability**
  - (A131) Compatibility with Controls´ Design
  - (A132) Controls' Physical Distribution
  - (A133) Visual Work Space Design
  - (A134) Information Load
  - (A135) Error Tolerance of Design
  - (A136) Functional Allocation of Design
  - (A137) Design for Maintainability
- (A14) **Equipment Emissions Requirements**
  - (A141) Temperature
  - (A142) Vibration
  - (A143) Noise
  - (A144) Residual Materials
- (A15) **Organizational Requirements**
  - (A151) Compatibility with Rate of Work
  - (A152) Compatibility with Total Work Content

Fig.2 Atributos de Compatibilidad Ergonómica en la Selección de la TMA

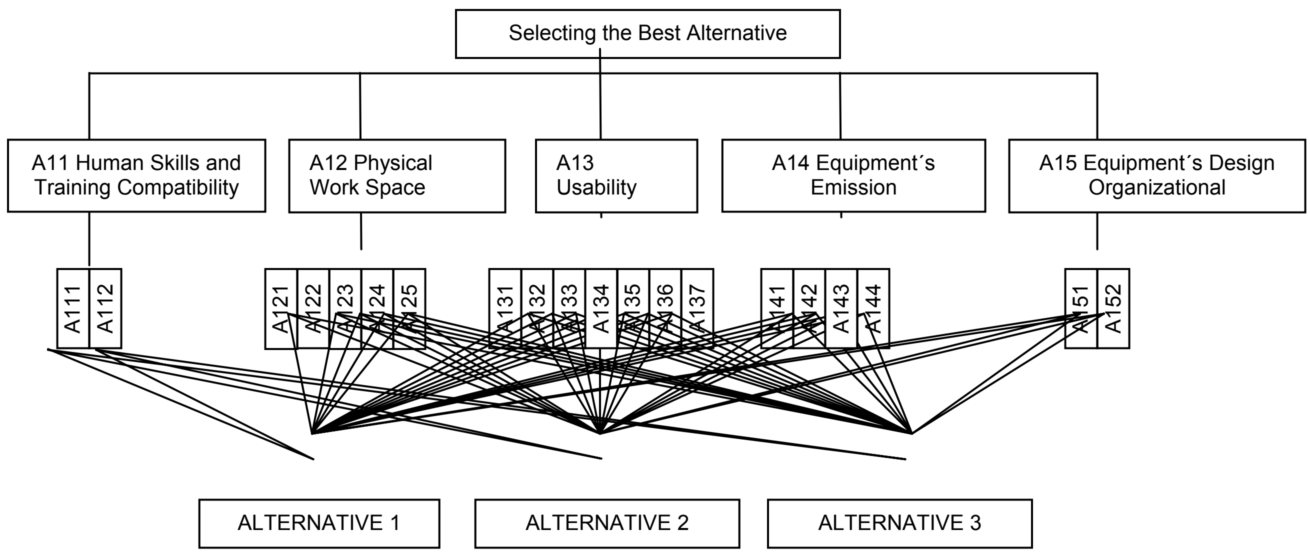

Figure 3. Selection of the Best Ergonomic Alternative

CONCLUSIONS

It can be concluded that the purpose of this paper has been accomplished in the way that comprehensive literature review have been exposed and important topics related with human factors, ergonomics and AMT were discussed. The increased application of AMT and other automated systems in industries worldwide have change the role of human intervention in the human-machine system intensifying its relevance and developing new skills. This role is even more important than before due to the highly automated operations which requires now of more cognitive demanding tasks rather than physical demanding tasks. The significant investments on AMT requires a more effective and successful implementation of it. Also the human errors and errors by design consequences, in addition to the elevated costs associated with them have been topics of interest for the Ergonomics science. However, actual models for evaluating and selecting technology are scarce of the ergonomic perspective; and a more pragmatic approach is necessary. Decision makers for AMT are often unacquainted of important ergonomics aspects;

models that can include them effectively to support their decisions are also scarce. In this way, a novel model for this purpose has been presented in this paper and may contribute to this problem by means the application of the model and its validation in industry.

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IDENTIFICATION OF ERGONOMIC RISK FACTORS IN MANUFACTURING AUTOMOTIVE WINDOW REGULATORS

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Resumen

A nivel internacional la industria automotriz genera uno de los índices generales de siniestralidad laboral más elevados en el sector manufacturero y las lesiones que genera son lo bastante graves para provocar pérdida de tiempo y errores en el trabajo de los empleados de este sector.

México se encuentra ente los diez principales países productores de automóviles a nivel mundial y en el estado de Sonora la industria de autopartes, elemento importante de la industria automotriz, impulsa la economía regional y genera una gran cantidad de trabajo en el sector, convirtiéndolo también en uno de los principales generadores de riesgos laborales.

La literatura especializada en salud y seguridad ocupacional ha demostrado que los riesgos ergonómicos son un factor importante que contribuyen a la buena salud de los trabajadores y que a partir de mantener buenas condiciones ergonómicas se puede mejorar su salud y seguridad.

El presente documento muestra los resultados de la investigación realizada en una empresa dedicada a la fabricación de elevalunas automotrices en Hermosillo, Sonora; identifica y caracteriza los factores de riesgo ergonómico y presenta una propuesta para la eliminación o reducción del posible impacto de los mismos en la salud de los trabajadores.

Palabras claves: riesgo ergonómico, elevalunas, salud ocupacional.

Abstract

Internationally the auto industry have one of the higher accident rate index in manufacturing sector and its injuries are as severe as to cause time loss and errors in employees job in this sector.

Mexico is one of the top ten car manufacturing countries worldwide and in the Sonora state the auto parts industry, an important element of the automotive industry, supports regional economy and generates a lot of work in the sector, making it also one of the main generators of occupational hazards.

Occupational health and safety researches have shown that ergonomic hazards are a major factor contributing with workers´ health and by a good ergonomics condition can improve your health and safety.

This paper aims at presenting the outcomes of an ergonomic evaluation carried out into an auto parts facility in which window regulators are manufactured. This firm is located in Hermosillo, Sonora, Mexico. Ergonomic risk factors are identified and characterized and proposals are made in order to eliminate or reduce their possible impact on this company workers' health.

Key words: ergonomic risk, window regulator, occupational health.

INTRODUCTION

Internationally the auto industry have one of the higher accident rate index in manufacturing sector and its injuries are severe enough to cause employees time loss and diseases in this factory.

Mexico is one of the top ten car manufacturing countries worldwide (OICA, 2010) and in Sonora state, the auto parts industry, an important element of the automotive industry, supports regional economy and generates a lot of work in the sector, making it also one of the main generators of occupational hazards (Marín, 2010).

Ergonomics is one of the most important topics for occupational health. If a workstation or a place where an employee is working it is not ergonomically designed, it can bothersome in the long term, and it will end up causing him some injuries, a syndrome, an illness, and so forth and consequently, the employee's work absences.

In Mexico, job injuries represent an important problem for small, medium and even large companies. The transcendences of the study of ergonomic risk factors have already been accepted in businesses, and it is considered that once they are identified, firms are able to eliminate or control them; this is the main reason why it is necessary to increase the interest of those who are involved in achieving the diminishing of their impact on employees' health.

The International Labour Organization, ILO, estimates that economic losses due to occupational hazards occurrences represent for Latin America, from 9 to 12% of Gross Domestic Product, GDP (OPS, 2005).

Often, workers in the activities of job are exposed to of physical, chemical, biological, psychosocial and ergonomic risk factors, which can alter their state of health, one of the most frequent alterations it's the musculoskeletal system disease (Luttmann, 2004).

Currently musculoskeletal disease represents one of the main consequences of injuries and work-related illness that every year employers report to the Bureau of Labor Statistics of the United States of America (NIOSH, 2010).

European researches have shown that some musculoskeletal disorders such as back, neck and upper limbs pain are a health problem and have large-scale labor costs (AESST 2000). It is estimated that this condition is similar to developed countries to those in developing countries.

Musculoskeletal disorders related to job are defined as a heterogeneous group of organic or functional disturbances in muscles, nerves, tendons, joints, cartilage and spinal discs, which are induced by neuromuscular fatigue due to very demanding jobs (Cueto, 2009).

Because many of these problems are associated with excessive physical work demands caused by poor workstation design, tools, and generally inadequate working methods, the literature on occupational safety and health suggests that ergonomic hazards made identify and from that apply ergonomic principles to design job demands and adapt it to the capabilities of the worker.

The information at local level published about the auto parts sector with regard to worker exposure to ergonomic hazards and assessing their potential impact on health and safety of themselves, so far has been revised is scarce.

It is known that in manufacturing processes for window regulators sometimes the worker must assume awkward postures, which leads him to be at increased risk of musculoskeletal disorders. However, despite being aware of these conditions and the impact on health worker in this industry in Mexico are few studies, mainly on ergonomic risk factors.

For this reason, the objective of this study is to identify and characterize the ergonomic risk factors involved in the manufacture of windows regulators and assess their potential impact on workers´ health

OBJECTIVES

The main purpose of this research is to identify, characterizes and quantify ergonomic risk factors associated with physical, functional and organizational characteristics of workplaces and their impact on workers' health.

Recommendations are given to reduce or eliminate those hazards, so job tasks carried out will be more efficient, productive and safe. That why we characterized important anthropometric data for personnel involved in the process of manufacturing windows regulators and identified the consequences for personnel working in manufacturing windows regulator of exposure to ergonomic risk.

METHODOLOGY

Research was conducted in a Ford Motor Company Tier 1 supplier, this factory has 223 total employees in the processes that it has, and it is located in Hermosillo, Sonora city.

We considered two types of assessments: 1) Workers or subjects: this included 31 workers from windows regulator area and 2) The workstation, were analyzed 25 workstation and their specific activities.

Since the company of auto parts was conceived as a unit, consisting of basic elements interact, such as technological, methodological and human, we used general systems theory to carry out this investigation.

By using the systems approach sought to understand the functioning of the company from a holistic and inclusive perspective, where the important thing was the relationship between components, and where components of the system are not physical components, but the functions they perform.

We kept in mind the fact that the study systems was conducted in Hermosillo, Sonora, Mexico, in an automotive window regulator manufacturing firm, from October to December 2010. A diagnosis of those who are involved in manufacturing these items for ergonomic risk factors was developed. And subsystems identified are outside inputs in different forms among which are:

information, physical resources, or energy, these entries are subjected to transformation processes which produce results or outputs very special.

The strategy used in this study to maximize the validity and reliability of the information and thereby reduce errors in the results of the research was triangulation, and several instruments were used to study the object, as well as various information sources (Pranee, 1999) used this strategy because it is considered one of the most rewarding for qualitative research, to give the rigor and depth study (Benavides, 2005), this method allowed to obtain a clearer picture of operations and environment that develops the auto parts industry engaged in the manufacture of automotive windows in Hermosillo, Sonora.

A literature review was conducted to find out the newest in occupational health in the auto parts industry issue, the aim of this review was to identify and analyze what types of risks causing poor posture and improper movements and how can identify and evaluate, develop proposals for improvement. We used the database of the Mexican Social Security Institute IMSS to estimate the rate of musculoskeletal injuries, INEGI and ISI-Thomson databases where used, with the intention that this review reflects current information, important and accurate, the initial horizon search was 10 years

To ensure the quality and completeness of the selected material is used sources of primary and secondary information, preference was given to that information from refereed journals and books, for databases access the information came from the Institutional Library System at the University of Sonora and the World Wide Web on the Internet. A very important source of information was the industry of auto parts in Hermosillo, Sonora when applying the instruments.

The OWAS method was applied to workers for assess the most awkward postures that require the activity in the work and also applied a musculoskeletal symptom questionnaire to understand their symptoms, and finally an anthropometric workers study to evaluate the fit that exists in every workplace and employee.

Several instruments were used but for the purpose of this paper, even though additional data are presented as the results of a questionnaire on musculoskeletal symptoms applied to understand their symptoms and an anthropometric study of workers are only the results of OWAS Method addressed in detail here.

The OWAS method (Ovako Working Analysis System) is used to assess postural efforts at work, was developed in response to the high prevalence of problems and musculoskeletal complaints, mainly low back pain among workers at a steel manufacturing company and its possible association with the positions work undertaken.

The method represents the classification of positions according to a conventional definition of four digits for each position. The first digit determines the position of the trunk, the second upper extremities, the third of the lower extremities, and the last digit of the magnitude of the load or applying force with your hands. In each of the defined working positions corresponding one of four categories representing the level of postural stress and this in turn is associated with a degree of urgency to implement corrective measures.

The positions classified for first category are not harmful and poses no degree of urgency which indicates that it requires remedial action. Those classified in category 2 indicate that this workstation involves positions with major stressors and degree of urgency which results in corrective measures should be implemented in the near future. The Category 3 positions correspond to positions involves working with very important stressors and indicating a degree of urgency which must implement corrective measures as soon as possible. The Category 4 indicates that the work involves postures with obvious harmful effects and remedial measures should be implemented immediately. The values assigned to the evaluation are shown below:

Table 1. Categories of risk posture codes.

Legs		1			2			3			4			5			6			7		
Load/Force		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Back	Arms																					
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	3	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
2	1	2	2	3	2	2	3	2	2	3	3	3	3	3	3	3	2	2	2	2	3	3
	2	2	2	3	2	2	3	2	3	3	3	4	4	3	4	4	3	3	4	2	3	4
	3	3	3	4	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	2	3	4
3	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1
	2	2	2	3	1	1	1	1	1	2	4	4	4	4	4	4	3	3	3	1	1	1
	3	2	2	3	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	1	1	1
4	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4
	2	3	3	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4
	3	4	4	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4

Table 2. Classification of body positions categories according to their relative frequency.

Back	1	Right	1	1	1	1	1	1	1	1	1	1
	2	Leaning forward	1	1	1	2	2	2	2	2	3	3
	3	With rotation	1	1	2	2	2	3	3	3	3	3
	4	Angle and rotation	1	2	2	3	3	3	3	4	4	4
Arms	1	Both below shoulder level	1	1	1	1	1	1	1	1	1	1
	2	One above shoulder level	1	1	1	2	2	2	2	2	3	3
	3	Both at or above shoulder	1	1	2	2	2	2	2	3	3	3
Legs	1	Sitting	1	1	1	1	1	1	1	1	1	2
	2	Right standing with both legs	1	1	1	1	1	1	1	1	2	2
	3	Stand with right leg	1	1	1	2	2	2	2	2	3	3
	4	Both knees bents	1	2	2	3	3	3	3	4	4	4
	5	A bent knee	1	2	2	3	3	3	3	4	4	4
	6	Kneeling	1	1	2	2	3	3	3	3	3	3
	7	Walking	1	1	1	1	1	1	1	1	2	2
% Time		0		20		40		60		80		100

The postural efforts were evaluated and analyzed through the videotapes of each of the activities jobs. An analysis of the responses expressed in the questionnaire and the relative magnitudes of the symptoms reported by workers and the body regions affected was obtained. A table of 14 relevant anthropometric parameters to the type of work in the area manufacturer of windows regulator, which will be used to compare anthropometric data with the workspace and implement necessary improvements.

RESULTS

The analysis of results revealed varying degrees of dangerousness of different ergonomic risk factors; here are some results from the analysis.

Table 3. Summary of postural stress analysis for Ford windows regulator

N°	awkward posture/ workstation	1	2	3	4	Action	Risk level
1	10	4	1	3	1	4	High Risk
2	20D	1	2	2	1	3	Moderate Risk
3	20T	2	2	2	1	3	Moderate Risk
4	30	3	3	2	2	4	High Risk
5	40DI	2	1	3	1	4	High Risk
6	40DD	2	3	2	1	3	High Risk
7	40T	1	3	2	1	3	Moderate Risk

Table 4. Summary of postural stress analysis for Chrysler front windows regulator

N°	awkward posture/ workstation	1	2	3	4	Action	Risk level
8	05 CHD	3	1	2	1	3	Moderate Risk
9	10CHD	4	1	2	1	3	Moderate Risk
10	20CHD	2	1	2	2	4	High Risk
11	30CHD	1	3	2	2	4	High Risk
12	40CHD	2	1	3	1	4	High Risk
13	50CHD	1	3	2	2	4	High Risk
14	60CHD	1	2	2	1	3	Moderate Risk
15	70CHD	3	3	2	1	3	Moderate Risk
16	front Inspection	1	3	2	2	4	High Risk

Table 5. Summary of postural stress analysis for Chrysler back windows regulator

N°	awkward posture/ workstation	1	2	3	4	Action	Risk level
17	10 CHT	4	1	2	1	3	Moderate Risk
18	20 CHT	2	1	2	2	4	High Risk
19	30 CHT	3	1	2	1	3	Moderate Risk
20	40 CHT	2	1	3	2	4	High Risk
21	50 CHT	1	3	2	2	4	High Risk
22	60 CHT	2	2	2	1	3	Moderate Risk
23	70 CHT	1	2	2	1	3	High Risk
24	80 CHT	3	3	2	1	3	Riesgo Alto
25	Back Inspection	1	3	2	2	4	High Risk

The symptom questionnaire applied to 31 workers in the study, showed that a significant number of workers surveyed have or have had any musculoskeletal discomfort considered to be work related in the last year (81%).

Table. 6. Workers who have or have had symptoms.

Presence of symptoms	Frequency	%
yes	25	81
no	6	19
Total	31	100

From employees who reported symptoms in the last year, 48% report be presented in more than one body region discomfort.

Table 7. Number of body regions with symptoms

Number of body regions with symptoms	Frequency	%
1	13	52
2	8	32
3	4	16
Total	25	100

For the distribution of complaints by body region, we note that the complaints filed by employees that have or have had discomfort, the first place is for shoulder discomfort with 40%, followed by back discomfort with 36 % where 20% corresponds to the upper back and 16% for lower back, and finally the hassle of hand/wrist and ankle/foot with 12% each.

Table 8. Number of complaints by body region

Body Region	Frequency	%
lower back	4	16
shoulder	10	40
hand/wrist	3	12
ankle/foot	3	12
upper back	5	20
Total	25	100

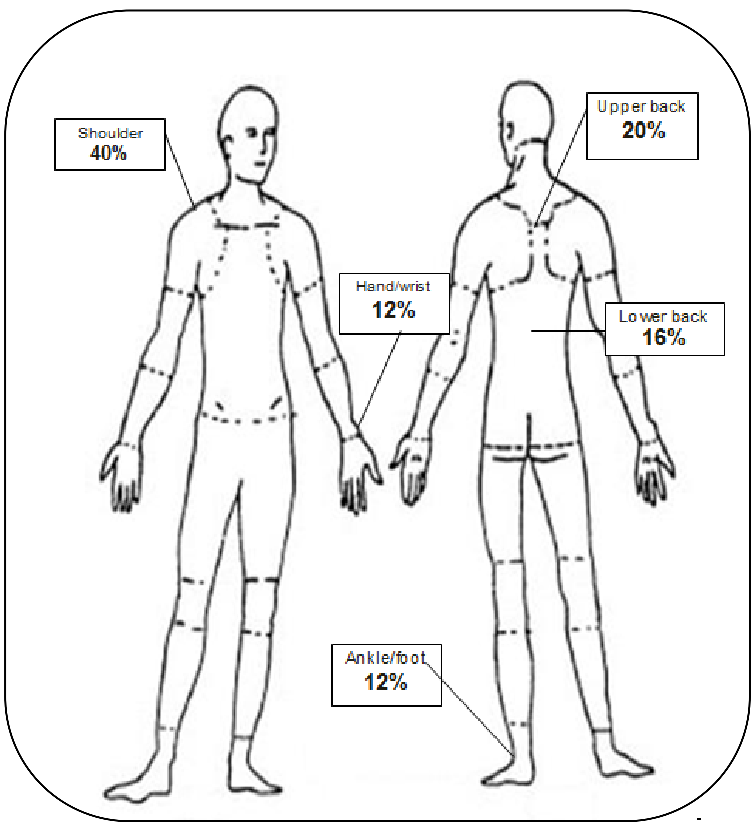

Figure 1. Complaints by body region (%)

Table 9. Anthropometric data (cm)

Parameter	μ	σ	P_5	P_{50}	P_{95}	Máx	Mín
Age	30.06	4.82	24.5	29	39.5	41	24
Weight	79.49	16.54	56.15	80.5	105	112.5	46.5
Height	167.5	9.34	153.5	165.5	182	186	150.5
Eye Height	156.82	9.76	141.75	156	173	175	139
Shoulder Height	138.73	8.09	126.5	137.5	150.25	154.5	122
Elbow Height	107.27	6	98	106.5	115.75	120	95
Waist Height	103.53	6.14	96	103	113	117.5	91
Wrist Height	81.76	7.46	66.75	82	90.75	93.5	61.5
Height to the middle finger	64.95	3.83	58.5	65	70	74	57
Long arm	73.77	5.64	66	72.5	81.75	84.5	61.5
Long arm from wall	84.85	6.18	76	85.5	95.25	96	74
Distance from the wall to the center of the fist	76.02	7.99	65.5	75.5	86	103.5	64
shoulder width	48.69	4.06	42.25	49	54.25	57	38.5
Grip diameter (interior)	40.97	3.77	36	41	47.5	48	35

CONCLUSIONS

In this study, ergonomic hazards were identifying which affected the good performance worker and evaluates their potential impact and consequences on the health of every one of them.

Workers expressed musculoskeletal disorders which they considered related with, repetitive movements of upper limbs as well as manual materials handling which implies an effort on his shoulders, or maintained static postures or abduction or flexion greater than 60 degrees; some of this factors was founded in tasks such as driving Tools about the height of the head or take and leave material during the manufacturing process.

It is found that 44% of the task measured with OWAS presents a moderated level risk and the other 66% was classified as high risk.

The musculoskeletal symptom questionnaire shows that 81% of participants in this study have or have had some musculoskeletal disorders in the past year associated with the tasks of their job. The affected body part are as follow, it is reported that 40% of sore shoulders, a back 36%, 12% in the lower extremities and another 12% in the upper extremities

From the foregoing, we conclude that for the company to improve the occupational health of their employees need to perform consistently ergonomic improvements, major efforts should be contemplated should include: the design or redesign of the areas, working in this area is important to consider anthropometric dimensions of the working population, it have to work in a training on working procedures, and establish administrative controls that carry a enhance the conditions on which, if carried out Tasks.

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ECOLOGICAL ERGONOMIC DESIGN OF WIND-DRIVEN CAR

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Resumen

Diseño de carro apoyado en ergonomía, ecología y diseño mecánico, impulsado por viento. Se realizo estudio ergonómico a estudiantes de ingeniería, con la finalidad de impulsar opciones de diversión sin afectar al medio ambiente. Se busco facilitar el desempeño en el manejo y comodidad de piloto del carro impulsado por viento mediante los principios del método RULA (Rapid Upper Limb Assessment), BRIEF, antropometría y principios de diseño ergonómico para autos.

Palabras Clave: Rula; Brief, Evaluación Ergonómica

Introduction

Car Design supported in ergonomics, ecology and mechanical design, driven by wind. Ergonomic study was conducted to engineering students, with the aim of promoting entertainment options without affecting the environment. It seeks to facilitate the handling performance and driver comfort of wind-driven carriage through the principles of RULA (Rapid Upper Limb Assessment), BRIEF, anthropometric and ergonomic design principles for cars.

Objective

Designing a car that is ergonomically easy to operate, that does not pollute the environment, and its design is strong, visually appealing and is a fun option for young people.

Methodology

- RULA assessment / BRIEF
- Anthropometric measurements
- Ecological and environmental principles
- Automotive mechanical design principles

Methodology used: Assessment RULA/BRIEF

Table 1. Assessment using Rula method right side

Puntos	Posiciones del cuello (Tabla 8)
1	Flexión 0° - 10°
Puntos	Posiciones que modifican puntuación del cuello (Tabla 9)
1	Cuello rotado
1	Inclinación lateral
Puntos	Posiciones del tronco (Tabla 10)
2	Flexionado 0° - 20°
Puntos	Posiciones que modifican puntuación del tronco (Tabla 11)
1	Inclinación lateral del tronco
Puntos	Posición de las Piernas (Tabla 12)
1	Sentado, con pies y piernas bien apoyados
	Puntuación Global Grupo B 3
Puntos	Postura
1	Estática, si se mantiene postura >1minuto seguido repetitivo (si se repite > 4 veces/minuto)
Puntuación para actividad muscular y fuerza ejercida	
Puntos	Posición (Tabla15)
2	Si la carga o fuerza esta entre de 2 - 10 Kg. y es estatica o repetitiva
Puntuación Global Grupo D 6	

Puntos	Posiciones del brazo (Tabla 1)
3	Flexión 45° - 90°
Puntos	Posiciones que modifican puntuación del brazo (Tabla 2)
1	Brazos abducidos
Puntos	Posiciones del antebrazo (Tabla 3)
2	Flexión < 60° o > 100°
Puntos	Posiciones que modifican puntuación del antebrazo (Tabla 4)
1	Si el antebrazo cruza la línea central del cuerpo
Puntos	Posiciones de la muñeca (Tabla 5)
2	Flexionada o extendida entre 0° - 15°
Puntos	Posiciones que modifican puntuación de la muñeca (Tabla 6)
1	Desviada radial o cubitalmente
Puntos	Posición Giro de la muñeca (Tabla 7)
1	Pronación o supinación en rango medio
	Puntuación Global Grupo A 5
Puntos	Postura
1	Estática, si se mantiene postura >1 minuto seguido repetitivo (si se repite > 4 veces/minuto)
Puntuación para actividad muscular y fuerza ejercida	
Puntos	Posición (Tabla 15)
2	Si la carga o fuerza esta entre de 2 - 10 Kg. y es estatica o repetitiva
	Puntuación Global Grupo C 8

Table 2. Assessment using Rula method left side

Puntos	Posiciones del brazo (Tabla 1)
4	Flexión > 90°
Puntos	Posiciones que modifican puntuación del brazo (Tabla 2)
1	Brazos abducidos
Puntos	Posiciones del antebrazo (Tabla 3)
2	Flexión < 60° o > 100°
Puntos	Posiciones que modifican puntuación del antebrazo (Tabla 4)
1	Si el antebrazo cruza la línea central del cuerpo
Puntos	Posiciones de la muñeca (Tabla 5)
2	Flexionada o extendida entre 0° - 15°
Puntos	Posiciones que modifican puntuación de la muñeca (Tabla 6)
1	Desviada radial o cubitalmente
Puntos	Posición Giro de la muñeca (Tabla 7)
1	Pronación o supinación en rango medio
	Puntuación Global Grupo A 7
Puntos	Postura
1	Estática, si se mantiene postura >1 minuto seguido repetitivo (si se repite > 4 veces/minuto)
	Puntuación para actividad muscular y fuerza ejercida
Puntos	Posición (Tabla 15)
2	Si la carga o fuerza esta entre de 2 - 10 Kg. y es estatica o repetitiva
Puntuación Global Grupo C 10	

Puntos	Posiciones del cuello (Tabla 8)
1	Flexión 0° - 10°
Puntos	Posiciones que modifican puntuación del cuello (Tabla 9)
1	Cuello rotado
1	Inclinación lateral
Puntos	Posiciones del tronco (Tabla 10)
2	Flexionado 0° - 20°
Puntos	Posiciones que modifican puntuación del tronco (Tabla 11)
1	Torsión del tronco
Puntos	Posición de las Piernas (Tabla 12)
1	Sentado, con pies y piernas bien apoyados
	Puntuación Global Grupo B 3
Puntos	Postura
1	Estática, si se mantiene postura >1minuto seguido repetitivo (si se repite > 4 veces/minuto)
Puntuación para actividad muscular y fuerza ejercida	
Puntos	Posición (Tabla15)
2	Si la carga o fuerza esta entre de 2 - 10 Kg. y es estatica o repetitiva
Puntuación Global Grupo D 6	

Anthropometric measuremennts of designers of car moved by wind

Fig. 1 Importance of anthropometry for design of car moved by wind

Some of the anthropometric measurements of the students who drove the car sailing in the test phase are shown in Table 3, Figure 1 shows some pictures of anthropometric measurements of the students (Niebel 2006)

Table 3. Some measurements of students who drove the car

Descripción de Medición (Cm)	Hombre	
	Promedio	Desviación
Peso (Kg)	74.5	6.1
1. Estatura	172.6	2.3
5. Altura cadera al suelo	101.2	0.3
6. Altura Rodilla al suelo	51.7	1.4
7. Altura dedos de la mano al suelo (brazo hacia arriba mano abierta)	223.2	0.3
8. Altura codo al suelo (brazo extendido hacia arriba)	176.0	0.5
9. Extensión brazo doblado, antebrazo pegado a cuerpo	39.1	1.1
11.Extension hacia el frente (tomado desde espalda)	71.5	1.8
12.Extensión ambos brazos	176.8	1.8
13.Ancho hombro a hombro	47.2	0.8
14.Ancho codo a codo	47.2	1.8
15.Ancho pecho-espalda	23.8	0.6
16. Altura sentados	86.5	1.3
17. extensión de piernas sentado	108.2	1.6
18.Calzado	29.3	0.6

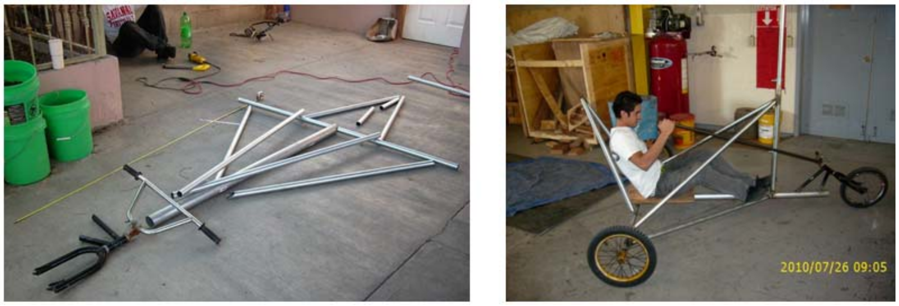

Figure 2. Identification of assemble line items according anthropometry

Principles of automotive mechanical design focused on ergonomic

The ergonomic design stages was based on the model ergonomic of Galer (1987).

1. Problem identification. Which assesses the impact of the ergonomics program can have on the process of design, development and manufacture thereof.
2. Characterization of user needs. Should be provided in the product qualities not found in other similar, so that is competitive to attract the consumer. In this case we relied on the youth market trends and preferences for the type of recreation that allows peaceful coexistence among individuals
3. Providing design criteria. Techniques to manufacture, such as anthropometry, psychological, to name a few. Allow to have data on the characteristics of the tasks carried out with the car candle. Impacting on the comfort, efficiency and user satisfaction with primary purpose
4. Product evaluation. Because they made a series of assumptions and preconditions to product design to be employed, it is necessary to evaluate different aspects of strength, safety, durability and comfort. It continues to seek information from individual prototypes to improve future versions

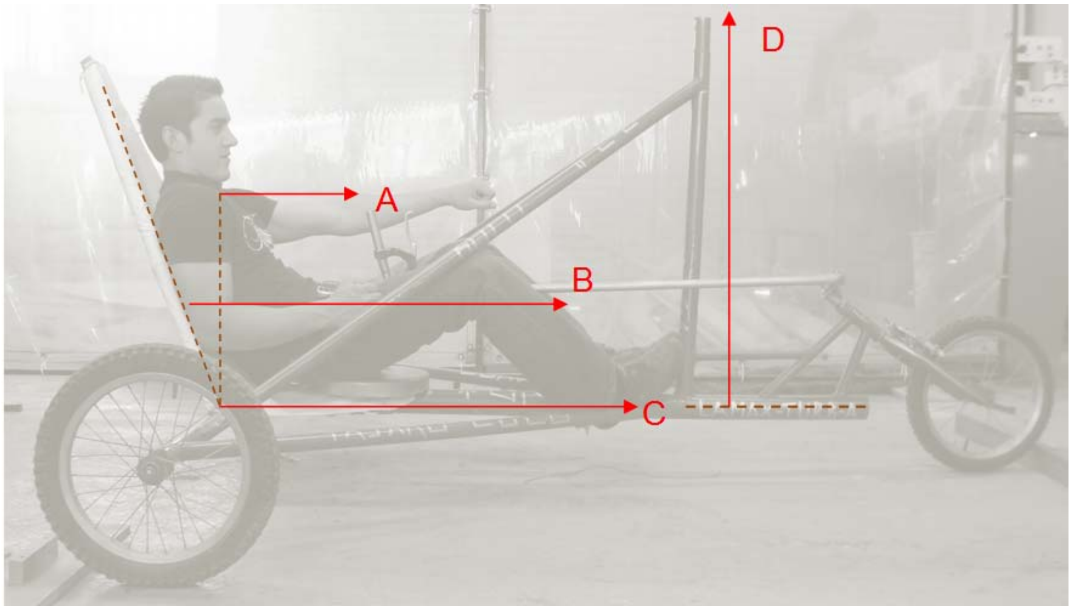

Figure 3. Recommended design dimensions. Kinkade (1983)

Table 4. Recommended design dimensions. Kinkade (1983) taken from students who designed and tested the car driven by wind

Nombre de Alumno	Control Volante A	Controles B	Control Frenos B	Control Manual B	Control Pies C	Altura Base D
González Reyna Leonardo	39	73.5	73.5	73.5	107.5	85.5
Rivera Mendía José	38	70	70	70	107	88
Raso Quevedo Edgar	40.2	71	71	71	110	86
Peraza Cervantes Alan	38	71	71	71	114	81
Ramirez Jimenez Victor A.	40.5	76	76	76	126	94.5
Recomendación	Cumple	Cumple	Cumple	Cumple	Cumple	Cumple

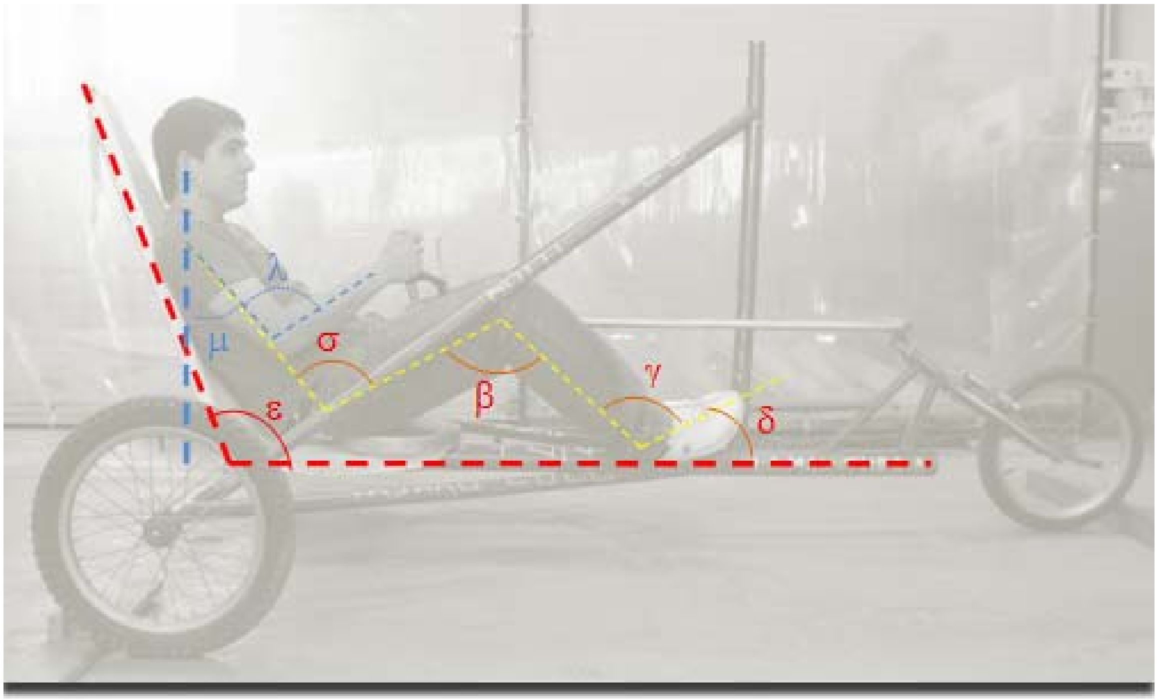

Figure 4. Angles among members who can give a satisfactory position when driving the car.

Rebiffé (1983) Kroemer (2001)

Table 5. Angles among members who can give a satisfactory position taken by students who designed and tested the car

Nombre Alumno	ε	σ Max. 120º	β	γ	δ Max. 38º
González Reyna Leonardo	115	115	110	110	30
Rivera Mendía José	115	110	102	100	35
Raso Quevedo Edgar	115	110	110	100	30
Gonzalez Tellez	115	125	118	93	40
Ramirez Jimenez Victor A.	115	120	90	90	45
Recomendación	Cumple	No	Cumple	Cumple	No

Table 6. Angles among members to operate the car. Rebiffé (1983)

Nombre Alumno	μ izq	μ nor Max. 45º	μ der Max. 45º	λ izq Max.120º	λ nor	λ der Max.120º
González Reyna Leonardo	45	35	77	150	90	120
Rivera Mendía José	35	45	108	145	87	145
Raso Quevedo Edgar	33	30	110	145	92	145
Gonzalez Tellez	32	55	85	142	115	145
Ramirez Jimenez Victor A.	32	45	70	150	115	138
Recomendación	Cumple	No	No	No	Cumple	No

Stress analysis considering only recommended by the MIL-HDBK 759 taking the implementation of 120 to 180 degres

μ_{izq} + 90º	μ_{nor}+ 90º	μ_{der}+ 90º
135	125	167
125	135	198
123	120	200
122	145	175
122	135	160

Table 7. Efforts made in transforming the car steering wheel table MIL-HDBK 759

Posición de Brazo en Volante	Jalar 100%	Empujar 89%	Arriba 43%	Abajo 46%	Dentro 39%	Fuera 28%
μ_{izq} +90º	Medio	Medio	Alto	Alto	Alto	Alto
μ_{nor} +90º	Medio	Medio	Alto	Alto	Alto	Alto
μ_{der} +90º	Alto	Alto	Bajo	Medio	Medio	Alto

Although the wheel is difficult to handle, are perceived as positive outcome if you leave the wheel in the center of the car

Table 8. Analysis of the improvement assessed by the method Rula

Puntos	Posiciones del brazo (Tabla 1)
1	Extensión 20° a flexión 20°
Puntos	**Posiciones del antebrazo (Tabla 3)**
1	Flexión 60° - 100°
Puntos	**Posiciones que modifican puntuación del antebrazo (Tabla 4)**
1	Si el antebrazo cruza la línea central del cuerpo
Puntos	**Posiciones de la muñeca (Tabla 5)**
2	Flexionada o extendida entre 0° - 15°
Puntos	**Posiciones que modifican puntuación de la muñeca (Tabla 6)**
1	Desviada radial o cubitalmente
Puntos	**Posición Giro de la muñeca (Tabla 7)**
1	Pronación o supinación en rango medio
	Puntuación Global Grupo A 3
Puntos	**Postura**
1	Estática, si se mantiene postura >1 minuto seguido repetitivo (si se repite > 4 veces/minuto)
	Puntuación para actividad muscular y fuerza ejercida
Puntos	**Posición (Tabla 15)**
1	Si la carga o fuerza esta entre de 2 - 10 Kg. y se levanta intermitentemente
	Puntuación Global Grupo C 5

Puntos	Posiciones del cuello (Tabla 8)
1	Flexión 0° - 10°
Puntos	**Posiciones que modifican puntuación del cuello (Tabla 9)**
1	Cuello rotado
1	Inclinación lateral
Puntos	**Posiciones del tronco (Tabla 10)**
1	Sentado, bien apoyado y con angulo tronco - caderas > 90°
2	Flexionado 0° - 20°
Puntos	**Posición de las Piernas (Tabla 12)**
1	Sentado, con pies y piernas bien apoyados
	Puntuación Global Grupo B 2
Puntos	**Postura**
1	Estática, si se mantiene postura >1minuto seguido repetitivo (si se repite > 4 veces/minuto)
	Puntuación para actividad muscular y fuerza ejercida
Puntos	**Posición (Tabla15)**
1	Si la carga o fuerza esta entre de 2 - 10 Kg. y se leventa intermitentemente
	Puntuación Global Grupo D 4

Table 9. Analysis of the improvement assessed by the method Rula

Puntuación	**Antes de la mejora**		**Después de la mejora**		**Resultados Propuestos**	
	Derecha	**Izquierda**	**Derecha**	**Izquierda**	**Derecha**	**Izquierda**
Global A	5	7	3	3	40%	57%
Global B	3	3	2	2	33%	33%
Global C	8	10	5	5	38%	50%
Global D	6	6	4	4	33%	33%
Final	7	7	5	5	29%	29%

Results

The result is not very significant but would improve in the following versions, especially in the management of the candle and trim

1. The significant achievement is taken into zero air emissions, no noise visible in its operation and management

2. First and second prototypes in university competition, the press reported on achievements

3. Stress was achieved as fun option for young people, who sought an entertainment that can be used anywhere without disturbing your environment in noise or emissions

Value of the car sailing within reach of the majority, who like having fun with cars and ride bikes

1. First and second prototypes in university competition, the press reported on achievements
2. Improvement in operating the car for auto adjustment of the middle student who wanted to handle.
3. Zero air emissions
4. Automotive mechanical design optimal
5. Achievement was noted as an option for fun for youngsters
6. Value of the car sailing within reach of the majority, who like having fun with cars and ride bikes.

Conclusions:

- improves operation ensures the car stick to the dimensions of the conductors
- The management was optimal as the car was adapted to the population mean anthropometric
- It was found that the cost benefit of the application of ergonomics led to significant improvements in environmental conditions and young people who lead these cars, (potential customers to get it)

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BACKPAIN RISK DIAGNOSIS IN CHILDREN FROM CABORCA, MEXICO CAUSED BY OVERLOAD OF SCHOOL SUPPLIES AND POOR DESIGN AND MANUFACTURING SCHOOL DESKS, WHICH DON´T FIT THEIR ANTHROPOMETRY

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RESUMEN

La incidencia del dolor de espalda en adultos es un problema de salud en todo el mundo reconoce y se acepta que esta enfermedad tiene su origen en la infancia asociada principalmente con las características de la persona junto con los factores en el entorno escolar. Algunos autores señalan que el dolor de espalda en niños aumenta con el aumento de la carga de mochilas escolares y se acepta que los niños, con fines educativos, al permanecer sentados durante largos períodos en los muebles que no se ajusta a la antropometría del estudiante puede producir dolor de cuello y espalda . El objetivo de este estudio fue realizar un diagnóstico de la situación que los niños de las escuelas públicas de nivel básico de la ciudad de Caborca, México tiene, en los dos factores mencionados. El trabajo fue una investigación transversal realizado en el año escolar 2009-2010, sin registrarse el día de la semana o la estación de año en que se hizo, se recogieron datos sobre el peso y el tipo de mochila sin registrar cómo la mochila se carga, si en la espalda o el hombro o la mano. En cuanto al tipo de mobiliario se registraron las dimensiones de la pieza más grande de muebles en cada salón de clase y grado. La muestra fue de 319 estudiantes (160 mujeres y 159 hombres) y los datos registrados fueron: edad, sexo, grado y grupo escolar, el

nivel del piso del salón de clases, el peso de la mochila y el tipo, después de eso, se les preguntó como habían llegado a la escuela si caminando, en coche o transporte público y, finalmente, se midieron 14 características antropométricas. Con esta información hemos analizado los datos con los siguientes resultados: Se estima en 95% de que entre 14.4% y 23.2% de los estudiantes llevan una mochila con peso superior a 15% del peso corporal (límite superior recomendado), si el límite se toma el 10% de peso corporal, el intervalo confidencial del 95% crecerá entre 47,9% y 59,1% de los niños que transportan cargas en exceso del límite bajo. Para ambos límites se observan, entre los 6, 7 y 8 años, un gran número de casos de sobrecarga con valores más altos. Por otra parte, se observó que la proporción de hombres que portaban mochilas con sobrepeso es menor que las mujeres debido a su peso corporal es significativamente mayor que el peso de las mujeres, P (α <0,057). Por otra parte, en la muestra se encontró 30,8% de escolares obesos (Cole et al. 2000), que causa que en algunos casos no refleja la sobrecarga transportada de esta porción de los niños. En la correspondencia entre las dimensiones de la mesa de la escuela y las medidas antropométricas del usuario, la literatura sugiere que las relaciones claves de revisión son: 1) la altura de la silla con la altura poplítea 2) la superficie de nivel de trabajo con la altura del codo a 900. En cuanto al primero, la literatura sugiere que una falta de coincidencia se produce cuando la altura del asiento de la silla es menos del 88% o superior al 95% de la altura poplítea del usuario, en virtud de este criterio se encontró que 99,05% de los elementos de la muestra tienen un desajuste fuerte . La altura del asiento es muy superior a la altura poplítea y, al estar sentado, sus pies no toquen el suelo, produciendo que la parte posterior de los muslos soportar el peso inferior de la pierna, causando presión sobre él, produciendo molestias y la restricción en el flujo de sangre . Con respecto a la segunda relación, superficie de trabajo con la altura del codo 900 se encontró que 97,7% (IC 95%, 96,2%, 99,4%) de todos los estudiantes en la muestra

tienen un gran desfase, la altura de la tabla excede, con mucho, el límite superior recomendado que hace que los niños desarrollen actividades con abducción de brazo, produciendo tensión fuerte en los hombros y el cuello. En conclusión podemos decir que la proporción significativa de niños, en las escuelas públicas de México Caborca, están en alto riesgo de tener dolor de espalda por la carga excesiva en su mochila y, principalmente, por el uso de mobiliario escolar con falta de coincidencia a su antropometría. Todo lo que puede llegar a ser un precursor del dolor de espalda en la edad adulta, lo que se recomienda a reconocer esto como un problema de salud pública y establecer las políticas del gobierno para reducir al mínimo estos riesgos.

Palabras claves: antropometría, mobiliario escolar, dolor de espalda, mochila

ABSTRACT

The incidence of back pain in adults is a recognized health problem worldwide and it is accepted that this disease has its origins in childhood associated primarily with the characteristics of the person along with factors in the environment school. Some authors point out that back pain in children increases with the increase in the burden of school bags and it is accepted that children, educational purposes, remain seated for long periods in furniture that does not comply with the student's anthropometry may produce neck and back pain. The aim of this study was to perform a diagnosis of the situation that public school kids basic level of the city of Caborca, Mexico have, in the two factors mentioned. The work was a transversal investigation made in the 2009-2010 school year, without register the day of the week or the year station in it was made, data were collected on weight and type of backpack without register how the back pack was loads, if in the back or shoulder or hand. Regarding the type of furniture were recorded the dimensions of the largest piece of furniture in every classroom and grade. The sample was of 319 students (160

women and 159 men) and recorded data were: age, sex, grade and school group, floor level of the classroom, the backpack weight and type, after that, they were asked as they had gotten to school if walking, car or public transport and, finally were measured 14 anthropometric characteristics. With this information we have analyzed data with the following results: Estimated at 95% confidence that between 14.4% and 23.2% of students carry a backpack weighing more than 15% of body weight (upper limit recommended), if the limit is taken 10% of body weight, the 95% confidential interval grow between 47.9% and 59.1% of children that carry loads in excess of the low limit. For both limits are observed, for ages 6, 7 and 8 years, a large number of cases of overload with higher values. Moreover, it was noted that the proportion of men carrying overweight backpacks is lower that the women because their body weight is significantly higher that women weight, P (α <0.057). Moreover, in the sample it was found 30.8% of obese school children (Cole et al. 2000), it cause that in some cases it does not reflect the transported overhead of this portion of children. On the correspondence between the dimensions of the school desk and the user's anthropometric measures, the literature suggests that the keys relationships to review are: 1) the chair height with popliteal height 2) level work surface with set elbow height 90^0. Regarding the first, the literature suggests that a mismatch occurs when the chair seat height is less than 88% or greater than 95% of the user's popliteal height, under this criterion was found that 99.05% of the elements of the sample have a strong mismatch. The seat height is well above the popliteal height and, to be seated, your feet do not touch the floor, producing that the back of the thighs support the lower leg weight, causing pressure on it, producing discomfort and restriction in the flow of blood. With regard to second relationship, level work surface with elbow height 900 was found that 97.7% (CI 95%, 96.2%, 99.4%) of all students in the sample have a big mismatch, the height of the table exceeds, by far, the upper limit recommended which causes that the children to develop activities with arm abduction, producing strong stress in the shoulders and neck. In conclusion we can say that significant proportion of children, in public schools Caborca Mexico, are at high risk of take back pain by excessive load on their backpack and, primarily, by the use of furniture school with mismatch to their anthropometry. All which may become a precursor of back pain in adulthood, so it is recommended to recognize this as a public health problem and establish government policies to minimize these risks.

Key words: anthropometry, school furniture, back pain, back pack

INTRODUCTION

It is globally recognized high incidence of back pain in adults (Sato et al. 2008), quoting Balague F et.al, Kelsey JK and Nachemson AL, says that between 70 and 80% of world population has suffered at some point in their life, a history of low back pain. Also emphasizes that this problem is for children, as great as in adults and indicates that the lifetime prevalence in children and adolescents reaches a level of 28.8%. Similarly, (Bejia et al. 2005) points to a 28.4% of cumulative lifetime prevalence in children and adolescents in school. (Trevelyan and Legg 2010) indicate a 35% prevalence of low back pain. (Kovacs et al. 2003) tells than in school children between 13 and 15 years there is a prevalence of LBP of 50.9% for males and 69.3% for female. On the other hand (Hestbaek et al. 2006) mentioned that high prevalence rates of back pain among children and adolescents has been demonstrated in several studies, and has been theorized that low back pain in childhood can have significant consequences for back pain in adulthood. Also notes that teens 12 to 22 years of age with persistent LBP during the previous year have an odds ratio of 3.5 persistent back pain eight years later. In another sense (Heuscher et al. 2010) evaluated the association between annual self-reported low back pain with the weight of the backpack use among college students, and the results of this study suggest that increased weight reported backpack is associated with increased annual prevalence of low back pain. (Korovessis, Kouros and Papazisis 2004) points out that back pain in children and adolescents increased with increasing backpack load. (Negrini and Carabalona 2002) state that the backpack for daily transport is a common cause of discomfort for schoolchildren. 79.1% of the children felt the excessive load, fatigue 67.5% and 46.1 lumbar pain which indicates that there is an association between this load and back pain, although the relationship is not direct. (Pau, Corona and Leban 2010) states: Although the scientific community widely recognizes that the transport bag in primary school children is a serious problem, its consequences in terms of postural disturbances and possible occurrence of musculoskeletal disorders is not understood and the results suggest that heavy loads, in the case of significant exposure times may increase the risk of discomfort of the foot and acting as a cofactor in the development of abnormal foot structure or pathology. Also the observed changes suggest that the transport bag balance causes deterioration and therefore may increase the risk of unintentional falls in children.

In another sense (Schröder 1997) states that inadequate school furniture used by children is often seen as the cause of severe postural problems in adulthood (Trevelyan and Legg 2006) states that back pain is now recognized that occurs in early childhood and is associated with high prevalence rates in children 11-14 years and the most important risk factors associated with back pain are in principle the characteristics of the person then the factors in the school environment. On an average day in school, a child in Caborca, Mexico, according to grade level, must go, because there is no system to prevent, a variety of school supplies, plus some have lunch and / or a sports article. Almost always for the child it´s very difficult to define what material can stay in the house and what should stay the school and vice versa, and the children almost always choose bring and carry all the tools and materials every day. These tools, in some cases must be transported in bags, most type back, walking considerable distances for their age, to reach school. Once the child reaches school will probably have to carry all this set up the second floor to reach the classroom; once class starts the child should remain about 5.5 hr., doing academic work and most of the time sitting at inadequate school desks for their anthropometrics. All this may become a high risk of back and neck pain which may be a precursor of similar pains in adulthood. In the absence of information in our environment, it is necessary diagnose this back pain risk. The aim of this paper is present a descriptive study of the situation of two aspects that may influence the onset of back pain in school children. Specifically the objectives are:

Estimate the statistical distribution of the percentage ratio between the weight of the burden of carrying school supplies with their body weight and compare with the recommendations made in the scientific literature. Analyze the concordance of anthropometric measures of students with the banks used in their school activities.

The hypothesis that arises is that: There is a high risk that school children are affected by load backpacks with a weight that exceeds the recommended weight and used furniture does not comply with their anthropometry. Research is carried out cross the 2009-2010 school year, excluding the day of the week or during the month. Data were collected on weight and type of backpack without taking into account the load as if in the back or shoulder or hand. Also not quantified the distances and the times when children carry the bag from home to school and vice versa. For furniture was observed that in the classrooms there are different types of school desks and it was taken the dimensions of the more numerous type of each grade.

FRAMEWORK

Load weight backpacks

There are some recommendations regarding the maximum burden that children should be carried in backpack, someone accept like limit 15% of the body weight other accept 10% limit of body weight, and others more recommend between 10% and 15% of body weight. (Brackley and Stevenson 2004) states: epidemiological, physiological and biomechanical suggest that the recommended weight limit for the backpacks of children is 10% to 15% of body weight. (Hong, Li and Fong 2008) suggests that the burden on the backpacks of children should be limited to no more than 15% for transportation for a period of up to 20 minutes to avoid muscle fatigue. (Wong, Lee and Yeung 2009) published that the results of their studies suggest that the raise reported in backpack weight is associated with increased annual prevalence of low back pain. However, these results provide no evidence to support the recommendation that the weight of the backpack should be necessary less than 10% of body weight. (Moore, White and Moore 2007) indicates that the data obtained in their work suggest the use of 10% body weight limit for the safe use of backpacks more some variety of practical methods to help students. It also states that the younger students and women are at greater risk due to relatively lower body weight while females also carry heavier backpacks than males.

Nonconformity of school furniture

(Molenbroek, Kroon-Ramaekers and Snijders 2003) quoting Faassen (1978), Liebisch (1990), Snijders et al (1995), states that the headache, neck pain, back pain and impairment in concentration in students, are the result of prolonged sedentary positions for educational purposes, so attention must be paid to the design of school furniture. (Parcells, Stommel and

Hubbard 1999) quoting Zacharkow D. (1988) states that, the adverse effects of inappropriate classroom furniture have been known for a long time. In the analysis of furniture suitable for students exist many interesting relations like: chair high to popliteal high, seat depth with the length from buttock to back of the knee, wide hips with seat width, height of table with elbow height 90^0, etc. (Saarni et al. 2007) mentions that the main measures are the differences between seat height and popliteal height and desk height and elbow-floor height. Therefore this study only analyzes these two relations.

Relationship between Popliteal height and Seat height

(Chaffin DB 1999) states that, when the seat height is too low, the knee bending angle becomes sharp, and the weight of the trunk should be transferred to the seat through the back of the thigh, is through a small area in the ischial tuberosity on the pelvis. When the seat height is very high so that the feet do not touch the ground, pressure on the back of the thigh is very not comfortable and the person tends to be forward of the seat of the chair, allowing feet are flat on the floor, but the back support is not used properly resulting in low back pain if the posture is long. Feet should rest firmly on the floor or foot support for the weight the lower leg is not supported by the back of the thighs on the seat. (STANDARS 1998, ISO 9241-5 1998) indicates: it is not acceptable to assume that people stay with the vertical legs, it is desirable, therefore, that the bottom of the leg to reach the ground in front of the knee joint to provide a greater than 90 º.

Work surface ratio elbow height

(Chaffin DB 1999) notes that the height of the table in relation to the person sitting is very important, not only for the low back it will affect the shoulders and torso height, depending on the position and arm support. A work surface located above elbow level, results in shoulder abduction, causing increased stress on shoulders, arms and neck. For prolonged tasks is recommended shoulder abduction angle between 15^0 and 20^0. It also mentions that Bendix (1987) recommended that the height of the desk, for adults, should be between 3 and 4 cm above the elbow of the person in a position sedative.

MATERIALS AND METHODS

For this investigation it was considered a target population of 7429 students from primary schools, public, urban, municipality of Caborca, Mexico, grouped in 28 clusters. The sample size was calculated for the variable of greatest interest is the proportion of students who exceed 15% of the ratio of backpack weight to body weight of children, to an accuracy of ± 5%, 95% confidence and was a hit ratio of 30%, obtaining a sample size of 337 students. To take the random sampling was considered a probabilistic design, the school like cluster and school grade and sex of students like stratums. From each student were took the data on age, sex, grade and school group, preferred hand and floor level of the classroom location, were recorded the weight and type of backpack, they were asked how they got to school if walking, by car or public transport in addition were take body weight and 13 anthropometric measurements. Finally we visited each classroom and were taken the style banks and were measured all their heights.

ANALYSIS OF RESULTS

This procedure was conducted in two stages

• Analysis of field data from the percentage ratio between the weight of the backpack and body weight of each child with a analysis of backpack type and transportation mode.

• Correspondence between school banks with anthropometric measurements of children.

Ratio between weight of the backpack and body weight In total it is estimated that 18.8% (CI 95%, 14.4% and 23.2%) of primary school children carry a backpack over the upper limit accepted of 15%. In Figure 1 presents the data dispersion of percent of weight of load in relation to body weight by age of the participants and can be seen that for ages 6, 7 and 8 years there is a lot of data showing relations higher than the accepted upper limit (15%) and also show an increasing trend. For ages 10, 11 and 12 years there are a lesser amount data above the upper limit and this is because with age and increased body weight reflects a lower value of the relationship between weights. Figure 2 shows the dispersion of data for girls and there is a 22.53% (95%, 15.8% -29.26%) of them in the sample, exceeding the high limit accepted. In Figure 3 shows the dispersion of data from kids and found that 15.6% (95%, 9.8% - 21.4%) loaded a backpack that weighs above the upper limit accepted. The proportion of girls is higher than that presented the men because the body weight of them is significantly higher than women´s weight, P (α <0.057). If we use the lowest acceptable limit of 10% of body weight the proportion of students who carry

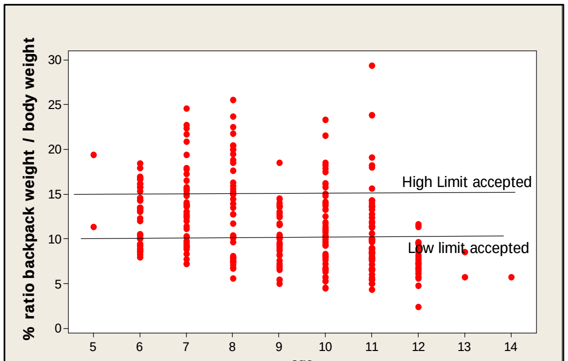

figure 1 Dispersed Data from all sample items

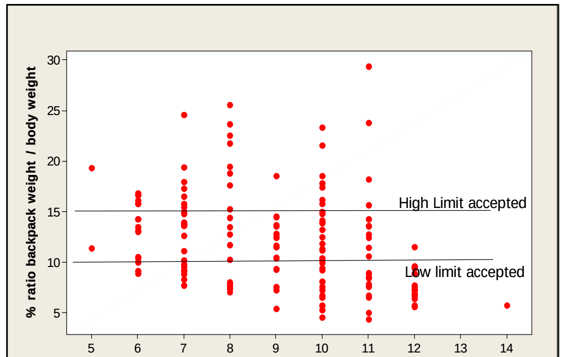

figure 2 Dispersed female participant data

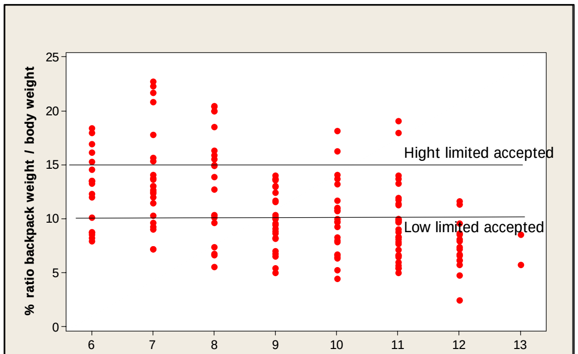

Figure 3 Dispersed male participants data

loads above this lower limit, it increase considerably, as seen in the graphs. Moreover, it was found that 54.53% of the students moved on foot to school and 25.6% of them (95%, 20.9% - 30.8%) carry a backpack weighing more than 10%, which increases the stress load. In another sense, the analysis of data revealed, according to international standards (Cole et al. 2000), 30.8% (95%, 25.7% - 35.9%) of participating children are obese, which causes in some cases, a relationship does not reflect percentage body-weight load, above the accepted limit.

Matching desks with anthropometric measurements

Analysis of the relationship popliteal height and seat height:

(Parcells et al. 1999) defined on the basis of existing research, a mismatch of popliteal height and seat height is presented for any seat height that is less than 88% or greater than 95% of popliteal height user. This allows there is a clear knee between 5% and 12% of popliteal height. Under this criterion it was found that 99.05% of the components of the sample give a strong mismatch. The seat height is well above the popliteal height of children causing their feet off the floor, causing the weight of the lower leg is supported by the back of the thigh causing pressure and discomfort in the same and decrease in blood circulation.

Analysis of relationship elbow height to 90^0 height to work surface:

For the analysis of this relationship was applicable to children literature. (Chaffin DB,1999) notes that the height of the table should be based on the user's elbow height so he recommended that the height of the desk, writing activity, must be between 3 and 4 cm above the elbow of every person in a position sedative for adults, this allows for shoulder abduction between 15^0 and 20^0 obviously this recommendation does not apply to children. To enable this same shoulder abduction in children we estimate that this range should be between 0.5 and 1.5 cm in height of the surface of work above elbow height. The research found that 97.7% (CI 95%, 96.2%, 99.4%) of all students in the sample show a strong mismatch, the height of the table exceeds by far that recommended limit which causes the children develop activities with arm abduction greater than recommended, it produce strongly stress in shoulder and neck.

CONCLUSION AND RECOMMENDATIONS

In conclusion we can say that a significant proportion of children in public schools of Caborca Mexico are at high risk for suffer back pain by excessive load on their back pack and, in particular, the risk is higher for ages 6, 7 and 8 years and for females, the same way, the risk increases significantly by the use of school furniture with dimensions not conforming to their anthropometry. All this can be a precursor of back pain in adulthood but, especially in children can cause headache, neck pain, back pain and poor concentration. Therefore it is recommended to recognize this as a public health problem and establish government policies to minimize these risks.

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WELDING TABLE DESIGN ERGONOMIC AND ENVIRONMENTAL SAFETY

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Resumen:

Diseño de mesa de prácticas de soldadura eléctrica, que cumple con requerimientos ergonómicos y de seguridad ambiental. Se utilizo el método RULA (Rapid Upper Limb Assessment) así como el BRIEF, así como normas de seguridad e higiene ambiental. Se desarrollo el Proyecto ergonómico en laboratorio y en *empresas considerando condiciones metalmecánica en la prevención de riesgos* ergonómicos y ambientales. En antropometría se considero únicamente alumnos que tomaban clases de soldadura industriales, mecánicos, mecatrónicos y aerospaciales

Objetivo: Diseñar mesa para soldadura eléctrica que permita soldar en distintas posturas y que tome en cuenta buenas condiciones ambientales de trabajo en area metalmecánica.

Metodología empleada:

- Normas oficiales Mexicanas de STPS (Secretaria de Trabajo y Previsión Social)
- Evaluación RULA/BRIEF
- Mediciones antropométricas
- Principios de diseño mecánico
- Diseño de separadores ciclónicos

Resultados:

- Técnicas de postura para soldadura 40% mejoradas
- Extracción de gases perjudiciales 80% mejoradas
- Iluminación 30% mejorada
- Recolección de desperdicios 80% mejorado
- Aplicación de normas de seguridad 100%

Conclusiones:

- Mejoramiento de la aplicación de técnicas de soldadura por poseer estación ergonómica adaptable a todos los alumnos
- Los gases emitidos de la soldadura se pudieron separar y extraer
- Mejoro estaciones de soldadura tanto en aplicación de soldadura como en gases en ambiente, y la aplicación de normas de seguridad
- Actualmente se invierte más tiempo en aplicar técnicas de soldadura que en corregir inconvenientes ambientales y de posturas para soldar.

- Se mejoro la iluminación en las estaciones de trabajo
- Se disminuyo extracción de desechos de soldadura

Abstract:

Table design welding practices, to meet ergonomic requirements and environmental safety. We used the RULA (Rapid Upper Limb Assessment) and the BRIEF method as well as safety and environmental hygiene. Ergonomic Project was developed in the laboratory and metallurgical companies, considering conditions in the prevention of ergonomic hazards and environmental. In anthropometry was considered only students taking classes in industrial welding, mechanical, mechatronics and aerospace

Objective: Welding table design that allows welding in various positions and takes into account good environmental working conditions in metalworking area.

Methodology

- Mexican Official Standards of STPS (Ministry of Labour and Social Welfare)
- RULA assessment / BRIEF
- Anthropometric measurements
- Mechanical design principles
- Cyclone Design

Results

- Welding Techniques for posture was improved 40%

- Extraction of injurious fumes was improved 80%
- Lighting was improved 30%
- Collection waste was improved 80%
- Application of 100% safety rules

Conclusions:

- Improved application of welding techniques have ergonomic station adaptable to all students
- The fumes emitted from the welding could separate and extract
- Improved welding stations and welding application both as fumes in the environment, and implementation of safety standards
- Currently spends more time for welding techniques applied to correct environmental problems and positions for welding.
- Lighting was improved workstations
- It decreased Waste Removal Welding

Introduction

The main problem we had was to comply with the requirements established by Commission certifying CACEI observation indicated that we were developing area of training in welding practices. Although initially wanted to meet certification specifications, we realized that we had not in fact many minimum security requirements, protection of students and ergonomic tables to properly develop their practices, had many defects awkward postures when performing welding .

As we took on the task of designing table welding practices, to meet ergonomic requirements and environmental safety.

We used the RULA (Rapid Upper Limb Assessment) and the BRIEF as well as safety and environmental hygiene. Ergonomic Project was developed in the laboratory and metallurgical companies, considering conditions in the prevention of ergonomic hazards and environmental. In anthropometry was considered only students taking classes in industrial welding, mechanical, mechatronics and aerospace

Objetive

Welding table design that allows welding in various positions and take into account good environmental conditions in metalworking sector work

Methodology used

1. Mexican Official Standards of STPS (Ministry of Labour and Social Welfare) NOM-027-STPS-2008, ACTIVITIES OF WELDING AND CUTTING SAFETY AND HEALTH CONDITIONS

Identificación del riesgo según el proceso de soldadura utilizado

El contenido de esta guía es un complemento para la mejor comprensión de esta Norma y no es de cumplimiento obligatorio. Se presenta con el fin de mostrar los diferentes riesgos que se pueden presentar durante el proceso de soldadura seleccionado.

	PROCESO DE SOLDADURA			
RIESGO	PLASMA (PAW/PAC) ARCO CARBON	SMAW GTAW (TIG) GMAW (MIG) FCAW	SOLDADURA DE ARCO SUMERGIDO (SAW)	OXICOMBUSTIBLE
Ergonómico	✓	✓	✓	✓
Choque eléctrico	✓	✓	✓	×
Luz intensa	✓	✓	(✓)	✓
Radiación no ionizante (infrarroja, ultravioleta, etc.)	✓	✓	(✓)	×
Gases y humos tóxicos	✓	✓	(✓)	✓
Calor, fuego y quemaduras	✓	✓	✓	✓
Ruido y vibraciones		×	×	×

Nota: ✓ = Indica que está presente el riesgo

(✓) = Indica que hay riesgo si no se usa "flux"

× = Indica que no hay riesgo.

Abreviatura	Concepto
PAW	(PAW) Plasma soldadura de arco
PAC	(PAC) Plasma de arco–carbón
SMAW	SMAW (SHIELDED METAL ARC WELDING) Soldadura de arco metálico protegido.
GTAW (TIG)	GTAW (GAS TUGNSTEN ARC WELDING) Soldadura de arco de tungsteno y gas.
GMAW (MIG)	GMAW (GAS METAL ARC WELDING) Soldadura de arco metálico y gas.
FCAW	FCAW (FLUX CORED ARC WELDING) Soldadura de arco cubierta de Flux.
(SAW)	SAW (SUBMERGED ARC WELDING) soldadura de arco sumergido

Figure 1. Show risk identification on welding NOM-027-STPS-2008

Exposure to ultraviolet radiation and light are produced by the arc. Health and safety conditions during welding activities

a) ABC type fire extinguisher with a capacity according to potential risks within a radius of no more than 7 meters in the area where the activities in welding.

b) Have welding booths or partitions to delineate areas where activities are carried out welding or cutting;

c) Use at least, face shields or welding shade lenses, face shields, hoods (nuns), breathing smoke, wahoo (apron), welder gloves, leggings, sleeveless and safety shoes;

d) Implement the safety procedures that include steps to prevent damage to exposed personnel and actions to be applied before, during and after the equipment or areas where activities are carried out welding and cutting;

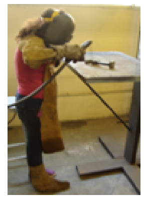
e) Post signs, notices, locks or safety labels, according to the provisions of NOM-004-STPS-1999 and NOM-026-STPS-1998, on electrical systems that provide power to welding equipment and cutting, and restrict the flow to areas where activities are carried out welding and cutting, and

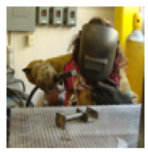
f) Have natural or artificial ventilation before and during welding and cutting activities in the areas of work.

Evaluation RULA/BRIEF

Table 1. Evaluation of Rula process of welding current right side

Puntos	Posiciones del brazo (Tabla 1)
3	Flexión 45° - 90°
Puntos	Posiciones que modifican puntuación del brazo (Tabla 2)
1	Hombro elevado o brazo rotado
1	Brazos abducidos
Puntos	Posiciones del antebrazo (Tabla 3)
1	Flexión 60° - 100°
Puntos	Posiciones que modifican puntuación del antebrazo (Tabla 4)
1	Proyección vertical del antebrazo se encuentra más allá de la proyección vertical del codo
Puntos	Posiciones de la muñeca (Tabla 5)
2	Flexionada o extendida entre 0° - 15°
Puntos	Posiciones que modifican puntuación de la muñeca (Tabla 6)
1	Desviada radial o cubitalmente
Puntos	Posición Giro de la muñeca (Tabla 7)
1	Pronación o supinación en rango medio
	Puntuación Global Grupo A 7
Puntos	Postura
1	Estática, si se mantiene postura >1 minuto seguido repetitivo (si se repite > 4 veces/minuto)
Puntuación para actividad muscular y fuerza ejercida	
Puntos	Posición (Tabla 15)
0	Si la carga o fuerza es menor de 2 Kg. y se realiza intermitentemente
	Puntuación Global Grupo C 8





Puntos	Posiciones del cuello (Tabla 8)
3	Flexión > 20°
Puntos	Posiciones del tronco (Tabla 10)
2	Flexionado 0° - 20°
Puntos	Posiciones que modifican puntuación del tronco (Tabla 11)
1	Torsión del tronco
Puntos	Posición de las Piernas (Tabla 12)
1	De pie con peso simétricamente distribuido y espacio para cambiar de posición
	Puntuación Global Grupo B 3
Puntos	Postura
1	Estática, si se mantiene postura >1minuto seguido repetitivo (si se repite > 4 veces/minuto)
Puntuación para actividad muscular y fuerza ejercida	
Puntos	Posición (Tabla15)
0	Si la carga o fuerza es menor de 2 Kg. y se realiza intermitentemente
	Puntuación Global Grupo D 4

Table 2. Evaluation of Rula process of welding current left side

Puntos	Posiciones del brazo (Tabla 1)
3	Flexión 45° - 90°
Puntos	Posiciones que modifican puntuación del brazo (Tabla 2)
1	Hombro elevado o brazo rotado
1	Brazos abducidos
Puntos	Posiciones del antebrazo (Tabla 3)
2	Flexión < 60° o > 100°
Puntos	Posiciones que modifican puntuación del antebrazo (Tabla 4)
1	Proyección vertical del antebrazo se encuentra más allá de la proyección vertical del codo
Puntos	Posiciones de la muñeca (Tabla 5)
1	Posición neutra respecto a flexión
2	Flexionada o extendida entre 0° - 15°
Puntos	Posiciones que modifican puntuación de la muñeca (Tabla 6)
1	Desviada radial o cubitalmente
Puntos	Posición Giro de la muñeca (Tabla 7)
1	Pronación o supinación en rango medio
	Puntuación Global Grupo A 7
Puntos	Postura
1	Estática, si se mantiene postura >1 minuto seguido repetitivo (si se repite > 4 veces/minuto)
	Puntuación para actividad muscular y fuerza ejercida
Puntos	Posición (Tabla 15)
0	Si la carga o fuerza es menor de 2 Kg. y se realiza intermitentemente
	Puntuación Global Grupo C 8

Puntos	Posiciones del cuello (Tabla 8)
3	Flexión > 20°
Puntos	Posiciones del tronco (Tabla 10)
2	Flexionado 0° - 20°
Puntos	Posiciones que modifican puntuación del tronco (Tabla 11)
1	Torsión del tronco
Puntos	Posición de las Piernas (Tabla 12)
1	De pie con peso simétricamente distribuido y espacio para cambiar de posición
	Puntuación Global Grupo B 3
Puntos	Postura
1	Estática, si se mantiene postura >1minuto seguido repetitivo (si se repite > 4 veces/minuto)
	Puntuación para actividad muscular y fuerza ejercida
Puntos	Posición (Tabla15)
0	Si la carga o fuerza es menor de 2 Kg. y se realiza intermitentemente
	Puntuación Global Grupo D 4

Anthropometrics measurements

Table 3. Measurements of studens considered for the design tables (Niebel 2006)

Mujer 12.5%		Hombre 87.5%		Descripción
Prom	Des	Prom	Des	de Medición (Cm)
160.5	9.2	176.8	9.3	1. Estatura
151.2	9.7	166.2	9.3	2. Altura de la vista al suelo
134.7	9.0	147.9	9.0	3. Altura hombro al suelo
102.3	6.7	112.3	6.5	4.Altura codo al suelo (brazo colgando)
97.0	3.5	103.8	7.0	5.Altura cadera al suelo
48.0	4.2	52.4	3.2	6.Altura Rodilla al suelo
205.5	15.6	227.0	12.8	7.Altura dedos de la mano al suelo (brazo hacia arriba mano abierta)
163.5	12.7	180.7	10.0	8.Altura codo al suelo (brazo extendido hacia arriba)
35.0	2.1	39.2	2.1	9. Extensión brazo doblado, antebrazo pegado a cuerpo
57.3	23.0	77.3	5.9	11.Extension hacia el frente (tomado desde espalda)
36.8	3.9	46.3	3.7	13.Ancho hombro a hombro
41.8	1.1	50.0	5.1	14.Ancho codo a codo
22.8	2.5	25.2	4.0	15.Ancho pecho-espalda
26.0	0.7	29.6	1.3	18.Calzado

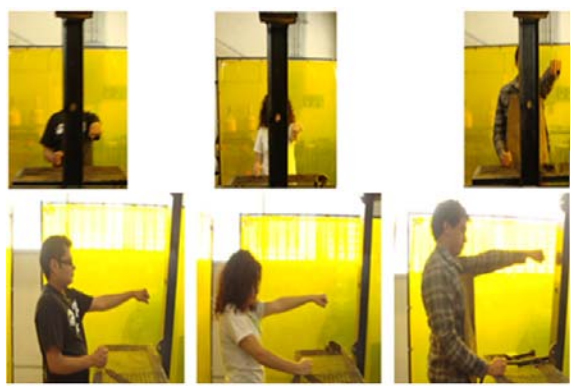


Figure 2. Importance of anthropometry in welding table set for short stature

Principles of mechanical design and ergonomic welding table

The ergonomic design stages based on the model of ergonomic plan Galer (1987).

1. Identifying the problem. To meet CACEI and table design you can keep the electrode in the 60th position when he moves to the piece can be welded properly. It was observed that there

was only one table for tall people, one for low and one with intermediate values, it aims to standardize ergonomic desk, for it was evaluated the impact of the ergonomics program can have on the process of design, development and manufacture thereof.

2. Characterization of user needs. Should be provided in the product qualities not found in other similar, so that is competitive to attract the consumer. In this case we rely on market trends, education, teaching in the same practice, including extraction of gases, change table height, electrode cleaning, removal of dangerous particles.
3. Providing design criteria. Techniques to manufacture, such as anthropometry, hygiene, safety, to name a few. Allow to have data on the characteristics of the tasks of the welding table. Impacting on the comfort, efficiency and user satisfaction welding practitioner.
4. Product evaluation. Because they made a series of assumptions and preconditions to product design to be employed, it is necessary to evaluate different aspects of strength, safety, durability and comfort. It continues to seek information from individual prototypes to improve future versions.

Table 4. Rula evaluation method for Improved welding table

Puntos	Posiciones del brazo (Tabla 1)
1	Extensión 20° a flexión 20°
Puntos	Posiciones del antebrazo (Tabla 3)
1	Flexión 60° - 100°
Puntos	Posiciones de la muñeca (Tabla 5)
2	Flexionada o extendida entre 0° - 15°
Puntos	Posiciones que modifican puntuación de la muñeca (Tabla 6)
1	Desviada radial o cubitalmente
Puntos	Posición Giro de la muñeca (Tabla 7)
1	Pronación o supinación en rango medio
	Puntuación Global Grupo A 2
Puntos	Postura
1	Estática, si se mantiene postura >1 minuto seguido repetitivo (si se repite > 4 veces/minuto)
	Puntuación para actividad muscular y fuerza ejercida
Puntos	Posición (Tabla 15)
0	Si la carga o fuerza es menor de 2 Kg. y se realiza intermitentemente
Puntuación Global Grupo C 3	

Puntos	Posiciones del cuello (Tabla 8)
3	Flexión > 20°
Puntos	Posiciones del tronco (Tabla 10)
2	Flexionado 0° - 20°
Puntos	Posición de las Piernas (Tabla 12)
1	De pie con peso simétricamente distribuido y espacio para cambiar de posición
	Puntuación Global Grupo B 2
Puntos	Postura
1	Estática, si se mantiene postura >1minuto seguido repetitivo (si se repite > 4 veces/minuto)
Puntuación para actividad muscular y fuerza ejercida	
Puntos	Posición (Tabla15)
0	Si la carga o fuerza es menor de 2 Kg. y se realiza intermitentemente
	Puntuación Global Grupo D 3

Figure 3.Prototype workbench of varying heights, ergonomic and environmentally safe

Cyclone Design

- The inhalation of smoke and toxic gases produced by the electric arc is very variable depending on the type of electrode coating or shielding gas and base materials and filler, and may involve exposure to fumes (oxides of iron, chromium, manganese, copper, etc..) and gases (carbon oxides, nitrogen, etc.).
- We can mention the exposures: UV radiation, light radiation, to fumes and gases, phosgene poisoning and noise.
- Design based on conventional cyclone tangential inlet and outlet axial
- Where is the cyclone diameter Dc
- total length of the cyclone will 4DC
- Waste gases Dc / 2
- Discharge of solid Dc / 4
- The entry will be given by a base Dc / Dc 4 and height / 2, which will get the input area and compared against incoming spending

Results

Welding Techniques posture improved 48%

Table 5. Improvements were assessed using a new method Rula welding table

Puntuación	Antes de la mejora		Después de la mejora		Resultados Propuestos	
	Derecha	Izquierda	Derecha	Izquierda	Derecha	Izquierda
Global A	7	7	2	2	71%	71%
Global B	3	3	2	2	33%	33%
Global C	8	8	3	3	63%	63%
Global D	4	4	3	3	25%	25%
Final	6	6	3	3	50%	50%

Removal of harmful gases 80% improved

30% Enhanced Lighting

Waste Collection 80% improved

Implementation of standards-based security NOM-027-STPS-2008

Program Requirements for welding and cutting activities.

There should be a program of cutting and welding activities.

Document (present evidence):

• Analysis of potential risks for welding and cutting activities

Training and training for maintenance workers to provide preventive and corrective maintenance of equipment and machinery, welding and cut

- Training in personal protective equipment (use, maintenance, replacement)
- Medical workers welders (every 12 months)
- Training and safety procedures (at least once a year)
- Rescue Training
- Training in first aid (at least once a year)

Physical

- Personal Protective equipment
- First Aids Kits

Conclusions:

1. Improved application of welding techniques have ergonomic station adaptable to all students by 50%
2. The gases emitted from the welding could separate and extract
3. Improved welding stations welding application both as gases in the environment, and implementation of safety standards
4. Currently spends more time welding techniques applied to correct environmental problems and positions for welding.
5. Lighting was improved workstations
6. It decreased Waste Removal Welding

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USE OF COLOR LIGHTS FOR THE DETECTION OF ANOMALIES IN QUALITY SYSTEMS

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RESUMEN

La importancia del cuidado visual es un tema de primer nivel en las empresas orientadas al ensamble o fabricación de diversos productos ya que requieren de atención directa de la salud general de los trabajadores y particularmente de la salud visual.

El sistema de iluminación, las características de las lámparas y las actividades a realizar son factores que inciden sobre el rendimiento visual del trabajador. Cada uno de estos factores, ya sea de manera individual o en conjunto, influyen sobre el rendimiento visual del trabajador y por tanto sobre su seguridad y eficacia.

La fatiga visual puede producirse por problemas de visión que pueda tener una persona, por el uso de gafas de corrección inadecuadas, diversas alteraciones del órgano de la visión, edad, por causas relacionadas en la estación de trabajo (deficiencias de alumbrado, contrastes inadecuado, etc.). Algunos de los síntomas que se presentan son: Problemas para fijar la vista, ojos rojos, lagrimeo, dolor de cabeza, visión borrosa, pesadez de los parpados y sequedad de ojos (Llaneza, 2006).

Esta investigación se realizó con 48 personas; de las cuales 27 pertenecen al género masculino y 21 al femenino, con edades entre los 17 y 58 años. Se utilizaron sistemas de iluminación basados en LEDs de color (blanco, azul, verde, rojo y amarillo) ya que emiten luz monocromática, además de que son una excelente alternativa en el ahorro del consumo de energía eléctrica; para encontrar el color adecuado para la detección de anomalías en las piezas de metal al momento de la inspección visual, ya que el ser humano es el recurso más importante para cualquier organización y/o sociedad, y de ellos depende el éxito de la empresa.

Palabras claves: Fatiga visual, Detección de anomalías y Diodos Emisores de Luz (LEDs, por sus siglas en inglés).

ABSTRACT

The importance of the visual care in the industry is a first level topic, due to most of the assembly and manufacturing aimed companies of various products that require direct health care of their employees, specially eye care.

The lighting system, the lamp features and job tasks are factors that impact over the visual performance of the worker. Each of these factors, either by themselves or in conjunction, influence the visual performance of the employee, and therefore its safety and efficacy.

Visual fatigue can be caused by the vision problems that a person may have, for the use of inappropriate corrective glasses, various alterations of the organ of vision, age, workplace related causes (lighting deficiencies, inadequate contrast, etc.). Some of the reported symptoms are:

problem of visual fixation, eye redness, tearing, headache, blurred vision, eyelids heaviness and dry eyes, (Llaneza, 2006).

The research was developed with 48 people, 27 male and 21 female, in the range of ages of 17 to 58 years old. In the experiment were used illumination system base on Diode Emitting lights (LED´s) of five different colors (White, Blue, Green, Red and Yellow), the reason of use of LED´s it is because are source of monochromatic light, also it is also saving power light and low heating dissipation. The LED´s illumination system was used in this research to detect defects in metal sheet pieces used in automotive body parts, simulating a work station related with inspection and quality department.

Keywords: Visual Fatigue, anomaly detection and Light Emitting Diodes (LEDs).

Introduction

The work environment is one of the key elements that really impact on the behavior, performance and motivation of the worker, impacting their health, performance and comfort (Ramírez Cavassa, 2006). A poor lighting can potentially increase the chance of mistakes while working and accidents, therefore can lead to visual fatigue, with all of the damages that this represent on people's health, for example, eye issues (dryness, itching), headache, fatigue, irritability, moodiness, etc.

Human beings possess an extraordinary ability to adapt to its ambiance. Of all the types of energy that humans can use, light is the most important. Light is an essential element of our capacity to see and its necessary to appreciate the shape, color and perspective of the objects that surround us in our daily living. Therefore the visual system is a major of the human being, due to most of the tasks are performed with the help of the eyes; it is also stated that 80% of the information we obtain through our senses we get it by the sight (Ramos Pérez & Hernandez Calleja, 1997).

There are over 284 million people are visually impaired worldwide: 39 million are blind and 245 have low vision. Most of the vision impairment it is caused for refractive errors (myopia, hypermetrophy and astigmatism), it means that we are facing a major public health problem, according to the World Health Organization (WHO, 2011).

According to the National Institute of Statics Geography and Informatics (INEGI) visual problems is the second leading cause of disability in Mexico. Between 25 and 30% of the Mexican population has a refraction deficiency, which is manifested at different ages and can develop into a disabling factor according the Mexican Social Security Institute (IMSS, 2010).

OBJECTIVES

To determine the favorable visual environment for the appreciation of defects in metal parts by using lights of different colors. To find the right color of light to detect scratches, dings, chop and chip on metal pieces.

3. METHODOLOGY

The following describes the methodology used to conduct the research:

1. This research used LED lights color: white, green, blue, red and yellow.

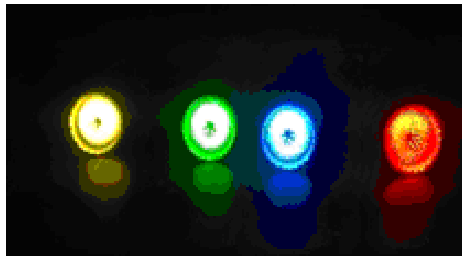

Figure 1. LED lamps

2. The use of black light, is known to be used in quality control for the detection of anomalies, being that by illuminating certain materials such anomalies highlight due to a phenomenon called fluorescence.

Figure 2. Black light

3. The type of material used in this research were samples of automotive body parts (18 pieces) which were provided by an automotive company for visual inspection with LED´s light of different colors, therefore you must know the exact size, thickness, material type, shape, texture and color.

Figure 3. Metal sheets to inspect

4. The metal sheets will be listed from 1 to 18 (with a small number, that person cannot easily see), so this doesn't influence remembering the defect depending on the number of the metal sheet.

5. Some of the 18 metal sheets to be used will have some defects such as: scratches, dings, chop and chip, while others will be presented in perfect condition.

Table 1. Expected results in each metal sheet

Metal sheets	Expected results	Metal sheets	Expected results
1	Chop	10	Dings
2	Scratch, chop	11	Good
3	Dings, scratch	12	Dings, scratch
4	Good	13	Good
5	Dings	14	Dings, scratch
6	Scratch	15	Scratch
7	Dings, scratch	16	Dings
8	Good	17	Good
9	Scratch, chip	18	Dings

6. Arrangement for metal sheets and color lights in the experiment. It is a format with the experiment procedure to develop (See annex 1). The arrangement of the 18 metal sheets was performed randomly assigned to the 48 people included in this case of study.

7. It will be used the format shown in Annex 2 for recording results of each experiment is performed, this in order to capture the events objectively shed with every variation of light and metal sheet to use.

8. Laboratory tests (Experimental phase):

8.1 One of the cubicles of the Division of Graduate Studies and Research of the Technological Institute of Hermosillo will be used.

8.2 The cubicle's windows will be blinded so other cubicles' artificial and natural light does not affect.

8.3 The experiment will be performed with 48 samples (persons).

8.4 All unnecessary obstructions in the visual field will remove, since the person (inspector) must be in a position to detect anomalies at the time the metal sheets enter its visual field.

Steps for the experiment:

a) Arrangement of metal pieces was made according experiment procedure (See annex 1).
b) It was explained to the person the types of anomalies (Scratches, dings, chop, chip) that could be found or if the metal sheet is in perfect condition.
c) The Inspection format is provided to each person.
d) Will locate the LEDs lamp (white, blue, green, red or yellow) or black light depending on what arrangement procedure establish (See annex 1).
e) Will turn off the cubicle's light so it does not affect LED lamp's light.
f) The person inspects the metal sheet.

Figure 4. Visual inspection

g) Cross with an "X" the inspection format (See annex 2), depending on what is detected in the metal sheet.

h) The average inspection time is approximately 30 seconds per metal sheet.

i) The step f) and g) will take place 18 times, since it is the total of metal sheets.

j) Once the inspection of the 18 metal sheets is finished, will be given 1 minute for the accommodation of the eye, as well as for the preparation and arrangement of the metal sheets.

k) Carry out the above steps d), e), f), g), h), i), j), each time you change the colors of light.

l) After completing these steps with the 6 lights will end the experiment for each person.

- The total time the experiment will take each person will be approximately 1 hour.

9. Capture the results of experiment in spreadsheets.

RESULTS

Information was analyzed by asking each person ¿what is the best color to find anomalies in metal sheets?, the results are: 35% of people said that the best is green light, followed by blue light with 21% and finally the red light with 10%, because they have difficult to inspect de metal sheets and the defects didn't appreciate by the red light. These results can be seen in figure 5.

67.6% of the scratches are more easily identified with the green light, 69.7% of the dings with the blue light, the 94.9% of the chop with blue light and 98.6% of the chip with green light in the metal sheets, see Table 2. In annex 3 we see the data obtained of how to inspect scratches in metal sheets.

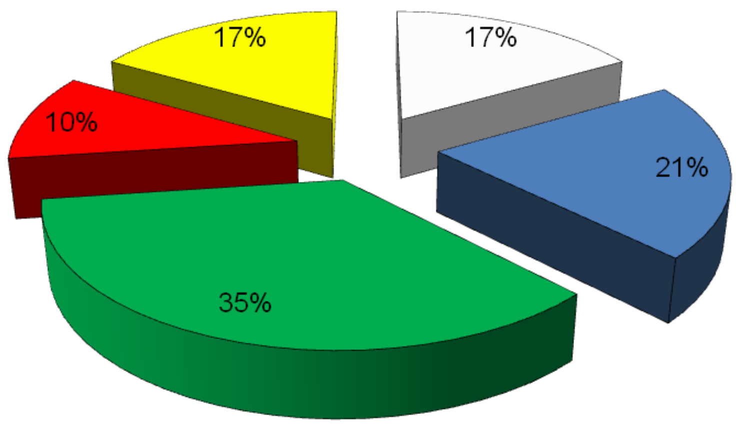

Figure 5. Results of appreciation using different colors of light

Table 2. Experiment results

	WHITE LIGHT	BLUE LIGHT	GREEN LIGHT	RED LIGHT	YELLOW LIGHT
SCRATCH	0.640046	0.66088	0.675926	0.633102	0.6412037
DINGS	0.668981	0.696759	0.663194	0.668981	0.6736111
CHOP	0.946759	0.949074	0.946759	0.943287	0.9444444
CHIP	0.980324	0.982639	0.986111	0.978009	0.9826389

CONCLUSIONS

Based on the data collected and the analysis of data, considering the conditions under which the work was done, we conclude that it is much easier to illuminate the object from side to highlight your relevant details and that 73% of people who made the experiment said they are thus more easily appreciate defects (Scratches, dings, chipping and chopped) that if you put the light directly on the object to be inspected because it is more difficult, which can cause glare on the person.

It was determined that the LED lamps (Light Emitting Diode) green and blue are the best in the detection of scratches, bumps, bites and chipping for visual inspection of automotive body parts and that better results were obtained in the analysis data.

One of the reasons why you should pay attention to the type of lighting used in the workplace is because people who perform visual inspection are at risk of Asthenopy (Visual Fatigue), which is a latent uneasiness in most companies, If not treated, can lead to serious defects in vision, such as decreased visual acuity, defective color vision and accidents.

RECOMMENDATIONS

- Validate the results obtained in the industrial sector.
- Expanding the field of materials for inspection.
- Increase the training time.
- Increase the number of sample to achieve results more representative of the working population in the City of Hermosillo.

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ANNEX 1. Arrangement for metal sheets and color lights

Inspector	Color light	Metal sheets	Color light	Metal sheets	Color light	Metal sheets	Color light	Metal sheets	Color light	Metal sheets
1	Blue	6,3,8,4,1,9,2,5,7, 15,12,17,13,10, 18,11,14,7	White	9,6,8,4,3,1,2,5,7, 18,15,17,13,12, 10,11,14,16	Yellow	2,3,7,1,5,9,4,6,8, 11,12,17,10,14, 18,13,15,17	Red	2, 3,1,7,8,5,9,4,6, 11,12,10,16,17, 14,18,13,15	Green	3,7, 8,1,6,2,9,5,4, 12,16,17,10,15, 11,18,14,13
2	Yellow	7,4,3,5,6,8,9,2,1, 16,13,12,14,15, 17,18,11,10	Green	1,2,7,8,6,3,9,4,5, 10,11,16,17,15, 12,18,13,14	Blue	2,8,4,6,1,3,7,5,9, 11,17,13,15,10, 12,16,14,18	White	1,2,3,8,9,5,6,7,4, 10,11,12,17,18, 14,15,16,13	Red	2,3,4,9,7,6,5,1,8, 11,12,12,18,16, 15,14,10,17
3	Green	8,5,6,3,1,2,7,4,9, 17,14,15,12,10, 11,16,13,18	Red	3,2,5,4,8,9,6,7,1, 12,11,14,13,17, 18,15,16,10	White	5,6,8,7,4,9,2,1,3, 14,15,17,16,13, 18,11,10,12	Blue	6,4,9,5,3,7,2,1,8, 15,13,18,14,12, 16,11,10,17	Yellow	9,5,8,4,2,1,6,7,3, 18,14,17,13,11, 10,15,16,12
4	White	1,2,9,8,6,5,3,4,7, 10,11,18,17,16, 14,12,13,16	Yellow	1,7,4,2,3,6,9,5,8, 10,16,13,11,12, 15,18,14,17	Red	7,6,9,8,4,3,2,1,5, 16,15,18,17,13, 12,11,10,14	Green	8,5,2,4,7,9,1,3,6, 17,14,11,13,16, 18,10,12,15	Blue	5,3,6,4,1,8,2,9,7, 14,12,15,13,10, 17,11,18,16

5	Blue	7,8,5,3,2,6,4,9,1, 16,17,14,12,11, 15,13,18,10	Green	8,3,1,7,9,6,2,4,5, 17,12,10,16,18, 15,11,13,14	White	9,3,7,1,8,4,6,5,2, 18,12,16,10,17, 13,15,14,11	Red	9,2,3,8,5,4,6,7,1, 18,11,12,17,14, 13,15,16,10	Yellow	3,6,9,8,7,1,2,4,5, 12,15,18,17,16, 10,11,13,14
6	Red	2,9,7,1,5,6,4,8,3, 11,18,16,10,14, 15,13,17,12	Green	8,2,3,6,7,5,9,1,4, 17,11,12,15,16, 14,18,10,13	White	6,7,9,4,1,8,2,3,5, 15,16,18,13,10, 17,11,12,14	Yellow	6,3,4,1,5,8,7,9,2, 15,12,13,10,14, 17,16,18,11	Blue	1,8,5,3,4,7,6,2,9, 10,17,14,12,13, 16,15,11,18
7	White	4,7,8,9,2,5,1,3,6, 13,16,17,18,11, 14,10,12,15	Blue	9,2,1,6,3,5,8,7,4, 18,11,10,15,12, 14,17,16,13	Green	7,4,5,3,6,9,2,8,1, 16,13,14,12,15, 18,11,17,10	Yellow	9,1,7,4,8,5,2,6,3, 18,10,16,13,17, 14,11,15,12	Red	4,1,3,2,6,7,5,9,8, 13,10,12,11,15, 16,14,18,17
8	Yellow	8,6,1,7,9,2,3,4,5, 17,15,10,16,18, 11,12,13,14	Green	7,4,3,1,6,2,9,8,5, 16,13,12,10,15, 11,18,17,14	White	4,5,7,8,6,9,2,1,3, 13,14,16,17,15, 18,11,10,12	Blue	9,5,7,2,8,4,3,6,1, 18,14,16,11,17, 13,12,15,10	Red	3,1,6,5,7,8,4,2,9, 12,10,15,14,16, 17,13,11,18
48	Green	9,1,6,7,4,5,2,3,8, 18,10,15,16,13, 14,11,12,17	White	6,4,1,9,7,5,8,2,3, 15,13,10,18,16, 14,17,11,12	Blue	5,3,7,1,8,2,4,9,6, 14,12,16,10,17, 11,13,18,15	Yellow	1,9,3,8,6,7,2,4,5, 10,18,12,17,15, 16,11,13,14	Red	9,8,2,4,1,3,5,7,6, 18,17,11,13,10, 12,14,16,15

ANNEX 2. Inspection format

WHITE LIGHT

	Scratch	Dings	Chop	Good	Chip
1					
10					
9					
18					
2					
11					
6					
15					
3					
12					
7					
15					
4					
13					
5					
14					
8					
17					

BLUE LIGHT

	Scratch	Dings	Chop	Good	Chip
1					
10					
5					
14					
7					
16					
2					
11					
8					
17					
4					
13					
3					
12					
9					
18					
6					
15					

GREEN LIGHT

	Scratch	Dings	Chop	Good	Chip
2					
11					
7					
16					
3					
12					
5					
14					
9					
18					
6					
15					
1					
10					
8					
17					
4					
13					

RED LIGHT

	Scratch	Dings	Chop	Good	Chip
3					
12					
5					
14					
4					
13					
7					
16					
2					
11					
6					
15					
9					
18					
1					
10					
8					
17					

YELLOW LIGHT

	Scratch	Dings	Chop	Good	Chip
6					
15					
8					
17					
5					
14					
9					
18					
1					
10					
2					
11					
7					
16					
4					
13					
3					
12					

BLACK LIGHT

	Scratch	Dings	Chop	Good	Chip
18					
1					
15					
9					
17					
2					
13					
10					
3					
4					
16					
7					
5					
11					
14					
8					
6					
12					

ANNEX 3. Example of data analysis for the detection of scratches in the metal sheets

Metal sheet #	Expected results	Inspector # 1	
1	PASS	PASS	OK
2	FAIL	FAIL	OK
3	FAIL	PASS	NO
4	PASS	FAIL	NO
5	PASS	PASS	OK
6	FAIL	PASS	NO
7	FAIL	FAIL	OK
8	PASS	PASS	OK
9	FAIL	FAIL	OK
10	PASS	PASS	OK
11	PASS	PASS	OK
12	FAIL	PASS	NO
13	PASS	PASS	OK
14	FAIL	FAIL	OK
15	FAIL	FAIL	OK
16	PASS	FAIL	NO
17	PASS	PASS	OK
18	PASS	PASS	OK

Metal sheet	
1	Chop
2	**Scratch**, chop
3	Dings, **scratch**
4	Good
5	Dings
6	**Scratch**
7	Dings, **scratch**
8	Good
9	**Scratch**, chip
10	Dings
11	Good
12	Dings, **scratch**
13	Good
14	Dings, **scratch**
15	**Scratch**
16	Dings
17	Good
18	Dings

Total OK	$\boxed{13}$
% OK	0.7222

Total of times the person agrees with the expected results of the inspection.

Total of OK qualified by the person divided by the 18 metal sheet pieces.

GRADUATE ACADEMIC PROGRAM AS A STRATEGY FOR PROMOTING THE PROFESSIONALIZATION OF ERGONOMICS IN MEXICO.

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Resumen

Debido a la creciente demanda de especialistas en Ergonomía en México en los últimos 15 años, se desarrolló un proyecto de diseño curricular para implementar un programa de posgrado en Ergonomía a nivel Maestría, en la Universidad de Guadalajara. El proyecto incluyó un estudio del mercado de trabajo a nivel nacional encuestando industrias, empresas y universidades con necesidades de contar con especialistas en ésta importante área. Se construyó una Estructura Conceptual de los campos de conocimiento y aplicación de la disciplina y se realizó una revisión de las exigencias de las principales agencias de certificación profesional en ergonomía en E.UA. y Europa, así como una revisión de los programas de estudio de maestrías en ergonomía. Con éstos elementos y utilizando técnicas de diseño curricular actualizadas, se diseñó un programa de estudios de dos años, con dos orientaciones especializantes, que permitirá una formación profesional de alta calidad para impulsar el conocimiento, aplicación y difusión de la Ergonomía en nuestro país

Palabras clave: Ergonomía; Formación profesional, Titulaciones de Posgrado,

Abstract

Given growing demand for Ergonomics specialists in Mexico over the past 15 years, a curricular design was developed to implement a Masters level graduate program at the University of

Guadalajara. The project included a market study into the national labor market, surveying industrial plants, other firms and universities regarding their need for specialists in this important field. A Conceptual Framework was built for areas of knowledge and applications within the discipline, and a review made of requirements by the main ergonomics accreditation agencies in the U.S. and Europe, as well as a review of plans of study for Masters degrees in ergonomics. With these elements in place, and using updated curricular design techniques, a two-year course of study was created, with two specialization options, to provide high-quality professional training that will promote knowledge, application and diffusion of Ergonomics in our country.

Keywords: Vocational training, Graduate degrees, Ergonomics

INTRODUCTION

In the past 15 years in our country, the need for knowledge, application, transmission and dissemination of ergonomics in their different fields and areas of study, has spread from transnational and national corporations' needs to implement programs and ergonomic solutions in processes and products, to undergraduate degrees in Industrial Design, Graphic Design, Interior Design, Architecture, Industrial Engineering, Mechanical Engineering, Mechatronics, Psychology, and Medicine, as well as various graduate degrees such as the Masters in Occupational Health, Masters in Engineering and Masters in Design and Product Development; where both companies and public and private institutions have suffered from the lack of professionals in the field of ergonomics, to be supplied by professionals who have only very basic training in self-supported short courses, whose breadth and strength is far from real training. Based on this situation and in order to meet the demand of ergonomics professionals in our country, we propose the implementation of a graduate program with two specialization options.

OBJECTIVES

To design and implement a Graduate Program in Ergonomics at Master of Science-level degree, to contribute to the training of ergonomists with the knowledge, skills, values and attitudes that enable them to solve problems with a high level of efficiency and effectiveness in the fields of Occupational and Design Ergonomics in Mexico.

The design, content and implementation of the program will address the basic needs of vocational training in ergonomics to meet the demands of the industrial, business and educational institutions in our country, preparing students to solve specific problems and develop an internationally high standard of performance.

METHODOLOGY

Curriculum Design methodology included the following steps:

1. Building a theoretical curriculum model based on reviewing curriculum design theories from the most important authors in the field.
2. A study of the labor market nationally.
3. Developing a Basic Ergonomics Conceptual Framework.
4. A review of ergonomics accreditation standards in various parts of the world.
5. The review of graduate curricula in Ergonomics from around the world.

Building a theoretical curriculum model.

The first stage took into account such recognized theoretical guidelines for curriculum design as Taba (1993), Tyler (1973) Johnson (1967), Sarramona, Lafourcade (1969), Posner (1979), Furlan (1979), Coll (1991), Arnaz (1995) and Bruner (1972), to establish a Curricular

Model that would direct further actions. The model arose from an analysis of social needs as they determine demand for professionals in the field of ergonomics. Figure 1.

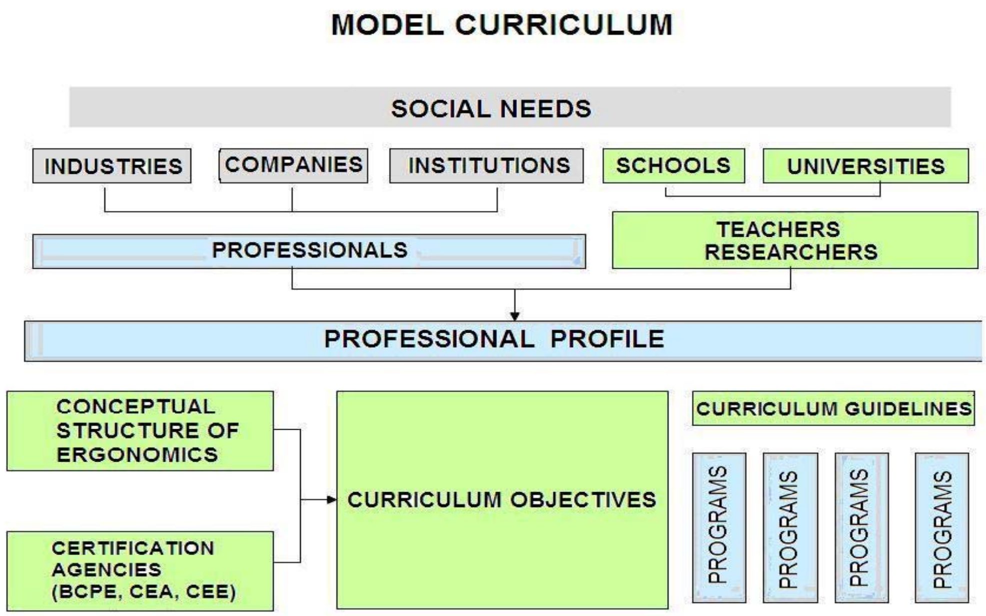

Figure 1. Curricular Model

Study of the national labor market.

A study was conducted into the potential labor market for ergonomics in Mexico, with the University of Guadalajara Center of Opinion Studies (CEO, for its acronym in Spanish) using a national sample of 26 of the most important universities, and 50 industrial plants and other companies of various sizes, to arrive at the following results:

<u>Universities</u>

a) 77 % of them offered regular courses in Ergonomics,

b) Importance given to ergonomics within design and engineering departments: for 85% of them ‘important’ to ‘very important’, for 15% ‘unimportant’ to ‘not very important’.

c) 77 % would hire a professional specializing in ergonomics to teach classes to design majors. Of those, 67% considered ergonomics' main field of application to be Design Ergonomics, 17% Occupational Ergonomics and 16% Environmental Ergonomics.

d) 77 % knew of no other institution offering courses, diploma or graduate programs in ergonomics, while 23% were only aware that the UNAM did.

e) As for inaugurating a Masters in Ergonomics program in our country, 55% considered it a good idea and 45% a very good one; it is important to note that there was not one negative response.

f) Prospective benefits of having specialists in Ergonomics:

69 % : Better product design.

23 % : Higher teaching quality.

8 % : Better specialized applications.

g) Interest by professors in undertaking a Masters in Ergonomics:

81 % thought they would be interested, and

19 % had no interest.

Industrial Plants and other Companies

Over the past several years, transnational corporations like Kodak, Hewlett Packard, Siemens, BorgWarner, Ford, General Motors, Honda, Jabil Circuits, Fresenius Medical Care and others have begun to implement complete ergonomic programs for their subsidiaries in Mexico and other countries; with all facing the problematic lack of specialists in this field.

Given the demand for applied ergonomics in assembly plants along the border with the U.S., the Association of Labor Medicine, National Federation of Associations and Societies for

Health in the Workplace and Mexican Society of Ergonomists, have for several years offered short courses in Occupational Ergonomics to companies in the region, though with all the limitations that the brevity of these programs implies.

Based upon the above and following the proposed Curricular Model, a nationwide sample of 50 firms (30 medium and 20 large) was surveyed, with the following results:

a) 60% have some knowledge of ergonomics and apply it in their work processes.

b) 62 % believe ergonomics to be ‘important’ or ‘very important’ to their firms.

c) 48 % of the companies would hire ergonomic specialists.

d) 80 % consider the opening of a Masters in Ergonomics in our country to be from ‘good’ to ‘very good’ news.

e) Prospective benefits thought to result from having ergonomic specialists:

24 % Greater efficiency in the workplace

20 % Better working conditions

14 % Reduction in workplace injuries and illnesses

12 % Reduction in accidents

10 % Greater job satisfaction

20 % Other (reduction in insurance premiums, better workstations, etc.)

Developing a Conceptual Framework - Basic Ergonomics

Professional training processes encounter many of their methodological bases in the body of knowledge from various disciplines they draw upon to solve the problems they address. Integrated knowledge of their Conceptual Framework is thus essential. According to specialists in curricular design, a conceptual framework is formed by the series of principles, theories, hypotheses, laws and concepts at various levels that actual practitioners of a science produce in the course of their professional activity. This aggregate knowledge gives way to fields, areas and specialized groups within which professional work takes place, making way for specialized methods and techniques.

Thus, beginning with an extensive review of the principal books, manuals, journals and products as presented at international conferences, as well as guidelines by the main professional accreditation agencies for Ergonomics, the BCPE (2009), CEA, and CREE (2007); the first stage meant establishing a Conceptual Framework for Ergonomics that would establish the main areas of knowledge in this interdisciplinary field. Given space limitations, plus the wide range and multiplicity of concepts involved, this work will present only those that are most essential. See Fig. 2, 3 and 4.

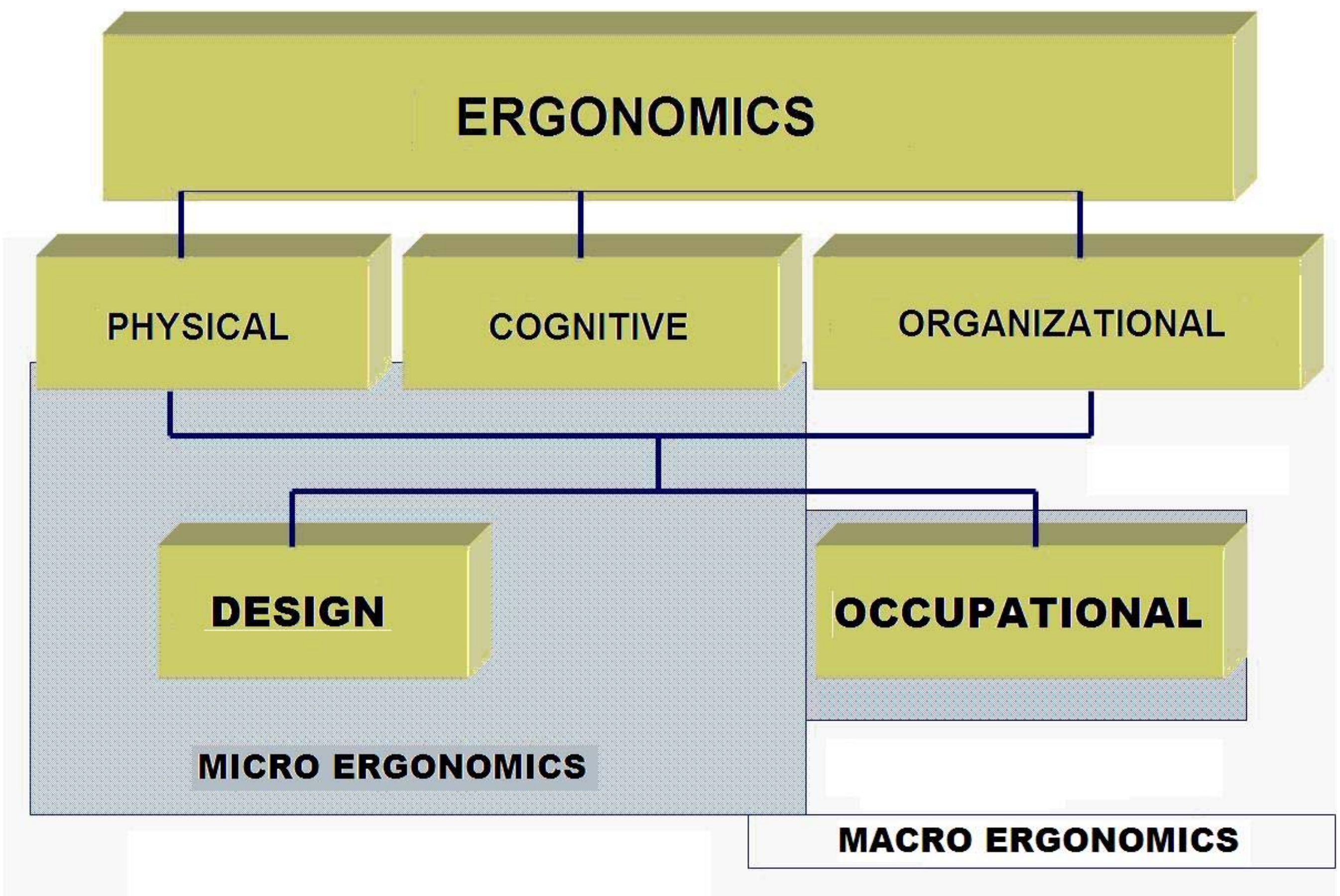

Figure 2. Fields of ergonomic knowledge and application.

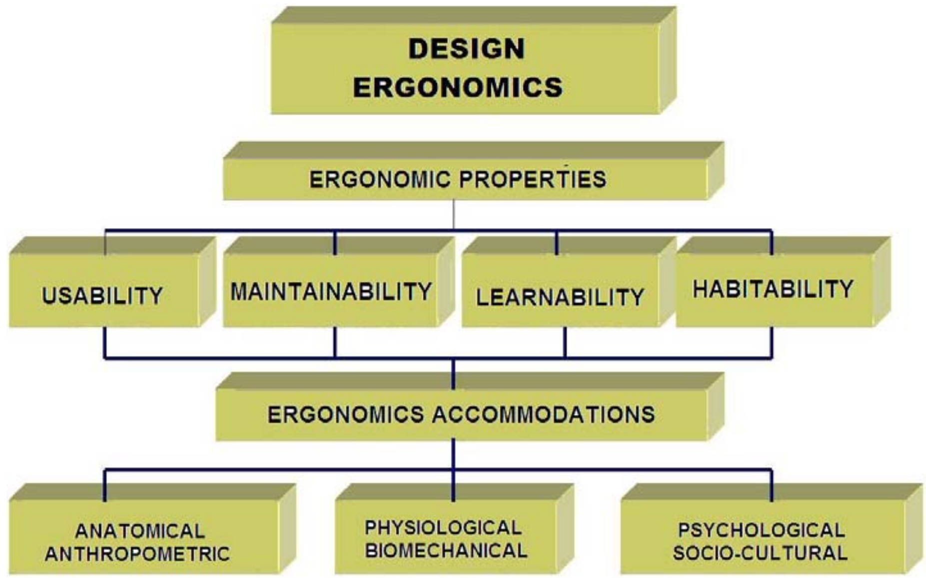

Figure 3. Concepts essential to Design Ergonomics

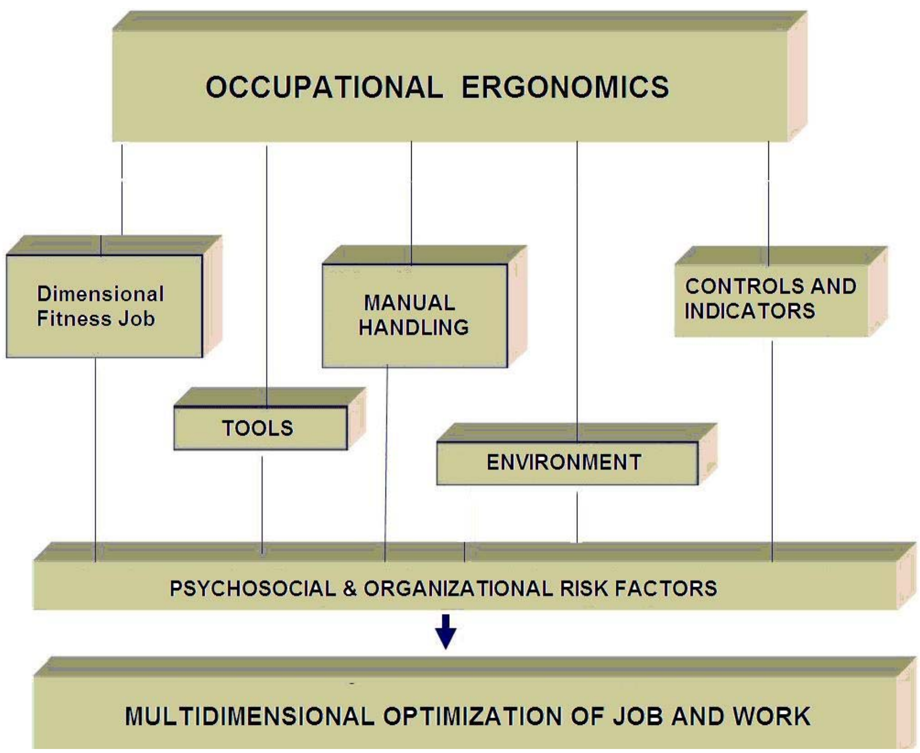

Figure 4. Concepts essential to Occupational Ergonomics

A review of ergonomics accreditation standards in various parts of the world.

In reviewing accreditation agencies, five (5) areas of learning were identified:

1. General Ergonomic Principles: general study of ergonomics, its historic evolution, objectives, principles, concepts, methodologies, techniques, research and application fields. Current paradigms and schools of thought.
2. Knowledge of Human Functioning: studies into the characteristics of human beings as related to man-object-setting systems. Capacities and Limitations: physical, physiological, biomechanical, perceptual, cognitive and sociocultural aspects.
3. Work Analysis: methodological and technical tools for researching, teaching and applying ergonomics. General analytical methods, techniques, procedures, verification lists. Instruments, measuring equipment.
4. Population and Technology: Analysis and solutions for ergonomic design and occupational problems within a historic context and specific setting, taking into account economic, social and technological differences, as well as sociocultural idiosyncracies.
5. The Application stage: Strategies for applying concepts, principles, methods and techniques to resolve particular case studies.

Review of graduate Ergonomics curricula from around the world.

Using the conceptual framework, and having defined theoretical, methodological and technical training guidelines, twelve (12) Masters in Ergonomics programs were analyzed, at various U.S. and European universities and one Brazilian institution; to identify the most commonly and frequently offered courses and program content coinciding with our Conceptual Framework.

From these courses, we selected those that assured acquisition of knowledge essential to the discipline, promoting understanding and skills necessary for solving ergonomic problems in our social context and meeting the requirements of accrediting organizations. Basic required courses were complemented with courses in scientific, statistical and pedagogic research methodologies, to provide the minimum elements for developing skills in research and instruction; with care taken to integrate common knowledge from the areas of Occupational and Design Ergonomics, given the known demand for these two specializations. Finally, courses were grouped and arranged according to standards and prerequisites set by the University of Guadalajara.

RESULTS

The result was a Master of Science graduate degree to prepare Ergonomics professionals: with its first stage of curricular organization providing a basic common trunk branching first into the general knowledge, and basic skills of Ergonomics and, secondly into methodologies, techniques and procedures essential for basic and applied scientific research. In its second stage, students will have the opportunity to choose between two specialties, one in Occupational Ergonomics, including the basic knowledge and skills for comprehensive analysis of jobs, workstations and systems, and the other in Design Ergonomics, with professional training for generating and transmitting knowledge regarding anatomical adaptations, anthropometric, physiological, psychological and sociocultural professional approaches involved in the design of consumer products, machine tools, graphic communications products, and living spaces. See Fig. 5.

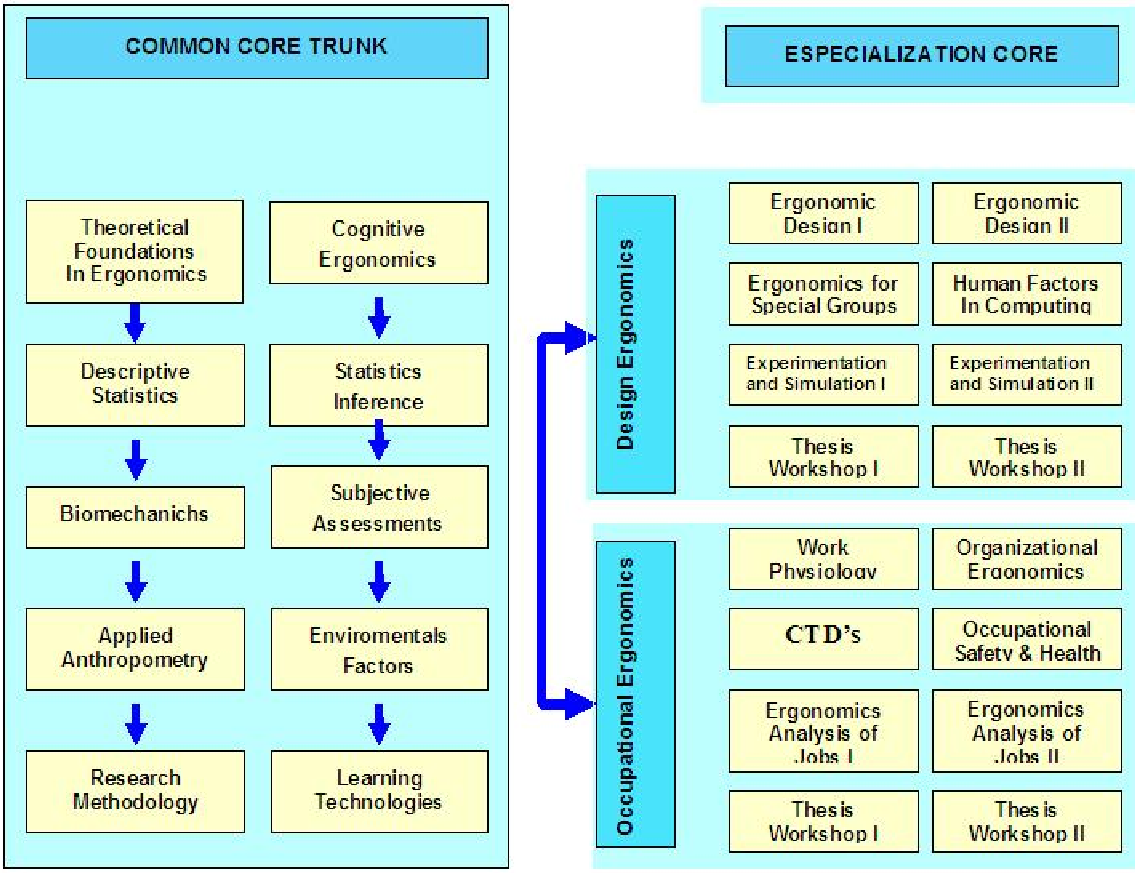

Figure 5. Curricular map of the Masters in Ergonomics.

Academic Organization.

For academic administration of the Masters, courses were grouped and arranged according to requirements set by the University of Guadalajara for educational stages, organizing them into the following didactic areas:

Basic communal education, comprised of five (5) courses during the first and second semesters, offers methodological tools for research and technological approaches to learning. Table 1.

Table 1. Area of Required Basic Communal Education

COURSE	TYPE	KEY	HOURS U.A.S.	HOURS I.S.	TOTAL HOURS	CREDITS	PREREQUISITES
Research Methodology	CW	BC-01	40	24	64	4	-
Descriptive Statistics	CW	BC-02	40	24	64	4	-
Inferencial Statistics	CW	BC-03	40	24	64	4	BC-02
Subjective Assessments	CW	BC-04	40	24	64	4	BC-01
Learning Technologies	S	BC-05	40	24	64	4	-
Total			**200**	**120**	**320**	**20**	

C : Course; (W): Workshop; S: Seminar; U.A.S.Under academic supervision, I.S. : Independent study

The area of basic individual education is also comprised of five (5) courses during the first and second semesters. These provide basic theoretical elements for ergonomics as a field of study, and generally for professional work in the field. Table 2.

Table 2. Area of Required Basic Individual Education

COURSE	TYPE	KEY	HOURS U.A.C.	HOURS I.S.	TOTAL HOURS	CREDITS	PREREQUISITES
Theoretical Foundations in Ergonomics.	S	BP-01	64	-	64	4	-
Biomechánics	CW	BP-02	40	24	64	4	-
Applied Anthropometry	CW	BP-03	40	24	64	4	BC-02
Cognitive Ergonomics	S	BP-04	40	24	64	4	BP-01
Enviromental Factors	CW	BP-05	40	24	64	4	BP-01
Total			**224**	**96**	**320**	**20**	

C : Course; (W): Workshop; S: Seminar; U.A.S.Under academic supervision, I.S. : Independent study

The area of specialist training is distinguished by selecting one of two curricular directions: focusing on the fundamental support Ergonomics provides all aspects of design for Ergonomic Design, or on analysis of tasks and processes of all types, principally in industry, for the Occupational Ergonomics specialization. Both areas are made up of six (6) course-workshops and two Thesis workshops starting in the third semester. Thesis workshops refine the research projects which lead to granting of the degree. Table 3.

Table 3. Courses in Occupational Ergonomics.

COURSE	TYPE	KEY	HOURS U.A.S.	HOURS I.S.	TOTAL HOURS	CREDITS	PREREQUISITES
Work Phisiology	S	ESO-01	40	24	64	4	BP-02
CTD's	S	ESO-02	40	24	64	4	BP-02
Ergonomics Analysis of Job I	W	ESO-03	30	34	64	4	All BP*
Ergonomics Analysis of Job II	W	ESO-04	30	34	64	4	ESO-03
Organizational Ergonomícs	S	ESO-05	40	24	64	4	All BP*
Occupational S & H	S	ESO-06	40	24	64	4	
Thesis Workshop I	W	TO-01	20	44	64	4	All BC y BP
Thesis Workshop II	W	TO-02	20	44	64	4	TO-01
Total			**260**	**252**	**512**	**32**	

C : Course; (W): Workshop; S: Seminar; U.A.S.Under academic supervision, I.S. : Independent study

Thesis	40	200	240	**15**	

Table 4. Courses in Ergonomic Design.

COURSE	TYPE	KEY	HOURS U.A.S.	HOURS I.S.	TOTAL HOURS	CREDITS	PREREQUISITES
Experimentation & Simulation I	CW	ESD-01	40	24	64	4	All BP
Experimentation & Simulation II	CW	ESD-02	40	24	64	4	ED-01
Ergonomics for special groups	S	ESD-03	30	34	64	4	All s BP
Ergonomics Design I	CW	ESD-04	30	34	64	4	All BP
Ergonomics Design II	CW	ESD-05	40	24	64	4	ESD-04
Human Factors in Computing	S	ESD-06	40	24	64	4	All BP
Thesis Workshop I	W	TD-01	20	44	64	4	All s BC y BP
Thesis Workshop II	W	TD-02	20	44	64	4	TD-01
Total			**260**	**252**	**512**	**32**	

C : Course; (W): Workshop; S: Seminar; U.A.S.Under academic supervision, I.S. : Independent study

Thesis	40	200	240	**15**	

CONCLUSIONS

After several years of study, reflection, and review by specialists in ergonomics and Higher Education, a graduate program has been developed that meets the essential requirements of ergonomics training suited to our national needs, and lays the groundwork for higher-level development in the future. The program has a core group of educators with more than 15 years of experience in research, teaching, application and dissemination of ergonomics in our country, supported by a select group of visiting professors from countries such as the U.S., England, France, Brazil, Chile and Spain. It also has a comprehensive library and equipment, basic instruments and software for various specialized uses; as well as an established network of industrial plants, other firms, public and private institutions that will provide opportunities for professional practica that address issues within our own social reality.

We are aware that the program is perfectible, and hope to be able to improve it over time with help from experienced specialists in the field of ergonomics on both sides of the Atlantic; but we feel satisfied at having been able to initiate this process that we believe will substantially impact application of Ergonomics in our country.

The project has been approved by the University General Council, the highest authority of the University of Guadalajara, and plan to launch activities in August 2011.

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ASSESSMENT OF NOISE LEVELS IN A COMPANY THAT MANUFACTURES ELECTRONIC HARNESSES IN HERMOSILLO, SONORA.

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Resumen

Propósito - El propósito de este trabajo es analizar el nivel de ruido sonoro al que se encuentran expuestas las personas que laboran en la empresa con el fin de evaluar o comparar con ciertos estándares incluidos en las normativas.

Metodología - En este análisis de ruido se aplica el método por prioridad de áreas de evaluación (Apartado B.6.3 de la NOM-011-STPS-2001 – ruido) para la determinación de las zonas con niveles de ruido no ideales o fuera de estándares dentro de esta organización, en conjunto con metodología para la toma de mediciones semi-continuas para la toma de las lecturas (norma oficial Mexicana NOM-081-ECOL-1994).

Resultados - Partiendo de los resultados del análisis realizado en la organización, se evidencia que la contaminación sonora inherente es elevada. Los niveles allí percibidos determinan que 3 zonas específicas donde se desarrollan actividades de enmallado (ENM-9, ENM-22, ENM-X), no cumplen con las recomendaciones normalizadas a escala nacional de niveles permisibles de ruido. Los niveles de ruido registrados en estas zonas puede caracterizarse en condiciones no ideales, ya que no solo actúan sobre el sistema auditivo, si no también, sobre el sistema nervioso central de los que se exponen sin protección (o con protección inadecuada) a un nivel continuo equivalente superior a los 90 dB(A), con tiempos de exposición prolongados.

Palabras clave: *Ruido, ergonomía, estación de trabajo, aislamiento, protección, control, zona critica, nivel de ruido*

Abstract

Purpose - The purpose of this study is to analyze the noise level of sound that are exposed to people working in the company to evaluate or compare with certain standards contained in regulations.

Methodology - Design / Methodology - In this noise analysis is the method used for assessing priority areas (paragraph B.6.3 of NOM-011-STPS-2001 - noise) to determine areas with noise levels less than ideal or out of standards. within the organization, together with methods for making semi-continuous measurements for taking readings (Mexican Official Standard NOM-081-ECOL-1994).

Results - Based on the results of the analysis in the organization, is evidence that noise pollution inherent is higher. Levels measured there determined that 3 specific areas where activities netting (ENM-9, ENM-22, NME-X), the recommendations do not meet national standard permissible levels of noise. The noise levels recorded in these areas can be characterized in non-ideal conditions, as not only act on the auditory system but also on the central nervous system that are exposed without protection (or inadequate protection) to a level equivalent continuous than 90 dB (A), with long exposure times.

Keywords: Noise, Ergonomics, Work station, Sound insulation, Noise protection, Control, Critical, zone, Noise level.

INTRODUCTION

The existence of noise in organizations represents one of the most common occupational hazards, as it interrupts the effective communication between members of this and may involve hearing loss, including physiological and psychological disorders. Burrows (1960) defines noise as "an audience of stimuli unrelated to the presence or the completion of the task at hand" is an aspect of this work and the noise levels in the environment fostered and / or generated for equipment, machinery and tools for daily use. In general, it is identified as the most important issue in their work environment (Karlson, 1989).

In Mexico, workers are exposed daily to noise weighted average of 85 decibels (dB A) during working hours, which goes until eight hours a day, seven in the night and, seven and a half hours the mixed, as expressed in Article 61 of the federal labor law. This represents a potential risk to their hearing and can also produce other effects. The current regulations in the gazette of the federation by the NOM-011-STPS-2001 expressed as its main objective to establish the safety and health in workplaces where noise is generated by its characteristics, levels and time of exposition, capable of altering the health of workers. It also expresses the maximum levels and the maximum permissible exposure time per day of work, their correlation, and the implementation of a prevention program for hearing loss.

In industry, hazardous noise levels are easily identified and in most cases it is technically viable to control excess noise by applying commercial technology, equipment or process reshaping or transforming the noisy machines. But too often, nothing is done. There are several reasons for this; firstly, although many noise control solutions are remarkably economical, others are very expensive, especially when you have to make reductions to levels of 85 to 80 dB A. A major reason is the lack of prevention programs for hearing loss and pollution control, noise is generally accepted as a necessary evil, part of the organization, an inevitable aspect of industrial work, and because it does not produce a significant damage that anyone can see, the workers during the same exposure, often have the feeling of getting used. Another important reason is the lack of recognition of the dangers such as hearing impairment, Kryter (1985) states that hearing loss may be partial or total, temporary or permanent.

In a company which manufactures electronic harnesses, in the city of Hermosillo, Sonora, one of the main polluters are presented in work performance is the noise generated in the department of netting case, where the decibel generated exceed the maximum permitted levels. In the present paper we provide an analysis of noise in the apartment netting case, likewise, results and improvement proposals.

METHODOLOGY: EVALUATION OF NOISE LEVELS

We performed a study of noise in a harnesses company which is located in the city of Hermosillo, Sonora, whose main activity is to manufacture electronic harnesses. The analysis includes the following: As a first activity is a preliminary run to determine the areas where the pollutant comes with higher incidence, and the preferred method to start the evaluation. As a second activity areas once detected, the decision of the application of the priority areas for assessment (Section B.6.3 of NOM-011-STPS-2001 - noise) together with a methodology for making semi-continuous measurements of the following Mexican Official Standard NOM-081-ECOL-1994. Third, it is the analysis of results, conclusions and proposed solutions. It is important to note that, given the limits of time and resources, the results of case studies presented in this article cover only up to the stage of proposals.

FIELD ACTIVITIES

Description of activities potentially noisy

13 areas were identified where potentially noisy activity, which are:

Table 1. Areas with noise higher levels

Áreas con nivel NSA mas alto
Caseta de enmallado ENM-31
Caseta de enmallado ENM-46
Conveyor 601
FOAM mezclado
Extractor FOAM
Maquina KOMAX
KAPPA 1
Área de Moldeo
Cuarto de estañado
Moldeo
Enmallado ENM-9
Enmallado ENM-22
Enmallado X

Identification of critical areas

Based on the provisions of NOM-011-STPS-2001 was determined the starting point of evaluation at the boundaries of the areas selected from the tour, recording the same as level "Z" used as a reference for beginning the evaluation. Moves the observer with the meter in a predetermined direction until a noise level "A” which differs by + / - 3 dB (A) over the level 7, continuing the path to find another point that differs from the previous + / - 3 dB (A). We conducted a cross-path by the same procedure that ensures that completely cover the work area.

Measurement

Because noise generating equipment does not work continuously, the readings are semi-continuous, so we opted for the use of NOM-081-ECOL-1994. The measurement was carried out with the sound level meter microphone placement at each point directed toward the emitting source and the reading was taken in each of them, were made in each area 250 readings, these readings were taken in periods of 5 seconds summary was obtained in 50 measurements per hour.

Results

From the readings were performed and got the following results:

Calculation of weighted sound level "A" for the three critical areas.-

$$NS_A i = 10 \log \frac{1}{150} \sum_{j=1}^{150} 10^{\frac{Nj}{10}} \quad (1)$$

Where:

NSAI is the NSA point average of measurement i

Nj is the registered NSA

Table 2. Weighting results in three critical areas

NSA Results
Enmallado ENM-9 = 93.1 dBA
Enmallado ENM-22 = 92.2 dBA
Enmallado X= 92.7 dBA

Calculation of noise exposure level for the three critical areas:

$$NER = 10 \log \sum_{i=1}^{n} ti\, 10^{\frac{NS_A i}{10}} - 10 \log Te \tag{2}$$

Ti is the exposure time at the point of measurement i

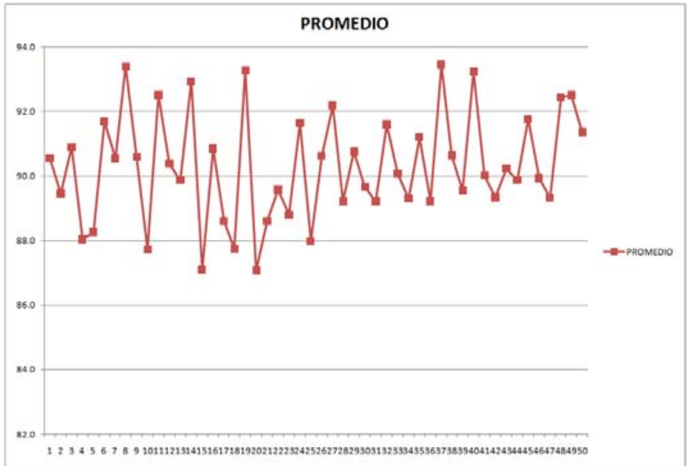
$$Te = \sum_{i=1}^{n} ti \quad = 8 \text{ horas} \tag{3}$$

Te is the total exposure time

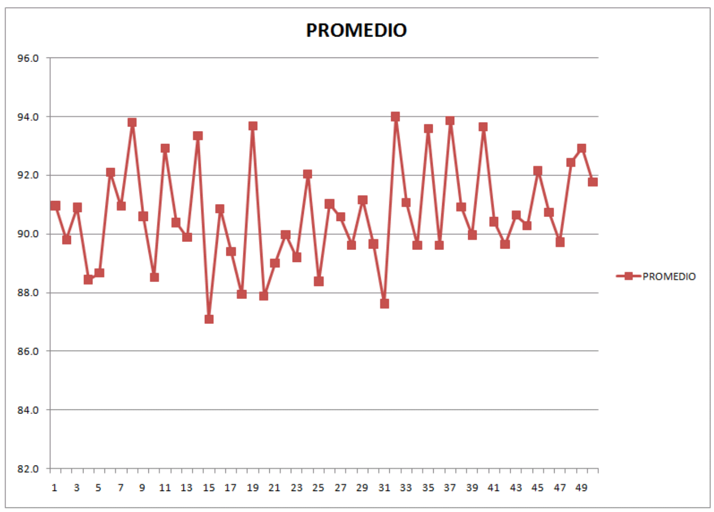
Table 3. Exposure Level

NRE Results
Enmallado ENM-9 = 91.1 dBA
Enmallado ENM-22 = 90.2 dBA
Enmallado X= 90.7 dBA

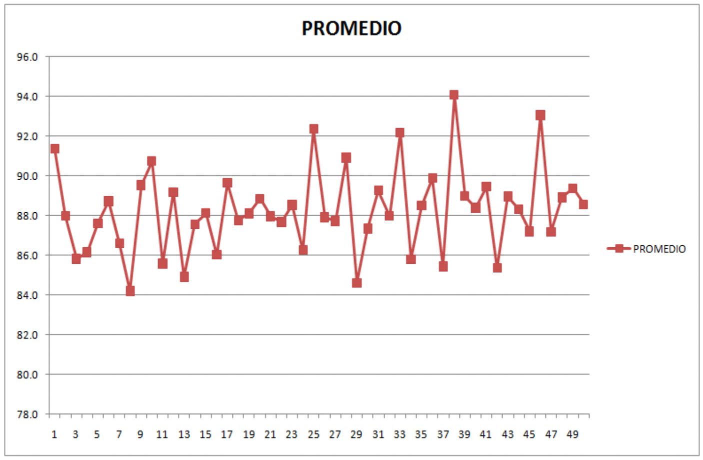
RESULTS



Graphic 1. Behavior of noise readings in ENM-X



Graphic 2. Behavior of noise readings in ENM-09



Graphic 3. Behavior of noise readings in ENM-22

CONCLUSIONS

Based on the results of the analysis, is evidence that noise pollution inherent in this organization is high. Levels measured in areas where specific recommendations do not meet national standard. This situation shows that the work environment, from the standpoint of sound, can be characterized as extreme and working conditions are risky.

The noise levels recorded in the analysis detected that probably in the future the amount of noise does not only act on the auditory system, but also on the central nervous system of workers who are exposed without protection or inadequate protection, an equivalent continuous level above 90 dB (A), with long exposure times. It proposes the implementation of a plan to protect staff and reduce the high levels of noise pollution emissions.

RECOMMENDATIONS

Obviously technology manufacturer of electronic harnesses emits high noise levels, however, it is possible to implement a series of measures to help reduce noise and protect personnel. Listed below are some recommendations that can be considered as elementary. These can be classified into protection of the operator and work on the source. Each of these measures should be appropriately tailored to the specific situation of the organization, the recommendations are:

- ✓ Establish mandatory use of hearing protection and ensure the existence and appropriate model.
- ✓ Advice with visible signs of noise levels to the personnel who work in a given area.
- ✓ Perform audiometric testing at least twice a year, staff working in the areas of mayor risk.
- ✓ Work with education and motivation of workers.
- ✓ Eliminate all sources of interference and excessive vibration.
- ✓ To isolate the workers from the noise-generating sources to the extent possible.

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DETERMINATION OF MAXIMUM ACCEPTABLE WORK TIME AND HEART RATE IN WORKERS OF FOOD MARKETS IN THE CITY OF LOS MOCHIS, SINALOA

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Resumen

Introducción: Esta investigación buscó determinar el tiempo que una persona puede trabajar sin incrementar su Frecuencia cardiaca dando lugar a esfuerzos excesivos motivo de fatiga. La Frecuencia Cardiaca se midió con un dispositivo electrónico que registró de manera continua la FC de una persona y sus variaciones durante una jornada laboral. **Objetivos:** Determinar la relación entre la Frecuencia Cardiaca Relativa y el TMTA en trabajadores de mercados de abastos de Los Mochis Sinaloa. **Delimitación:** La investigación se llevó a cabo en los mercados de abastos de la ciudad de Los Mochis donde los trabajadores realizan actividades que requieren esfuerzos y no hay ningún parámetro que sirva de referencia para regular las jornadas laborales. **Metodología:** Se tomó una muestra poblacional de más de 30 trabajadores y los datos se analizaron estadísticamente por medio de un software (statistica). Los que resultaron aptos de la preselección se les colocó un dispositivo electrónico (Polar FT60) para medir su Frecuencia Cardiaca en Reposo, posteriormente se programo para almacenar los datos durante la jornada laboral, al término se retiró el dispositivo y se almacenó la información. Una vez recabados los datos se introdujeron al software para hacer el análisis correspondiente. **Resultados:** De las variables analizadas se encontró que la edad afecta la Frecuencia Cardiaca en Reposo, la Frecuencia Cardiaca Máxima, el TMTA y la Frecuencia Cardiaca Relativa; el medio de transporte afecta su Frecuencia Cardiaca Máxima; la Actividad Extra afecta la Frecuencia Cardiaca Máxima;

y la Jornada laboral afecta la Frecuencia Cardiaca Máxima. En base a estos resultados se encontró que las personas de 40-49 años trabajaban casi dos horas más de las que deberían con respecto a los datos del TMTA. **Conclusiones:** Podemos sugerir que las personas de 40-49 años tengan descansos estratégicos para que su Frecuencia Cardiaca no se altere y puedan rendir mas, por el contrario las personas menores de 20 años tienen un TMTA mucho más alto y pudieran trabajar más horas sin necesitad de descansar.

Palabras clave: Fatiga, frecuencia cardiaca, ergonomía, capacidad de trabajo

Abstract

Introduction: This study looks to determine how long a person can work without increasing their heart rate leading to abnormal cause of fatigue. The heart rate was measured with an electronic device that continuously records a person's heart rate and its variations during a workday. **Objectives**: To determine the relationship between relative heart rate and workers TMTA in food markets in Los Mochis Sinaloa. **Delimitation**: The study was conducted in food markets in the city of Los Mochis where workers carry out activities that require no effort and serve as a reference parameter to regulate working hours. **Methods**: A sample population of more than 30 workers and the data were statistically analyzed using a software (Statistica). Those who were eligible for screening were fitted with an electronic device (Polar FT60) to measure their resting heart rate, which was programmed to store data during the workday, after the device was removed and the information stored, the data was introduced into the software to make the corresponding analysis. **Results**: Of the variables analyzed, it was found that age affects Resting Heart Rate, Maximum Heart Rate, the TMTA, and relative heart rate, the means of transportation affects your maximum heart rate, the extra activity affects the maximum heart rate; Working days affect the maximum heart rate. Based on these results it was found that people aged 40-49 years worked nearly two hours longer than they should with respect to the data of TMTA. **Conclusions**: We suggest that persons aged 40-49 years with strategic breaks your heart rate is not altered and can pay more. Instead, people under 20 have a much higher TMTA and could work longer hours without needing to rest, provided they do not violate relevant laws.

Key words: fatigue, heart rate, ergonomics, work capacity

INTRODUCTION.

Work is a source of psychological and social well-being of value to humans, and it provides most of the meaning and structure of our life. However, it can also cause adverse effects such as tiredness, stress, injury, DTA's, accidents, fatigue, and many others. We should consider the importance of an individual to develop their business activities in an environment where the employee makes the most physical and mental capabilities possible, therefore resulting in higher productivity, fewer accidents and greater satisfaction for the staff.

One way to measure the physical capacity of a Yorker is by monitoring their heart rate, which reflects the momentary physical state of the individual. We can then compare that with the parameters that can be obtained at rest and when performing a physical activity (FCR).

In recent times, devices have emerged that allow continuous heart rate recordings with no difficulty. The proposed system for the analysis of heart rate is more focused on sports medicine and not to the work environment. On this occasion we will use these devices for research that will carry out.

This research aims to keep track of the heart rates of people who work in food markets, with a heavy workload and long hours in the city of Los Mochis, Sinaloa and determine the TMTA (maximum acceptable work time) in order to present a history that serves food for thought for those who perform these tasks.

OBJECTIVES

GENERAL OBJECTIVE: To determine the relationship between physical load, expressed as relative heart rate (FCR) and the maximum acceptable work time (TMTA) on workers in food markets in the city of Los Mochis, Sinaloa.

SPECIFIC OBJECTIVES:

- Determine heart rate of workers at food markets in the city of Los Mochis, Sin.
- Determine the maximum acceptable work time (TMTA) to establish working days to help maintain a normal heart rhythm.
- Use the results to establish breaks at strategic times during working hours, thereby increasing worker productivity and prevent injuries or accidents.

MATERIALS AND METHODS.

METHODOLOGY

To obtain valid results it is necessary to use the appropriate methodology, the following will show how it will be carried out and how they will conduct the study to achieve the desired objective.

SUBJECT

The results of this research will be analyzed statistically. A sample population of more than 30 workers in one of the existing supermarkets in the city of Los Mochis (According to John E. Freund and Richard Manning Smith in his book "Statistics (1989)" he mentions that "You can not say exactly how large “n” should be so that you can apply the central limit theorem, but unless the distribution of the population has an unusual shape, n = 30 is usually considered large enough ") N $\geq$ 30 approaches the normal distribution , making it statistically valid to use the mean and standard deviation of the sample. After selecting the appropriate population to determine the heart rate of workers using the Polar FT60 which will give us the results and changes in heart rate during a worker's workday.

Methods.

1. Workers were pre-selected to conduct the investigation and were told about the importance of their cooperation in conducting the study in order to obtain real and reliable results
2. Explain to the employee the purpose of research and measurements to be performed and the methodology to follow, to subsequently sign the acceptance letter which confirms his permission to conduct this study.
3. Apply the survey to particular habits and physical condition.
4. Determine if the employee is eligible for the study, ie, has good health, does not suffer any chronic illness.
5. After determined that the worker is fit for study, proceed to place the polar and data transfer band.
6. We take the resting heart rate, that is, left undisturbed for 10 minutes than a worker, in the last 3 minutes, takes the heart rate, which will be recorded in the Polar FT60
7. Having set your heart rate at rest, the set the polar to "Start", to begin to measure heart rate of the worker and place your normal working hours for data collection.
8. At the end of the day reflected on, the polar sends the data to computer for later analysis.

9. We focus on the information collected through the survey and monitor Polar FT60 heart rate of total subjects

10. Once you have data from all individuals that are analyzed, use the Statistica program to determine the influence of variables on the TMTA on workers.

11. We get results, we can suggest some actions that would be of benefit to the participants.

12. Writing the final report which presents the final results and conclusions.

RESULTS.

This section is referred to the results obtained during the investigation, which shows all the variables that were examined. They have some degree of impact on the dependent variables, which in this case are Resting Heart Rate, Heart Rate Relative, Heart Rate Maximum, and maximum acceptable work time.

To facilitate the analysis they are grouped by age classes, and are as mentioned below.

1. <20 years
2. 20-29 years
3. 30-39 years
4. 40-49 years or more

With regard to means of transportation used by workers was the next group.

1. Public Transport.
2. Car.

3. Bicycle.

4. Motorcycle.

To identify whether workers perform some extra activity outside of work in which they were monitored. The following list took place.

1. Study

2. Work

3. No

4. Study and work

In relation to working hours the following classification.

1. 6-7 hrs.

2. 8-9 hrs.

3. 10-11 or more.

Age-FC Rest

Here are the results obtained by analysis of variance for data Resting heart rate taken from the study variables, taking into account that for all cases in this study, a α = 0.05.The analysis was performed with analysis of variance study, which was carried out using the computer program "Statistics". Each of the independnt variables were analyzed individually with each of the dependent variables.

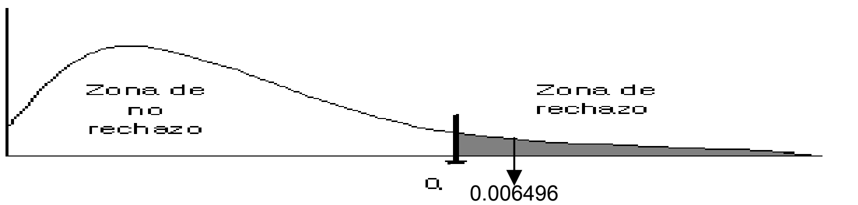
Table 1. Analysis of variance for data Resting heart rate depending on age.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-EDAD

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	449,8419	29	90,08114	4,993742	,006496

Table 2. F distribution for data Resting Heart Rate by the ages



As you can see from the graph the probability level (p level) of 0.006496 is within the area of rejection, and can say that the hypothesis that the means of the variances are equal and is rejected. So here, it is statistically proven that there is a significant difference in Resting Heart Rate Average in age classes that were analyzed. Therefore the Duncan Multiple Intervals test is performed to find the differences between ages.

Resting Heart Rate does affect workers differently depending on their ages.

Table 3. Duncan's multiple range data Resting heart rate depending on age

Duncan test; FC_REPO (tmta oficial..sta)

GENERAL MANOVA	Probabilities for Post Hoc Tests MAIN EFFECT: EDAD			
EDAD	{1} 93,00000	{2} 71,10000	{3} 82,46154	{4} 70,44444
1 {1}		,010028	,177172	,009850
2 {2}	,010028		,146720	,932100
3 {3}	,177172	,146720		,146331
4 {4}	,009850	,932100	,146331	

In making the comparison of means by the method of Duncan multiple interval, Table 2 shows that group 1 (93.00000) is the most affected in Resting Heart Rate, then there is group 3 (82.46154), a little less severely affected. We found that in groups 2 (71.10000) and 4 (70.44444) that younger people have a resting heart rate higher than other groups. We formed the following blocks.

{4} 70.44444	
{2} 71.10000	Block 1
{3} 83.83334	

{1} 93.00000 } Block 2

Based on the results, two blocks can be formed. Block 1 composed of people of 20-49 years which have a resting heart rate lower (75 531 ppm) compared with those aged under 20 years, which have a resting heart rate higher (93 ppm).

Age – CF Maximum

For this analysis we took into account the classification of the ages mentioned at the beginning of this section

Table 4. Analysis of variance of the maximum heart rate data by age.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-EDAD

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	766,1447	29	9,301650	82,36653	,000000

Table 5. Duncan's multiple range for maximum heart rate data at different ages

Duncan test; FC_MAX (tmta oficial..sta)

GENERAL MANOVA

Probabilities for Post Hoc Tests
MAIN EFFECT: EDAD

EDAD		{1} 202,0000	{2} 196,5000	{3} 185,1538	{4} 175,7778
1	{1}		,032530	,000062	,000054
2	{2}	,032530		,000202	,000062
3	{3}	,000062	,000202		,000752
4	{4}	,000054	,000062	,000752	

In making the comparison of means by Duncan's multiple interval, we can see that all means are different as different age affects the maximum heart rate of people, however, we can say that the level of involvement increases as age decreases, i.e. those under 20 have a maximum heart rate higher than others.

Relative Age- CF

Table 6. Analysis of variance for relative heart rate data by age.

Summary of all Effects; design: (tmta oficial..sta)

1-EDAD

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	,015166	29	,004620	3,282351	,034821

Table 7. Duncan's multiple interval for the relative heart rate data at different ages

Duncan test; FC_RELAT (tmta oficial..sta)

GENERAL MANOVA — Probabilities for Post Hoc Tests, MAIN EFFECT: EDAD

EDAD	{1} ,0366972	{2} ,1595019	{3} ,1083887	{4} ,1850394
1 {1}		,040536	,199187	,017189
2 {2}	,040536		,356631	,643301
3 {3}	,199187	,356631		,194769
4 {4}	,017189	,643301	,194769	

.

{1} .0366972 } Block 1

{3} .1083887
{2} .1595019 } Block 2
{4} .1850394

Taking into account Duncan's Multiple Intervals, we can form two blocks because there is no significant difference between means of groups 2, 3 and 4 (Block 2), but between the mentioned groups and group 1 (Block 1). We can conclude that people of 20-49 years have the same effect on the relative heart rate, i.e. no significant difference between the relative heart rate.

It should be mentioned that the people of Block 1, being the youngest, they have a relative heart rate lower than those of block 2, that is the people of 20-49 years.

Age - TMTA

This comparison takes into account the grouping of ages into classes as mentioned at the beginning of the paragraph, the maximum acceptable work time is obtained by applying the formula mentioned in the theoretical framework.

Table 8. Analysis of variance for TMTA data by age.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-EDAD

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	146493,5	29	34660,08	4,226577	,013512

Table 9. Duncan's multiple range data TMTA depending on age.

Duncan test; TMTA (tmta oficial..sta)

GENERAL MANOVA — Probabilities for Post Hoc Tests MAIN EFFECT: EDAD

EDAD	{1} 904,2840	{2} 480,0739	{3} 636,0993	{4} 410,2464
1 {1}		,010923	,083216	,004292
2 {2}	,010923		,305094	,643854
3 {3}	,083216	,305094		,163597
4 {4}	,004292	,643854	,163597	

{4} 410.2464

{2} 480.0739 Block 1

{3} 647.3143

{1} 904.2840 Block 2

Based on these results we can say that in groups 2, 3 and 4, the mean difference was not significant so they can form a block (Block 1), age affects the same way on TMTA, however, group 1 compared with the other groups had significant difference so it will form another block (Block 2) In conclusion, people between 20-49 years are those with a lower TMTA (8.7303 hours on average) and people aged under 20 increased TMTA (15.0714001 hours on average)

Transportation – Max CF

Table 10. Analysis of variance of the maximum heart rate data as transport.

Summary of all Effects; design: (tmta oficial..sta)

1-TRANSPOR

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	252,0229	29	62,48666	4,033227	,016336

Table 11. Duncan's multiple interval for maximum heart rate data as transport.

Duncan test; FC_MAX (tmta oficial..sta)

GENERAL MANOVA

Probabilities for Post Hoc Tests
MAIN EFFECT: TRANSPOR

TRANSPOR		{1} 194,1250	{2} 183,1905	{3} 192,0000	{4} 186,0000
1	{1}		,108271	,728200	,215129
2	{2}	,108271		,179534	,646119
3	{3}	,728200	,179534		,329871
4	{4}	,215129	,646119	,329871	

In this analysis we do not form blocks because there is no significant difference between the means of the data from these means of transport, ie, maximum heart rate is the same alteration in a person being transported by bicycle to another who moves in any of the before mentioned transportation.

Extra activities- Max CF.

This analysis considers Extra Activity, those activities that people perform after completing their workday.

Table 12. Analysis of variance of the maximum heart rate data according to the extra activity.

Summary of all Effects; design: (tmta oficial..sta)

Continue... 1-ACT_EXTR

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	553,8144	29	31,26685	17,71251	,000001

Table 13. Duncan's multiple interval for maximum heart rate data according to the extra activity.

Duncan test; FC_MAX (tmta oficial..sta)

GENERAL MANOVA

Probabilities for Post Hoc Tests
MAIN EFFECT: ACT_EXTR

ACT_EXTR	{1} 198,3750	{2} 181,5000	{3} 182,2727	{4} 196,0000
1 {1}		,004340	,005162	,645708
2 {2}	,004340		,880958	,010972
3 {3}	,005162	,880958		,011971
4 {4}	,645708	,010972	,011971	

{2} 181.5000

{3} 182.2727

Block 1

{4} 196.0000

{1} 198.3750

Block 2

According to Duncan Multiple intervals can be two blocks because there is no significant difference between means of groups 2 and 3 (Block 1) and the means of groups 4 and 1 (Block 2). In conclusion, people who do not work (3) and those who work (2) have the same involvement on the maximal heart rate and people who study (1) and those who study and work (other than the described work) (4) have the same involvement of Maximum Heart Rate. It is worth mentioning that people who work well studied (1) and those who study and work (4) elsewhere have a higher maximum heart rate (182.2083 ppm on average) than those not working (3) and those that only work (2) (198.1111 ppm on average).

Working hours – max CF

Table 14. Analysis of variance of the maximum heart rate data according to the workday.

Summary of all Effects; design: (tmta oficial..sta)

1-JOR_LAB

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	238,6367	30	69,69695	3,423920	,045776

Table 15. Duncan's multiple interval for maximum heart rate data according to the workday.

Duncan test; FC_MAX (tmta oficial..sta)

GENERAL MANOVA

Probabilities for Post Hoc Tests
MAIN EFFECT: JOR_LAB

JOR_LAB	{1} 184,2667	{2} 183,6250	{3} 192,3000
1 {1}		,862905	,037177
2 {2}	,862905		,032173
3 {3}	,037177	,032173	

{2} 183.6350

{1} 184.2667 Block 1

{3} 192.3000 Block 2

In relation to the results of Duncan Multiple intervals no significant difference between groups 1 and 2 which form in Block 1 but no difference between the means of these groups and mean group 3 which is Block 2. In conclusion, those working between 6-9 hours daily have a lower maximum heart rate (184.0478 ppm) than people who work 10 hours or more per day (192.3 ppm)

COMPARISON OF TMTA

One of the objectives of the research is to determine the TMTA in order to know whether people are working harder than your body can endure without reaching the heart rate above the maximum levels already mentioned. That is why the following is a table that reflects the average age TMTA rated compared with the hours they work, which was obtained from the records that showed the heart rate monitor Polar FT60 while the workers performed their tasks.

Table 16. Comparison TMTA

	AVERAGE TMTA (HRS)	**AVERAGE JOR REAL (HRS)**
TMTA 1 (less tan 20 yrs.)	15,07	10:55:02
TMTA 2 (de 20-29 yrs.)	8,00	8:44:52
TMTA 3 (de 30-39 yrs.)	10,60	8:42:41
TMTA 4 (de 40-49 yrs.)	6,84	8:09:34

Looking at the table, there is a big difference between the time that people in these age ranges may labor without their heart rate being significantly affected.

DESCRIPTIVE STATISTICS

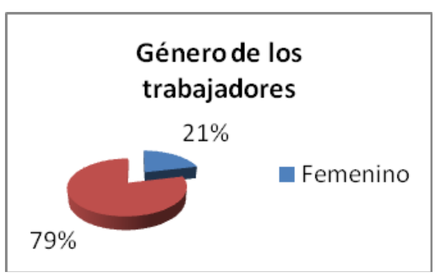


Figure 1. Gender statistics of those who were under study.

21% of people who underwent this study are women and 79% are men.

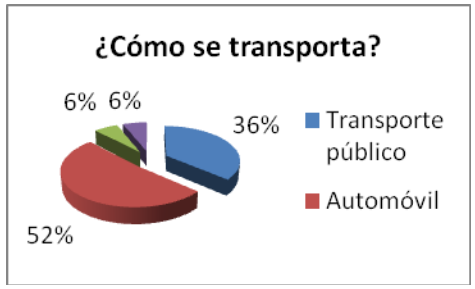


Figure 2. Statistical means of transport used by workers.

30% use public transport, 42% travel by car, bike 5%, 3% by motorcycle and 18% by walking.

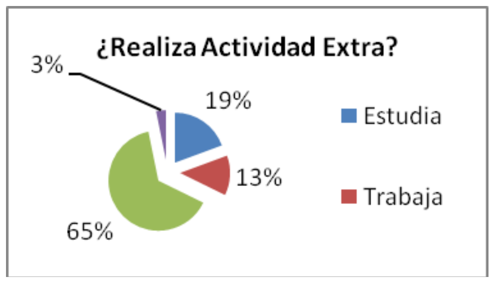


Figure 3. Statistics extra activities performed by workers

19% study, 13% work in another job, 65% have no activity, 3% study and work apart from the work that was done from the research.

Figure 4. Statistics of hours working per day.

The 40% work 6-7 hours daily, 16% of 8-9 hours and 44% of 10-11 hours or more.

CONCLUSIONS AND RECOMMENDATIONS.

Under the results of this research we can make some recommendations mentioned below

- . It is true that people aged 40-49 years had an average of 6.84 hrs TMTA

Table17.TMTA comparison

	AVERAGE TMTA (HRS)	AVERAGE REAL (HRS)
TMTA 1 (LESS THAN 20 yrs. old)	15,07	10:55:02
TMTA 2 (de 20-29 yrs.)	8,00	8:44:52
TMTA 3 (de 30-39 yrs)	10,60	8:42:41
TMTA 4 (de 40-49 yrs)	6,84	8:09:34

Table 18. Comparative table betwen real and TMTA

AGE	N	AVERAGE TMTA (hrs)	AVERAGE REAL TIME WORK (hrs)	TIME EXCEEDED ON AVERAGE	% OF POPULATION
Less than 20 yrs.	1	15.07	10:55:02	0	3.03 %
20-29 yrs	10	8	8:44:52	44 min	30.30 %
30-39 yrs	13	10.6	8:42:41	0	39.39 %
40-49 yrs	9	6.84	8:09:34	1:19 hrs	27.27 %

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APPLICATION OF RULA METHOD FORT HE REDESIGN OF A HAND TOOL

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RESUMEN:

INTRODUCCIÓN. Este proyecto se elaboró en una panadería, en donde se elaboran panes, como donas, conchas, bollos, entre otros. Para la elaboración de la dona se utiliza una herramienta de mano de con lámina galvanizada, en forma de dona, con un diámetro de 10 centímetros; la utilizan los trabajadores, tomándola con la mano extendida, abarcando la forma del diseño, para poder golpear el molde sobre la masa y formar las donas. **OBJETIVOS:** Rediseñar una herramienta de mano, la cual será utilizada en la elaboración de donas, en una panadería establecida en la Ciudad de Los Mochis, Sinaloa. **METODOLOGÍA**: 1.- Se Identificaron 75 personas que participan en el área de producción (puestos rotativos). 2.- Se aplicó la evaluación del método RULA, se tomaron fotos y video de lo observado mientras se realizaba el trabajo. Se aplicó la evaluación, resultando un nivel 5 (5 or 6 investigación futura y cambio pronto); es necesario hacer una investigación y el rediseño.3.- Se toman las medidas antropométricas de los trabajadores y en base a esto se elabora el rediseño ergonómico.4.- Se elaboró el prototipo del rediseño, observando la reacción de los trabajadores al momento de su utilización. 5.- Se aplicó nuevamente el método RULA, para la mejora de resultados obtenidos por el rediseño, tomando fotos y video de lo observado. 6.- Se realizaron ajustes necesarios. Se ajustó la altura de la mesa a una medida estándar para mayor comodidad del trabajador. **RESULTADOS: S**e aplicó la evaluación RULA antes del rediseño, dando un resultado de 5. Fue necesario hacer una investigación y cambiar el rediseño de la herramienta. Una vez que se trabajó con el rediseño de la herramienta de mano, se evaluó el rediseño resultando un nivel de 2; siendo un nivel aceptable (1 o 2 Aceptable). **CONCLUSIONES:** Utilizando el método RULA, con fotos y videos, se logró rediseñar la herramienta de mano, la cual provocó una notable mejoría en los trabajadores al momento de su uso. La herramienta de mano para hacer donas, está rediseñada para cualquier persona, logrando que sea una herramienta de mano ergonómica.

Palabras claves: herramienta de mano, evaluación ergonómica, panadería,

ABSTRACT

INTRODUCTION. This project was developed for a bakery in Los Mochis city, Sinaloa, in which a variety of breads, are made as donuts, shells, rolls, among many others. Particularly for baking donuts is a tool of hand made from galvanized sheet, in the form of donuts and with a diameter of 4 in; This tool is used by workers taking it extended hand covering the shape of the design, to be able to hit the mold on the mass and to create donuts. **OBJECTIVES**: Redesign a hand tool, which will be used in the preparation of donuts, in a bakery established in Los Mochis city. **METHODOLOGY:** 1. Identified 75 participants in the area of production (which these posts are rotating). 2. Applied the evaluation of the method RULA, where first took photos and video of what is observed while they performed the work with the hand tool. And then applied the assessment, resulting in a 5 level. 3. Take the anthropometric measures of workers and against this background it is made the redesign. 4. Was the prototype of the redesign, observing the reaction of the workers at the time of its use. 5. Was applied again the method of RULA, improving results obtained by the redesign, taking photos and video of what is observed. 6. Finally were some adjustments, adjusted the height of the table to a standard measure for convenience in carrying out the work. **RESULTS.** First the evaluation before the redesign, giving a result of 5 (5 or 6 investigate further and change soon), so it is necessary to make an inquiry and change as soon as possible the redesign of the tool. Once worked with the redesign of the hand tool, it assessed the redesign resulting in a level of 2 (1 or 2 Acceptable). **CONCLUSIONS.** On the basis as the method RULA, photos and videos. This is seen to somewhat change the shape of things, in this case to the hand tools, can be achieved generating higher productivity, the better results, but gain, but always in a safe manner.

Keyword: hand tool, ergonomic evaluation, bakery.

INTRODUCTION

The company was founded in the City of Los Mochis, Sinaloa in 1994, with the concept of bakery and deli, the need was seen in the market for vendors to supply them with hot dogs, burgers and cakes. It was for this reason that we acquired a small equipment to produce bread, which consisted of an oven and a mixer, with a production area of 16 square meters. In the development stage was noted that the detail or grocery market, was not operated with a product and service quality was when we decided to explore this market with fresh bread and bakery products.

Today has been very significant growth, currently serving in northern and central Sinaloa and southern part of the sound, with a production of more than 100 workers. The production area is divided into 4 different lines in the processing of products handled by this company. Being in the bakery where the donuts are made daily, according to orders. For the preparation, it requires a manual tool. The production staff consists of men and women, which have heights and characteristics of different complexion. The process is carried out as follows:

1. - Prepare the mass needed for the number of donuts that will be worked out according to the order. 2. - After mixing the dough is rolled, that is, lying on the table to advance to the next step that is cutting. 3. - Molds are cut using the hand tool for making donuts. And placed in trays in quantities of 15 donuts per tray, letting stand for 2 hours or so to as to achieve consistency. 4. - The next step is to fry, to finally be glazed. The production is approximately 3500 donuts per working day 5 to 6 hrs.

Problem

The hand tool used to make donuts, is used by workers of the bakery being this, of galvanized sheet, donut-shaped with a diameter of 10 centimeters. It is used by grasping the extended hand is covering the design, so you can bang the mold on the dough and go to form the donuts. Product of this movement, while causing tiredness, fatigue, muscle aches workers in this area. Thus arises the interest and the need for research and redesign the tool.

General and Specific Objective

General Purpose. Redesigning a hand tool based on the need to use and anthropometric design, which is used in the production of donuts in a bakery established in the City of Los Mochis, Sinaloa.

Specific Objectives.

- 75 people were identified (morning and afternoon).
- We applied RULA assessment, taking photos and video of what is observed while performing the job. Assessment was applied, resulting in a level 5 (5 or 6 Investigate Further and change soon), it was necessary to initiate an investigation and redesign.

- Anthropometric measurements are taken and is prepared ergonomic redesign.
- It developed the prototype of the redesign.
- We applied again RULA, taking photos and video from the observed.
- Adjust the table height to a standard size for convenience in carrying out the work.

Justification

This redesign is warranted based on the reduction of fatigue and muscle aches that occur over time in workers, while reducing the number of workers with disabilities caused by such problems. It improves mental and physical performance of each person as well as the moral aspect, feeling that the company which is working really cares about their welfare. It increases the productivity of the company, because it improves the performance of each of the persons performing this work, as well as improving production, since it is much faster or in more quantity due to the use of the new hand tool.

RULA Method:

Evaluate specific positions, it is important to evaluate those that pose a higher postural load. Application of the method begins with the observation of the worker's activity for several cycles. From this observation should select the most significant tasks and positions, either on its duration, or for filing, a priori, greater postural load. These positions will be assessed. If the work cycle is long assessments can be made at regular intervals. In this case we consider also the time spent by the worker in each position.

To perform measurements on the positions adopted are primarily angles (the angles formed by the different members of the body from certain references in the position studied). These measurements can be performed directly on the worker by protractors, electro goniometers, or any device for making angular data. However, it is possible to use photographs of work by adopting the posture study and measure the angles on them. If using pictures is necessary to make a sufficient number of shots, from different points of view (standard, profile, detail views ...), and make sure to measure the angles displayed in true scale in the images.

The method should be applied to the right and left side of the body separately. The expert reviewer can choose a priori the side that is apparently subject to greater postural load, but in case of doubt it is better to look at both sides.

The RULA method divides the body into two groups, group A which includes the upper limbs (arms, forearms and wrists) and group B, comprising the legs, trunk and neck. By the tables associated with the method assigns a score to each body part (legs, wrists, arms, trunk, ..) to, in terms of these scores, assign values to each of the groups A and B.

The key to the assignment of ratings to members is to measure the angles of different parts of the body of the worker. Method determines for each member in the form of angle measurement.

Subsequently, the overall scores of groups A and B are modified depending on the type of muscle activity developed and applied force during the performance of the task. Finally, we get the final score from these values changed. The final value provided by the RULA method is proportional to the risk involved in performing the task, so that higher values indicate a higher risk of musculoskeletal injuries.

The method organizes the final scores on performance standards that guide the evaluator on the decisions to be taken after the analysis. The proposed performance levels ranging from level 1, which assessed that the position is acceptable, level 4, indicating the urgent need for changes in the activity.

Group A: Ratings of the upper limbs.

The method begins with the evaluation of the upper limbs (arms, forearms and wrists) organized in the so-called Group A: The arm, the forearm, the wrist, and the Group B: for the legs, trunk and neck

Overall rating for members of group A

Forearm		Wrist							
Arm		1		2		3		4	
		Wrist Spin		Wrist Spin		Wrist Spin		Wrist Spin	
		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
	1	5	5	5	5	5	6	6	7
5	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
	1	7	7	7	7	7	8	8	9
6	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Overall rating for members of group B

	Trunk											
	1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
Neck	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

Score type of muscular activity developed and applied force:

Points	Position
0	If the load or force is less than 2 kg and is carried out intermittently.
1	If the load or force is between 2 and 10 kg and stands up intermittently.
2	If the load or force is between 2 and 10 kg and is static or repetitive.
2	If the load or force is intermittent and more than 10 kg.
3	If the load or force is greater than 10 kg, and is static or repetitive.
3	If there are shocks or abrupt or sudden forces.

Final Score

	Score D						
Score C	**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

Methodology.

- 75 people were identified and applied RULA assessment, taking photos and video of what is observed while performing the job. Assessment was applied, resulting in a level 5 (5 or 6 Investigate Further and change soon), it was necessary to initiate an investigation and redesign.

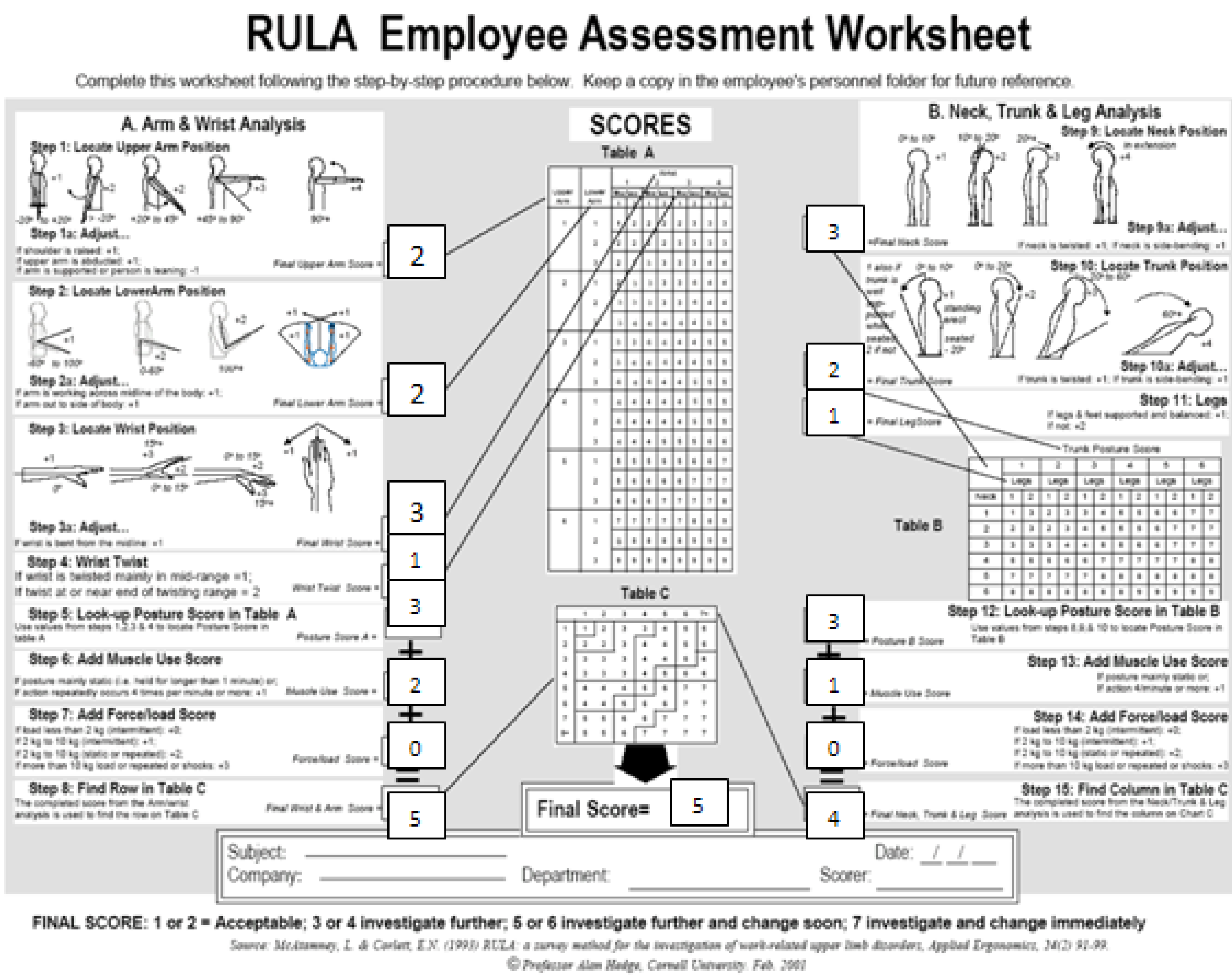

Figure.1. RULA application of the hand tool without redesign.

Figure 2. Tool Use

Figure 3. Original hand tool made of galvanized sheet metal

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It uses only 3 steps to develop this, which are the width of the palm, the grip and arm extended. Percentiles are determined according to each measure, to take with it a standard measure and develop an ergonomic redesign.

It listed the 75 measurements obtained in descending order, ie from largest to smallest (width of the palm grip and an outstretched arm).

Below is the table of measures, together with the equivalent percentiles to each value, taking only the 3 measures chosen for the development of the redesign.

Table 1 Measures of the width of the hand and percentiles

	PERCENTILES	WIDTH OF HAND
1	100%	10.5 cm.
2	98.66%	10
3	97.33%	10

4	**96%**	**10**
5	**94.66%**	**10**
70	8	7.5
71	6.66	7.5
72	5.33	7.5
73	3.99	7.5
74	2.66	7.5
75	1.33	7

Table 2 Measures of grip and percentiles

	PERCENTILES	GRIP
1	100%	5.2 cm,
2	98.66%	51
3	97.33%	51
4	**96%**	49
5	**94.66%**	49
70	8	36
71	6.66	36
72	5.33	35
73	3.99	35
74	2.66	33
75	1.33	33

.

Table 3 Measures Extended arm and percentiles

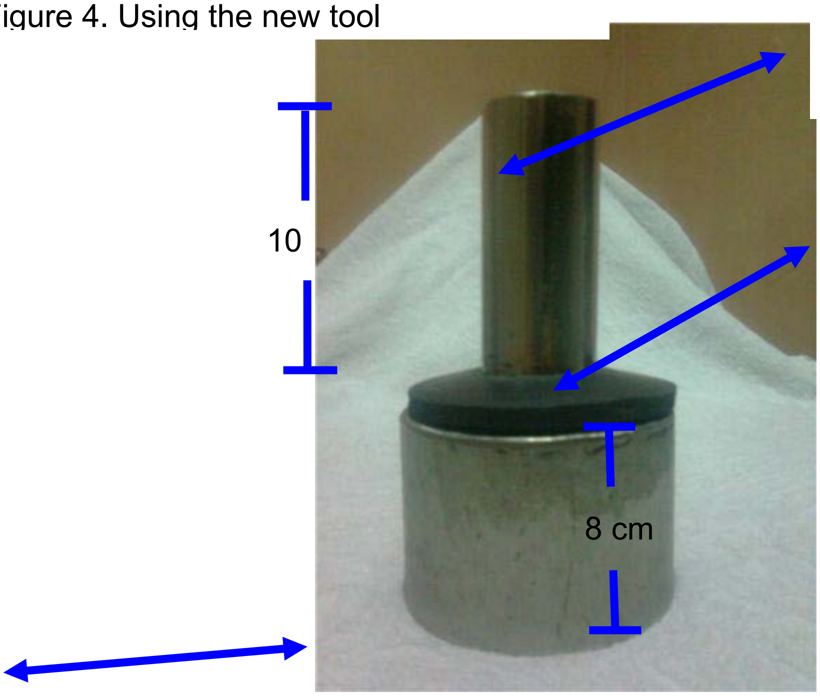
	PERCENTILES	EXTENDED ARM
1	100%	81 cm
2	98.66%	80
3	97.33%	75
4	**96%**	77
5	**94.66%**	78
70	8	72
71	6.66	68
72	5.33	70
73	3.99	71
74	2.66	63
75	1.33	72

.

- It developed the prototype of the redesign.

Figure 4. Using the new tool

Figure 5 Hand tool (redesign) made of stainless steel



Grip handle with a 5 cm.

Support of 1 cm thick.

Support made of neoprene

With a diameter of 10

Figure 6 Redesign of the hand tool made of stainless steel.

- We applied again RULA, taking photos and video of what is observed and evaluated.

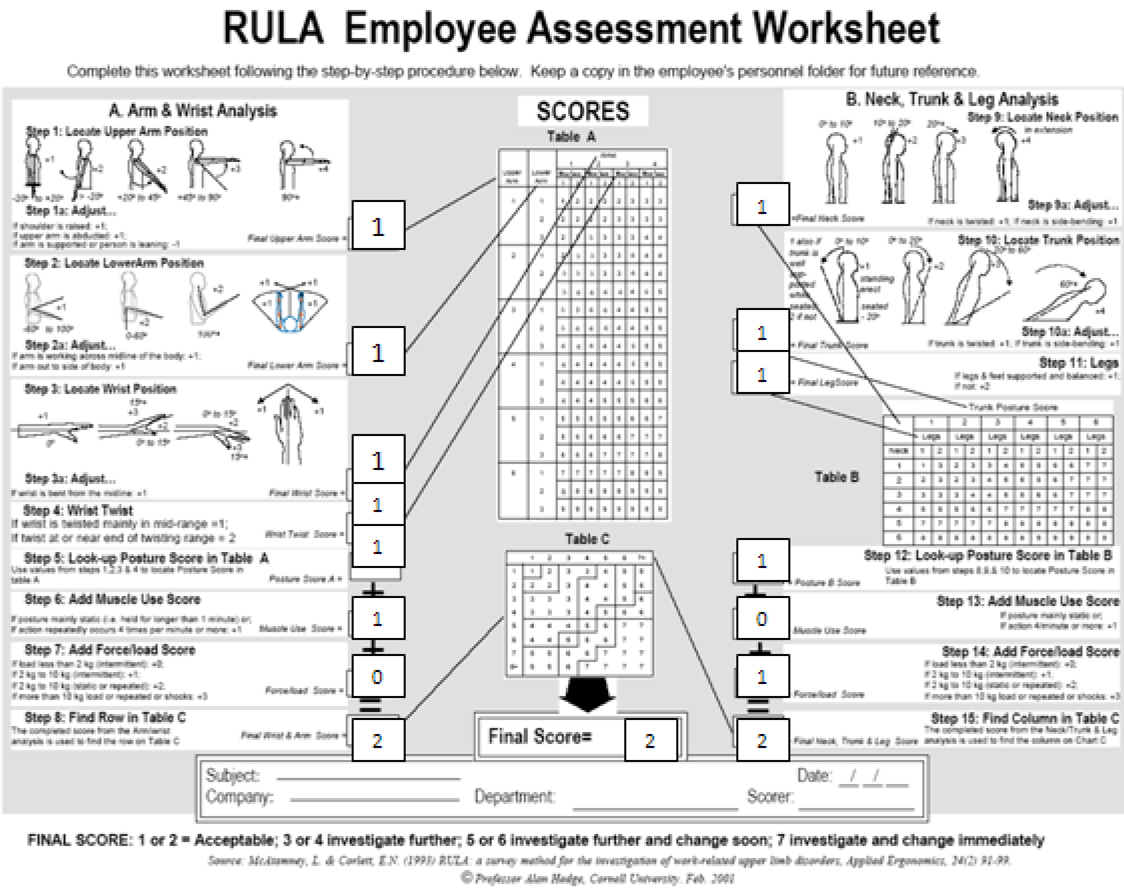


Figure 7 Method using the redesign RULA

- Adjust the table height to a standard size for convenience in carrying out the work.

CONCLUSIONS

Based on research conducted through surveys of a population of 75 employees of a bakery, and the use of tools such as the implementation of RULA, photos and videos, it was the redesign of this tool in hand, which resulted in a marked improvement in workers at the time of use.

RECOMMENDATIONS

That's why we recommend working on awareness training for staff to use hand tool, making do with this, the importance of this tool to use when creating awareness in them of both the risks of not using it and the benefits it will bring the use of this.

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ILLUMINATION LEVELS EVALUATION IN A WIRING SYSTEM COMPANY IN HERMOSILLO, SONORA.

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Resumen

El propósito del presente artículo es analizar los niveles de iluminación a los que encuentra expuesto el personal que laboran en una empresa manufacturera de arneses electrónicos del noroeste de México, con el fin de evaluar y comparar con ciertos estándares incluidos en las normativas vigentes. En este análisis se realizó de acuerdo a los lineamientos presentados en el apartado A.2.1 de la NOM 025-STPS-2008 – Iluminación, y en cuanto a los puntos de medición, fueron seleccionados en función a las necesidades y características de cada centro de trabajo. Los resultados generados en la investigación nos dan a conocer que en algunas de las zonas identificadas por recorridos previos, como puntos de conflicto, presentan una iluminación inadecuada, ya que sus niveles se encuentran con una iluminación superior a lo que la NOM 025-STPS-2008 considera es el estándar de la operación que en esa zona se realiza, mientras que otras se encuentran debajo del nivel que deberían presentar. El contar con una iluminación deficiente, pone de manifiesto que el ambiente laboral que se presenta en las zonas de estudio, puede afectar la salud de los trabajadores con distintos efectos como trastornos visuales, cefalalgias y/o fatiga general.

Palabras clave: Iluminación, seguridad industrial, lux

Abstract

The purpose of this paper is to analyze the employees' illumination exposure levels of a wiring system manufacturing company located Norwest of Mexico, to evaluate and compare them with certain standards included in the current Mexican regulations. Due to the double working shift of the company, measurements were taken at different hours, as demanded by section A.2.1 of the Illumination norm NOM 025-STPS-2008. The measurement points were selected according to the needs and characteristics of each workstation. Research results concluded that some previously identified zones as conflict points have an inadequate illumination based on NOM 025-STPS-2008 standard, due to higher illumination levels, while other zones presented lower levels. Having a deficient working environment illumination may have harmful effects in the employees' health such as blurred vision, headaches and/or general fatigue.

Key words: illumination, industrial safety, lux

INTRODUCTION

Rea, (1993) defines illumination as a radiant energy capable of exiting the retina and creating a visual sensation. Illumination is a crucial part in information gathering because more than 80% of the information received by people is through a visual sense. Sight has two basic mechanisms called accommodation and adaptation; while accommodation allows focusing sight at a specific point depending on the distance, interest and needs of the operator, adaptation makes possible to adjust sight sensibility to the existing level of illumination (Wolska 2003).

> "Occupants on those buildings with efficient lighting installations had positive perceptions of the lighting quality (Moore, Carter and Slater, 2003)."

The weak point of sight appears when it is necessary to observe very near small details with a low illumination level; in this circumstances mistakes increase, visual and mental fatigue may present, which is why determining the correct illumination levels for these tasks becomes fundamental. Illumination conformity should be at least 0.7 in a working area and 0.5 in the working environment (CIE, 2001).

Illumination: is the relation of incident luminous in a surface by unit area, expressed in lux. One lux is the illumination produced by a lumen uniformly distributed over a square meter.

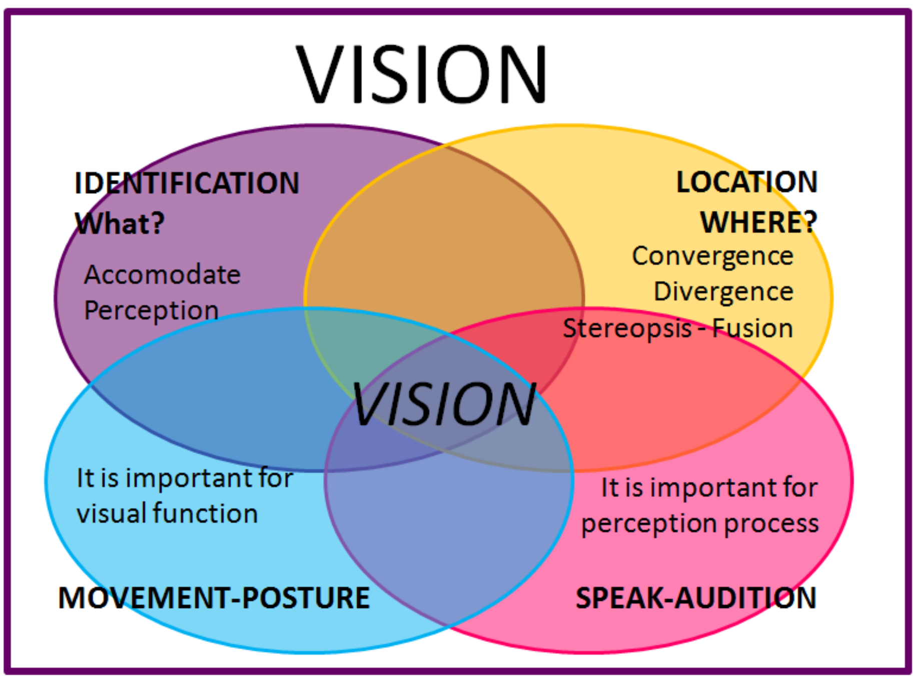


Figure 1

NOM-025-STPS-1999 establishes the illumination characteristics in the workplace, so that it will not represent a health risk for the workers while conducting their activities. Therefore it expresses a number of requirements that employers must meet in order to provide a comfortable working area.

Illumination Levels

Minimum illumination levels to be presented in a working area, for each type of visual task are established in table 1. Also, the reflection factor of surfaces situated inside the normal visual field generally has the following values according to the official Mexican standards:

Table 1

NIVELES MÍNIMOS DE ILUMINACIÓN

TAREA VISUAL DEL PUESTO DE TRABAJO	ÁREA DE TRABAJO	NIVELES MÍNIMOS DE ILUMINACIÓN (LUX)
En exteriores: distinguir el área de tránsito, desplazarse caminando, vigilancia, movimiento de vehículos.	Áreas generales exteriores: patios y estacionamientos.	20
En interiores: distinguir el área de tránsito, desplazarse caminando, vigilancia, movimiento de vehículos.	Áreas generales interiores: almacenes de poco movimiento, pasillos, escaleras, estacionamientos cubiertos, labores en minas subterráneas, iluminación de emergencia.	50
Requerimiento visual simple: inspección visual, recuento de piezas, trabajo en banco y máquina.	Áreas de servicios al personal: almacenaje rudo, recepción y despacho, casetas de vigilancia, cuartos de compresores y pailería.	200
Distinción moderada de detalles: ensamble simple, trabajo medio en banco y máquina, inspección simple, empaque y trabajos de oficina.	Talleres: áreas de empaque y ensamble, aulas y oficinas.	300
Distinción clara de detalles: maquinado y acabados delicados, ensamble e inspección moderadamente difícil, captura y procesamiento de información, manejo de instrumentos y equipo de laboratorio.	Talleres de precisión: salas de cómputo, áreas de dibujo, laboratorios.	500
Distinción fina de detalles: maquinado de precisión, ensamble e inspección de trabajos delicados, manejo de instrumentos y equipo de precisión, manejo de piezas pequeñas.	Talleres de alta precisión: de pintura y acabado de superficies, y laboratorios de control de calidad.	750
Alta exactitud en la distinción de detalles: ensamble, proceso e inspección de piezas pequeñas y complejas y acabado con pulidos finos.	Áreas de proceso: ensamble e inspección de piezas complejas y acabados con pulido fino.	1,000
Alto grado de especialización en la distinción de detalles.	Áreas de proceso de gran exactitud.	2,000

Table 2

NIVELES MÁXIMOS PERMISIBLES DEL FACTOR DE REFLEXIÓN

CONCEPTO	NIVELES MÁXIMOS PERMISIBLES DE REFLEXIÓN K_f
TECHOS	90 %
PAREDES	60 %
PLANO DE TRABAJO	50 %
SUELOS	50 %

Luminance and brightness distribution in the visual field should be as homogeneous as possible, because the eye must adapt according to the illumination intensity and it may produce fatigue and damage in the visual perception if done very often. Brightness uniformity is practically impossible to achieve. Therefore, considering three areas in the visual field (center of the working area, immediate surroundings and mediate surroundings) the differences between the brightness of the three areas should not be higher than the ratio 10:3:1 or vice versa 1:3:10..

When illumination is artificial, generally white light is recommended, or the most similar to day light (more precisly noon); thus, in addition of being the healthiest, the objets will be seen in thier true colors. Interest in natural illumination has increased recently. This interest its not due to quality, but rather the wellness it provides. But as natural illumination levels are not uniform, an artificial illumination system is required. The most common illumination systems are the following:

- *Uniform general illumination.* In this system, sources of light are uniformly distributed regardless job locations.
- *General illumination and localized support illumination.* It is a system that tries to strengthen the general illumination scheme by placing lamps in working surfaces.

Wolska (2003) expresses that interior environment illumination has to satisfy the following needs:

- Contribute on creating a safe working environment.
- Helps realize visual aids
- Create a proper visual environment.

The creation of a safe working environment has to be top on the list of priorities and, in general, security is raised by making dangers clearly visible. The order of the other two priorities will greatly depend of the interior working environment. Task performance can be improved by making every detail easier to see, while creating appropriate visual environments varying illumination emphasis according to objects and existent surfaces inside the working environment.

METHODOLOGY: EVALUATING ILLUMINATION LEVELS – FOAM AREA

An illumination evaluation study of a wiring system company in Hernosillo, Sonora was performed. This study was conducted on October 12 and 22, 2010 and was authorized by the industrial safety engineer.

The principal activity of the company is to ensemble wiring systems. The company is interested in determining if its illumination is a risk factor for the health of the workers while performing their activities.

Illumination Areas Recognition

To identify working areas, the visual tasks associated to each work and identify working areas with a illumination deficiency or excess of illumination that may cause glare, a tour through the entire company was made and the worker reports were considered. To determine the areas and the visual tasks of each job, the following information was gathered:

a) Work areas, illumination system (number and distribution of luminaries), machinery and equipment distributions;

b) Lamps characteristics;

c) Description of the illuminated area: color and types of surfaces. The interior of the company is painted white with blue details.

d) Description of the visual task and working areas; The area with the highest illumination is the quality inspection area, mostly where the accessories dimensions are checked. Each station counts with illumination above each working area.

The conveyor area also counts with illumination on each working station but not as intense as the quality inspection area. The riveting area was another well illuminated.

The opportunity areas detected where the Foam area and an area from segment 2 where different process take place, such as inspection, kitting, conveyor, meshing and electric testing.

e) Work job description that require localized illumination, and the authorization for taking pictures of the areas where localized illumination was required, areas like quality inspection and conveyor. This request was authorized by the Industrial Safety and Hygiene Coordinator.

f) The information about perception of illumination conditions from the workers to the employers. Employees from areas detected were surveyed. After making a preliminary survey to identify key points to consider as the Mexican Official Standard NOM-025-STPS-2008 establishes, it was decide to analyze the foam area and the meshing area.

Illumination Levels Evaluation – Foam Area

Before measurements were taken, it was reported that the fluorescent lamps had been turned on for more than 45 minutes to allow the light flow to stabilize. It was also reported that the ventilation systems were operating normally. Because natural light has a direct influence on the illumination levels in this areas, 3 measurements were taken in each point or determined zone distributed during the work shift (7:00 – 17:00 hrs):

1. The first measurements were taken at 8:00 am
2. The second measurements were at 12:00 pm
3. The third measurements were taken at 4:00 pm

According to the establishments on NOM-025-STPS-2008, the area index (1) for the foam area was obtained and the area was divided in equally size parts.

$$IC - \frac{(x)(y)}{h\,(x+y)} - \frac{(34)(8)}{4(34+8)} - 1.619 \qquad (1)$$

IC = area index

x, y = area dimensions (length and width), in meters

h = height from the working surface to the luminaries, in meters.

A preliminary recon study was made to determine the principal points to study as established in the Official Mexican Norm NOM-025-STPS-2008, finding 10 sampling points and covering the minimum required by the norm with an area index 1 < IC < 2.

Eight zones where identified were the visual task was of moderate distinction (machinery work), with a minimum of 300 luxes specification required. Two zones were identified as circulation zones or hallways with a minimum of 100 luxes specification required

Measurements were taken in the area with the highest concentration of workers, which did not coincide with focal luminary points. At least one measurement was taken in each work surface placing the luxometer 30 cm. above it to avoid projecting shadows or reflecting additional light over the luxometer.

Equipment

For this study, a Testo 540, Testo AG, luxometer was used.

Reflection Factor Evaluation

The reflection factor measurements were taken for each working surface and walls in contact with the study area. To determine the reflection factor, the first measurement (E1) was made with the luxometer's photocell facing the surface, at a distance of 10 cm. until the luxometer displayed a constant reading;

The second measurement (E2), was made with the photocell facing the opposite direction and supported on the surface, to measure the incident light.

The reflection factor (2) of the surface can be determined by the following equation:

$$Kf = \frac{E_1}{E_2} 100 \qquad (2)$$

RESULTS

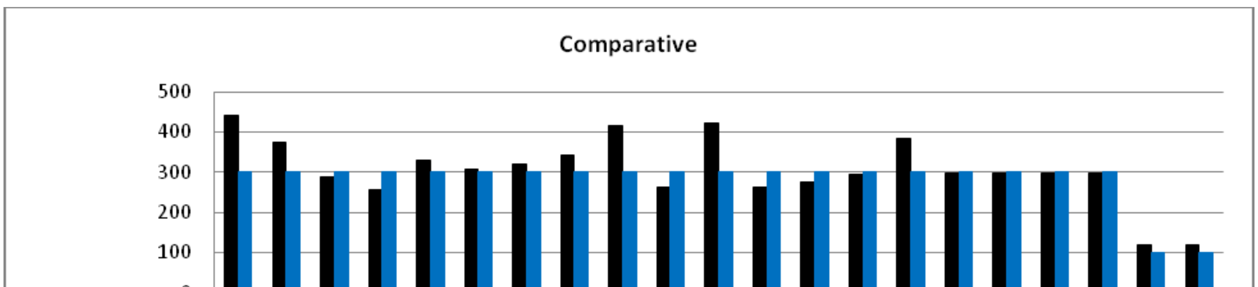
Table 3 presents the results of illumination levels and the reflection factor (kf) found in the same locations measured, there are also the minimum standard of illumination. The values of levels of illumination and reflection factor are an average of several readings taken at each point (three data each, three times in one turn.) It also shows the difference between the observed and dictated by the standard. As all the lighting is fluorescent product.

Table 3

Area	Visual task	Data number	Lux	Minimum Standard	Deference	% of reflection
1	*MDD*	3	442	300	142	13
2	*MDD*	3	376	300	76	7
3	*MDD*	3	289	300	-11	9
4	*MDD*	3	258	300	-42	11
5	*MDD*	3	330	300	30	9
6	*MDD*	3	308	300	8	8
7	*MDD*	3	320	300	20	11
8	*MDD*	3	344	300	44	8
9	*MDD*	3	417	300	117	46
10	*MDD*	3	264	300	-36	48
11	*MDD*	3	423	300	123	43
12	*MDD*	3	264	300	-36	18
13	*MDD*	3	275	300	-25	20
14	*MDD*	3	295	300	-5	16
15	*MDD*	3	384	300	84	7

16	*MDD*	3	299	300	-1	48
17	*MDD*	3	299	300	-1	46
18	*MDD*	3	299	300	-1	48
19	*MDD*	3	299	300	-1	45
20	*CAH*	3	120	100	20	N/A
21	*MDD*	3	118	100	18	N/A

Below is a comparison between the levels set by the standard and those observed in the measurements:



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Measumement	442	376	289	258	330	308	320	344	417	264	423	264	275	295	384	299	299	299	299	120	118
Standard	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	100	100

Figure 2

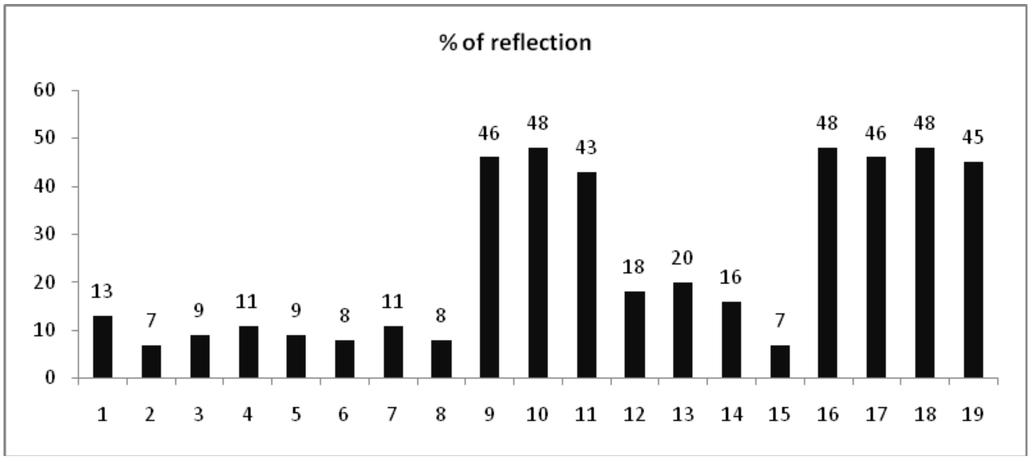


Figure 3

The second part of the lighting study was conducted in the area of meshing of a plant, carrying out the study in two of the assemblies, one on a conveyor with capacity for twelve boards and one for one with up to eight boards, two with their knitted, inspections and areas of stationary conveyor.

METHODOLOGY: ILLUMINATION LEVELS EVALUATION - GILL NET AREA

Before the measurements, we were informed that fluorescent lamps were more than 45 minutes of burning to allow the flow of light is stabilized. We were also informed that the ventilation systems were operating normally. Because it does influence the natural light in the installation, 3 measurements were made in each specific zone or point spread over the work shift (7:00 - 17:00 hrs)

1. The first measures were taken at 8:00 am
2. The second measures taken at 12:00 pm
3. The third measures took place at 4:00 pm

According to the provisions of NOM-025-STPS-2008, we obtained the area index (3) for the area of netting and divided the work area in areas of the same size.

$$IC = \frac{(x)(y)}{h\ (x+y)} = \frac{(30)(10)}{4(\ 30+10\ )} = 1.875 \quad (3)$$

IC = index of the area.

x, y = area dimensions (length and width) in meters.

h = height of the luminaire on the work surface, in meters.

In the plant we carried out a preliminary survey to identify key points to consider as the Mexican Official Standard NOM-025-STPS-2008, finding 10 points of sampling. The number of areas to be evaluated in this study were those referred to in the preceding paragraph, so that covers the minimum required by the regulations that are 9, the area index 1 <CI <2.

We identified four areas where lighting is required for distinguishing moderate required details, average work machine, and six areas where it has a simple inspection, in both visual tasks, the minimum is 300 light lux.

Measurement was performed in the area with the highest concentration of workers, which did not coincide with the focal points of the fixtures. Had at least one measurement at each level of work placing the light meter to 30 cm of the plane to not cast shadows or reflect additional light on the light meter.

Equipment

For this study we used a light meter mark Testo 540, Testo AG, Germany.

Evaluation of the Reflection Factor

It makes measuring the reflection factor for each level of work and the walls were in contact with them. To determine the degree of reflection, it made a first measurement (E1), with the light meter photocell positioned facing the surface, at a distance of 10 cm, until the reading remains constant;

The second measurement (E2), is made with the photocell facing in the opposite direction and supported on the surface, to measure the incident light.

The reflection factor of the surface (4) is determined by the following equation:

$$Kf = \frac{E_1}{E_2} 100 \quad (4)$$

RESULTS

According to the Norms of the Ministry of Labor minimum lighting values for different tasks within the factory are set out in Table 1. Table 4 presents the results of lighting levels and the reflection factor (kf) found in the same locations measured, there are also the minimum standard of illumination. The values of levels of illumination and reflection factor are an average of several readings taken at each point (three readings each, three times in one turn.) It also shows the difference between the observed and dictated by the standard. As all the illumination is a fluorescent product.

Table 4

Area	Visual task	Data number	Lux	Minimum Standard	Deference	% of reflection
1	*MDD*	3	260	300	-40	17
2	*MDD*	3	333	300	33	31

3	*MDD*	3	260	300	-40	33
3	*MDD*	3	319	300	19	20
3	*MDD*	3	306	300	6	13
3	*MDD*	3	335	300	35	23
4	*MDD*	3	337	300	37	32
4	*MDD*	3	267	300	-33	11
4	*MDD*	3	267	300	-33	24
4	*MDD*	3	306	300	6	22
5	*MDD, simple inspection.*	3	264	300	-36	22
5	*MDD, simple inspection..*	3	309	300	9	33
5	*MDD, simple inspection.*	3	306	300	6	23
5	*MDD, simple inspection.*	3	282	300	-18	30
6	*MDD, simple inspection.*	3	280	300	-20	14
6	*MDD, simple inspection.*	3	265	300	-35	15
6	*MDD, simple inspection.*	3	264	300	-36	18
6	*MDD, simple inspection.*	3	295	300	-5	34
7	*MDD, simple inspection.*	3	296	300	-4	18
8	*MDD, simple inspection.*	3	275	300	-25	22
9	*MDD, simple inspection.*	3	306	300	6	35
10	*MDD, simple inspection.*	3	283	300	-17	34

Below is a comparison between the levels set by the standard and those observed in the measurements:

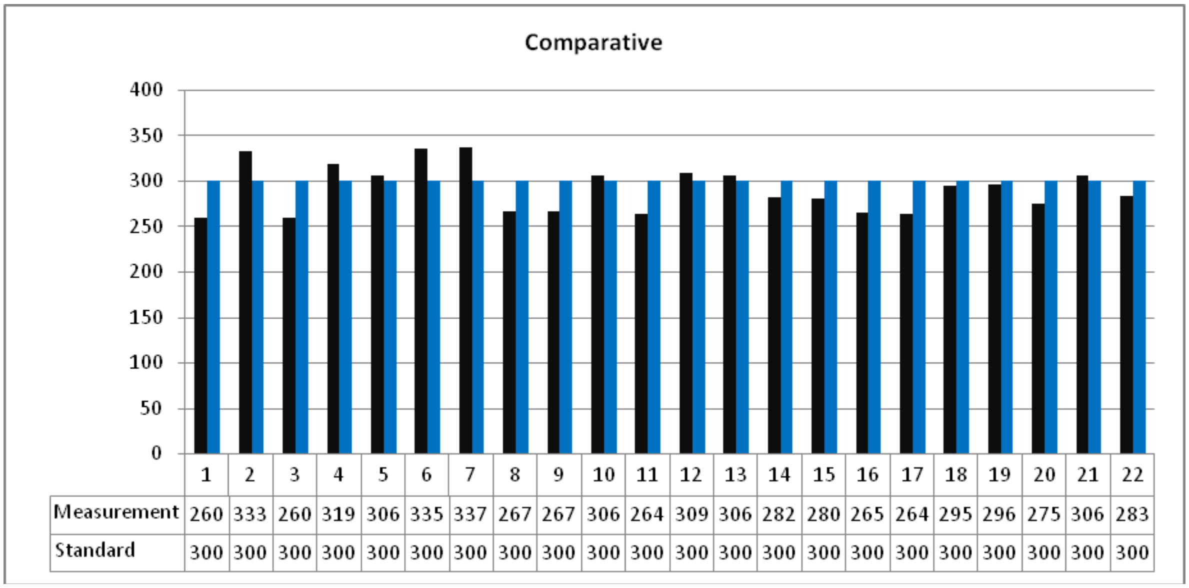


Figure 4

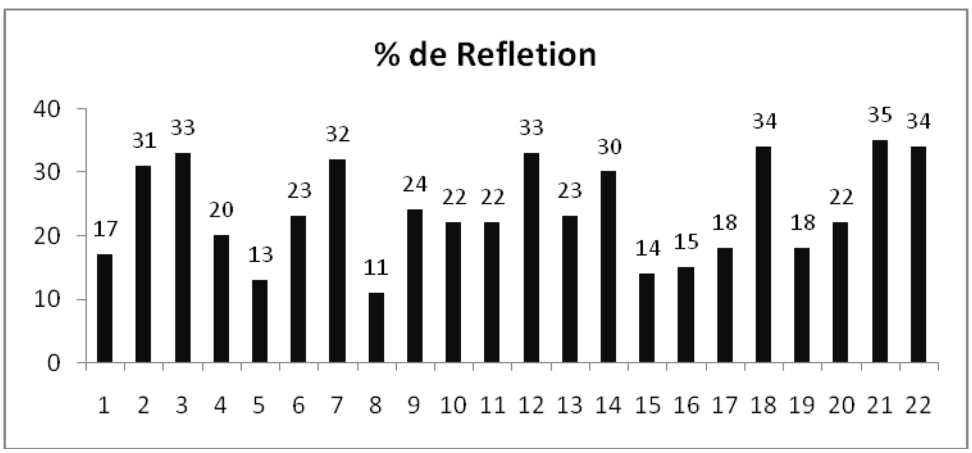


Figure 5

CONCLUSIONS

Based on the results of the analysis to the company, shows the light levels in a number of workstations are inadequate. The levels measured in some specific areas do not meet the national standard recommendations, with the NOM-025-STPS-2008. This situation shows that the work environment can be characterized as extreme and dangerous working conditions. Poor lighting can affect the health of workers with different effects such as blurred vision, headaches and / or general fatigue. The appropriate level of lux for tasks that require moderate distinction details, simple assembly and simple inspection is 300 lux. It proposes the implementation of a plan to protect staff and adequate lighting levels for the work done on the basis of NOM-025-STPS-2008.

RECOMMENDATIONS

Obviously the lighting in some areas of work investigated lack of adequate lighting on the basis of NOM-025-STPS-2008. However, it is possible to implement a series of measures that help to correct the lighting level. Here are some recommendations that can be considered basic:

- Maintain the luminaries;
    - Maintenance should consider the following aspects:
        - Cleaning of luminaires;
        - Ventilation of the luminaries;
        - The replacement of the lights when they stop working, or after the expiration of the predetermined number of operating hours set by the manufacturer;
- Modify the lighting system or its distribution.
- Install additional lighting or localized.
- For this last measure of control, where more light is required, consider the following:
- Avoid direct glare or reflection on the worker;
- Select appropriate visual background for the activities of workers;
- Avoid blocking the light while performing the activity,
- Avoid areas where there are sudden changes in lighting.

- Each of these measures should be appropriately tailored to the specific situation of the organization.

GENERAL CONCLUSION

In conclusion refers to the importance of this research as a process of improvement which show areas of opportunity within the plant. Based on the results of the analysis in the enterprise, evidence of exposure to unsafe conditions inherent in this organization, identifying areas that are outside the maximum permissible limits specified in the regulations in Mexico. Such factors beyond control may adversely influence the health of the operator, whether short or long term.

There levels measured in specific areas identified by the evaluation, the recommendations do not meet national standard. This situation shows that the work environment, from the standpoint of the research group can be characterized as extreme and unsafe working conditions. You must have knowledge of the current situation where these factors are involved by the worker and the staff responsible for their safety as well as negative impacts on the health of workers, which can lead to long exposures with the participation of environmental factors mentioned above. This knowledge can develop measures to counter the impact that may arise in the health of operators in the future.

In the present investigation procedures to counter facing unsafe working conditions and these are based on current regulations issued by the Ministry of Labour and Social Welfare (STPS), with the objective of maintaining a standard that allows workers to work in a safe environment and free to present health risks thereof. The company intends to follow up and make a management plan to keep running the mitigation measures proposed here.

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THE EFFECT OF NOISE AND TEMPERATURE THROUGH THE HEART RATE MEASUREMENT AND ITS INFLUENCE ON PRODUCTIVITY, ERGONOMIC EXPERIMENTAL STUDY IN CABINS

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RESUMEN

La población económicamente activa en México es de 44,651,832 de los cuales 16,847,300 son mujeres (INEGI, trimestre abril/junio 2010) aunándose a esto las labores cotidianas que tienen que realizar en el hogar, la mujer representa un importante rubro digno de estudiarse ya que a nivel Nacional son 2,469,636 las mujeres que laboran en la industria manufacturera y es una cantidad que tiende a la alza por las cualidades fisiológicas de la mujer apta para este ramo (BARRIENTOS 2004).

Por otro lado dentro del término enfermedad ambiental se designa un grupo de enfermedades no transmisibles, que excluyen los procesos derivados de hábitos personales como el fumar, el uso o abuso de fármacos o drogas como el alcohol, las llamadas enfermedades laborales, entre las que se encuentran las denominadas enfermedades profesionales, las relacionadas con el trabajo, los accidentes de trabajo y otros daños. La fatiga es una de estas, la cual se puede producir manifestaciones objetivas, fisiológicas, subjetivas y trastornos sensoriales (GONZALEZ, 1996).

Es por ello que se pretende mediante el estudio en mujeres de entre los 18 y 35 años, por ser esta la edad productiva más atractiva para los contratistas del ramo manufacturero, realizar una investigación que nos permita saber más acerca de las condiciones más favorables para laborar pudiendo así contribuir a una reducción de la fatiga en cuanto a las condiciones medioambientales se refiere

PALABRAS CLAVE: Fatiga, Ritmo Cardiaco, Condiciones Ambientales

ABSTRACT

The economically active population in Mexico is 44,651,832 of which 16,847,300 are women (INEGI, quarter April / June 2010) combined with daily tasks that have to do at home, women represent an important segment worthy of consideration as they National level are 2,469,636 women employed in manufacturing and is a quantity that tends to rise for the physiological qualities of women suitable for this industry.(BARRIENTOS,2004) On the other hand environmental illness within the term designates a group of no communicable diseases, which excludes the processes derived from personal habits like smoking, drug use or abuse alcohol or drugs such as, calls diseases, among which are the so-called occupational diseases, work related, workplace accidents and other injuries[10]. Fatigue is one of those, which can produce objective manifestations, physiological, subjective and sensory disorders. (GONZALEZ, 1996).

That is why it is intended by the study in women aged between 18 and 35, as this is the productive age group more attractive to the manufacturing sector contractors, an investigation that allows us to learn more about the most favorable conditions for labor may well contribute to a reduction of fatigue in terms of environmental conditions referred to.

KEYWORDS: Fatigue, Herat rate, Environmental Conditions.

INTRODUCTION

This research project was carried out in experimental cabins, which enable us to vary the conditions simulating a workplace as is the case of an assembly plant and the fact that the female population of more production jobs required by their characteristics natural (dedicated, methodical, more strength, to name a few) has decided to study both affect working conditions such as noise, temperature and lighting when you are performing a physical activity that usually hurt in a real job. According to the Sinaloa state government weather conditions for 8 months of the year the average temperature are ranging between 23 ° C and 4 months remaining ranges from 29 ° C on average. The average annual temperature is 25 ° C, reaching a record up to 45 º C in some months. Because this has been taken as an object of study for women of working age from 18 to 35 years, under changing conditions of temperature and noise during the work period of 6 hours or more variable heart rate response as an association with fatigue.

OBJECTIVES

GENERAL PURPOSE

Analyze how environmental effects (noise and temperature) generated by the various factors in cardiac rhythm disorders to be performing a work activity taking into account the age of the operator.

SPECIFIC OBJECTIVE

Monitor noise levels, temperature and age of different parameters within a controlled environment in the experimental field in order to analyze the rapid heartbeat caused by these factors, and thus determine the most appropriate level to reduce fatigue.

JUSTIFICATION

The human factor is one of the most important within an industry, so the good performance of them is vital if the work is carried out in the best possible way, and thus the product or service has the expected quality by the customer and be competitive in this globalized world (HOLVELL,1988).

To do this research we focus on the first line of ergonomic, one of the topics of our interest, since it provides a better quality of life for people. From this point so important that it is the human being, we have decided to conduct our research in this very factor, specifically focusing on women 18 to 35 years. We chose women because they are the least studied today.

Analyze factors such as noise, temperature, body mass and age, which cause a change in heart rate and hence fatigue.

In order to understand how these factors influence the fatigue of operators, which prevents him from carrying out their work efficiently, resulting in monotony (Fiala, 2001)

FATIGUE

Masud and Fernandez (1990), identified fatigue as a general feeling of exhaustion and that under these conditions the subject and has no desire to further develop the mental or physical effort required by the activity.

Fatigue is a state of mind which accuses the body's physiological changes, or psychological tiredness as a result of which the decrease in work performance is present (Nielsen, 2003)

FATIGUE THROUGH THE HEART RATE.

CALCULATION OF MAXIMUM HEART RATE.

Your maximum heart rate (MHR) in the maximum frequency that can reach this level corresponds to the maximum aerobic effort, based on your fitness and physiology.

The heart rate may vary depending on the number of muscle groups used, for example in a test cycling, you will reach a peak heart rate significantly lower than in the test Waterrower because more muscle groups are used.

FACTORS OF EXPERIMENT

NOISE

Not all sound is noise, noise is sound that does not like people, can be annoying and hinder the ability to work to create tension and disrupt concentration, cause accidents by hindering communication and alarm signals, cause problems chronic health and also cause you to lose your hearing.

TEMPERATURE

It is important to take into account the temperature factor as it is basically a quantity referring to the common notions of hot or cold. Generally, an object's "hottest" have a higher temperature, and if it is cold will have a lower temperature. Physically it is a scalar quantity related to the internal energy of a thermodynamic system.

Because the human body is warm-blooded, can maintain an internal temperature more or less constant, even when exposed to varying environmental temperatures. To maintain the internal temperature within safe limits, the body has to eliminate the excessive heat. To remove heat, the body changes the pace and amount of blood flow to the skin. Also changes the amount of liquid off the sweat glands in the skin (Givoni, 1973).

HEALTH PROBLEMS

Excessive exposure to very hot work environment can cause a variety of conditions from the heat. Heat stroke is the most serious problem for the health of everyone associated with work in hot environments. Heat stroke occurs when the system that controls body temperature and perspiration failure becomes inadequate. Perspiration is the only effective way that has the body to remove excess heat. The transpiration process can be put in jeopardy without the victim realizes having reached a state of crisis (DENMAN,1998)

HEAT EXHAUSTION

Heat exhaustion includes several clinical conditions that may resemble the early symptoms of heatstroke. Heat exhaustion results from loss of large amounts of fluid by sweating, sometimes with excessive loss of salt. A worker suffering from heat exhaustion still sweats, but feels a weakness or extreme fatigue, also dizziness, nausea, or headache. In more severe cases, the victim may vomit or lose consciousness.

AGE

The basal (minimum) high at birth we have, since then descend with age. On the maximum frequency over the pre-pubertal adolescents and those less than adults. The highest maximum frequency is reached between 8 and 10 years. Some studies claim that the major difference between the baseline and the maximum is reached after puberty and this difference diminishes with age.

MATERIALS AND METHODS

The development project was carried out experimentally in the cabins of industrial engineering laboratory where experiments were done working with duration of 6 hours each, applied to women 18 to 35 years of age.

The activity was conducted in the flashlight assembly, where he was monitoring the work area, taking into account the factors identified above, such as noise, temperature, age and body mass in order to demonstrate whether there fatigue or operators to perform a certain task, it was necessary to capture data on the behavior of heart rate in people who were tested by a pair of brand watches POLAR FT60, which store data on heart rate variability, primarily when the person is at rest, to determine your normal pulse, and during the day of the experiment. In the end, the clock we would produce the average and maximum frequency.

To determine body mass index, took the weight of people in kilograms and height in inches, using an electronic scale and a caliper. Noise controls it with a sonometer, temperature sensor using a Cube Science and was manipulated with a mini-split that is included in the cabin.

We obtained the pulse of the person with different factors, as was the temperature, noise, body mass worker and the worker still standing. Heart rate was measured by worker watches, which we show results of how well your heart rate during the working day.

Total runs for the experiments in this case use the Taguchi methodology to determine the appropriate number of samples, resulting in a total of 27 runs at different levels. (See Table 1). For each run made it took the weight and height of the person to determine your BMI, you told the person what would the experiment and was given a short training task to perform. After that he placed the watch and transmitter to take your resting heart rate which is sitting a period of 3 minutes, after which he was transferred to the assigned booth, which previously that under the conditions and levels specified.

During the period of 6 hours continuously monitor noise levels and temperature, to ensure that these remain within the range. At the end of the experiment data are recorded in the session, and he questions the person about how you feel, this part was subjected to a series of questions to record the parts of the body where the person feels tired or sore.

Matrix experiment

Controllable Factors	**Levels**		
	1	2	3
Temperature	20 °C	25 °C	30 °C
Noise	>80 dB	> 70 dB < 80	> 60 dB < 70

Noise Factors	**Levels**		
	1	2	3
Ege	18 a 23 años	24 a 29 años	30 a 35 años

The subject remained standing during the experiment.

Table 1. Taguchi design matrix

	Controlling factors		Noise factors				
		EDGE	1	2	3		
	Temperature	Noise				Y_{ij}	
1	1	1					
2	1	2					
3	1	3					
4	2	1					
5	2	2					
6	2	3					
7	3	1					
8	3	2					
9	3	3					

He carried out the experiment in random order provided by the Minitab statistical package. Taking as a response variable Yij production in the assembly of flashlights, and the frequency of heart rhythm.

RESULTS

The results of each of the treatments are presented in the following table (see table 2) showing the number of flashlights assembled in a day of 6 hours, and the frequency of heart rate and average during the day.

Table 2. "Readings of treatments for Taguchi analysis"

TEMPERATURE	NOISE	PRODUCTION	F.R.C	AVERAGE
1	1	970	135	107
1	1	710	126	97
1	1	720	123	93
1	2	854	103	80
1	2	887	215	99
1	2	680	135	108
1	3	1166	126	86
1	3	790	103	91
1	3	710	109	99
2	1	1115	228	107
2	1	662	103	90
2	1	840	123	115
2	2	875	127	90
2	2	752	226	127
2	2	730	133	115
2	3	645	130	108
2	3	825	119	101
2	3	812	124	110
3	1	535	193	197
3	1	986	140	99
3	1	810	104	93
3	2	1060	153	104
3	2	729	111	84
3	2	859	95	91
3	3	445	122	85
3	3	852	130	95
3	3	630	135	101

Data were processed using the Minitab statistical software.

RESULTS RESPONSE VARIABLE IN THE PRODUCTION

Table 3. Response signal to noise ratios.

"Bigger is better”.

Level	TEMPERATURE	NOISE
1	58.06	57.66
2	57.84	58.13
3	56.94	57.04
Delta	1.12	1.09
Sort	1	2

Average response table

Level	TEMPERATURE	NOISE
1	831.9	816.4
2	806.2	825.1
3	767.3	763.9
Delta	64.6	61.2
Sort	1	2

Table 4. Graph in terms of production waste.

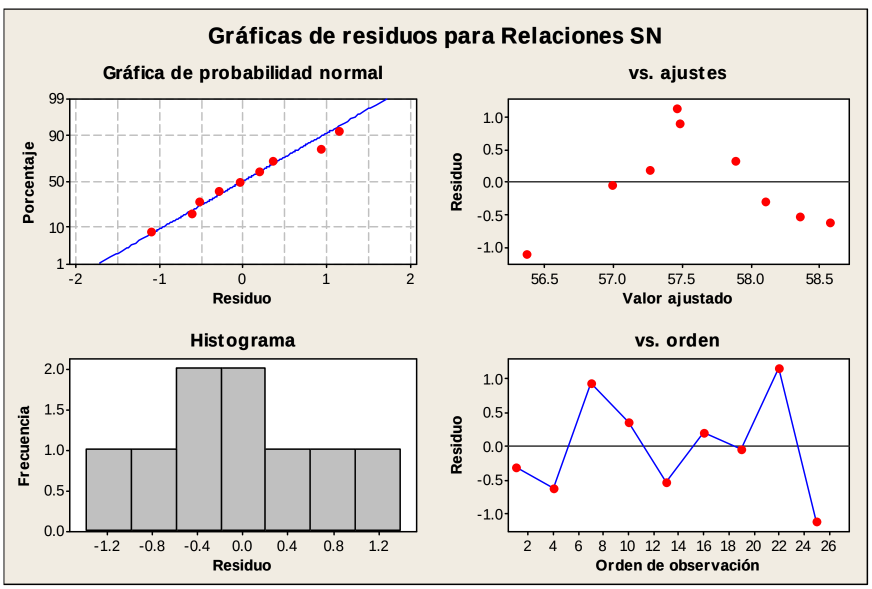


Table 5. Graph of means for main effects of production.

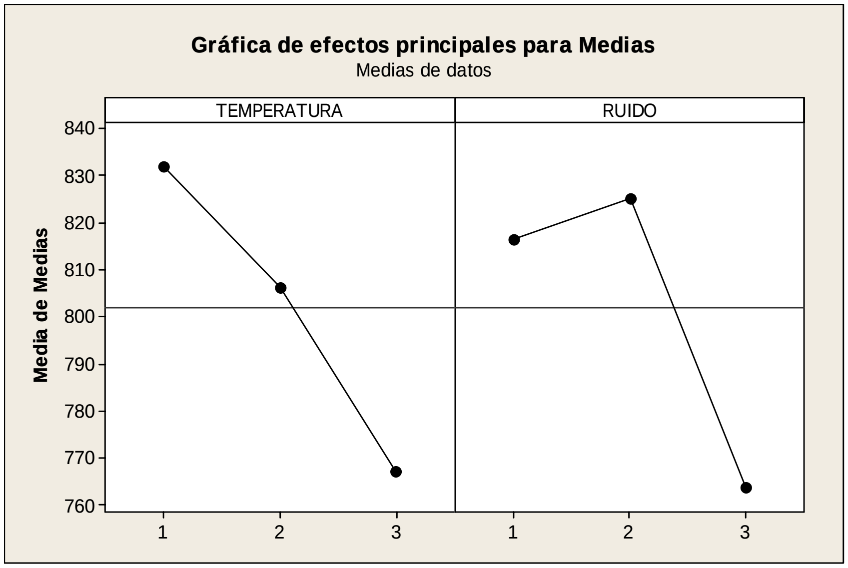
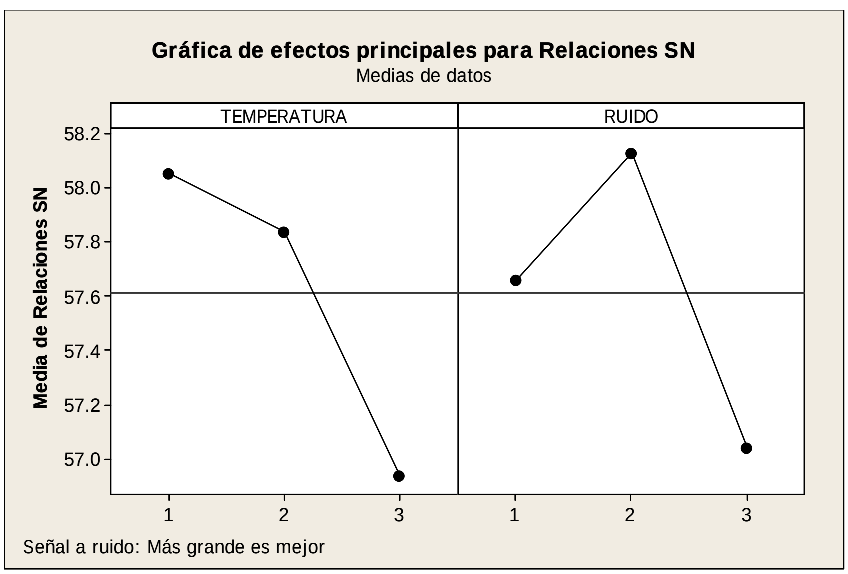


Table 6. Graphic variable effects on signal / noise (S / R) production



As can be seen from the graph of the main effects (Table 4-6) and taking into account the analysis of data "more is better" in this case we are considering a level 1 for temperature and noise level 2.

Results in terms of heart rate frequency (FRC)

Table 7. residual plots in terms of heart rate

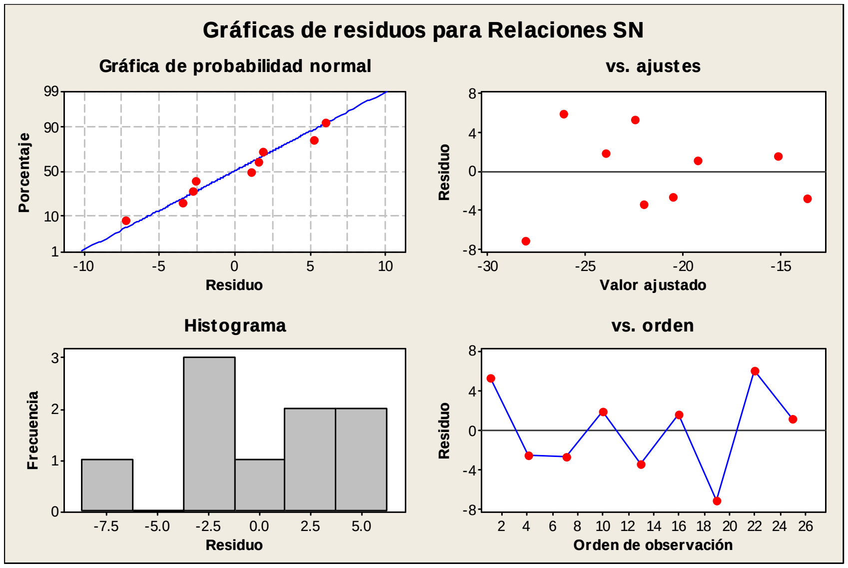


Table 8. Main effects on the heart rate.

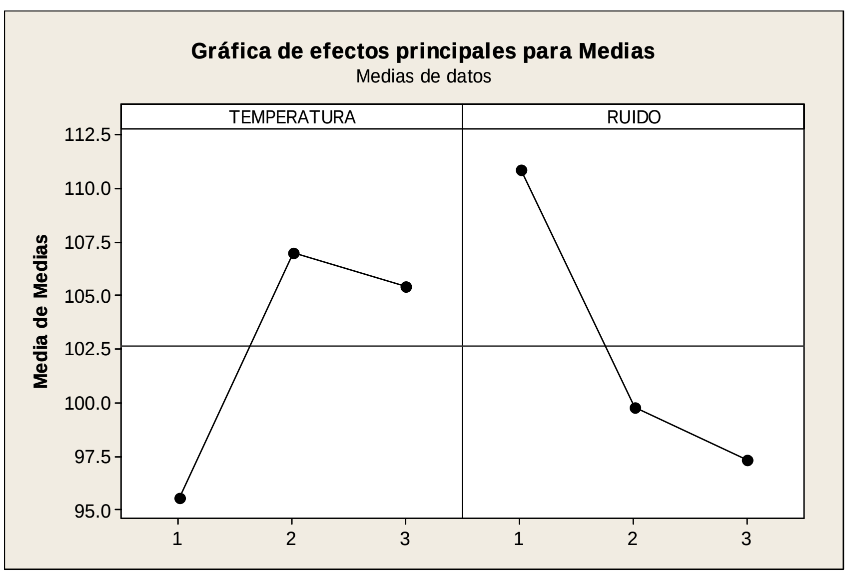
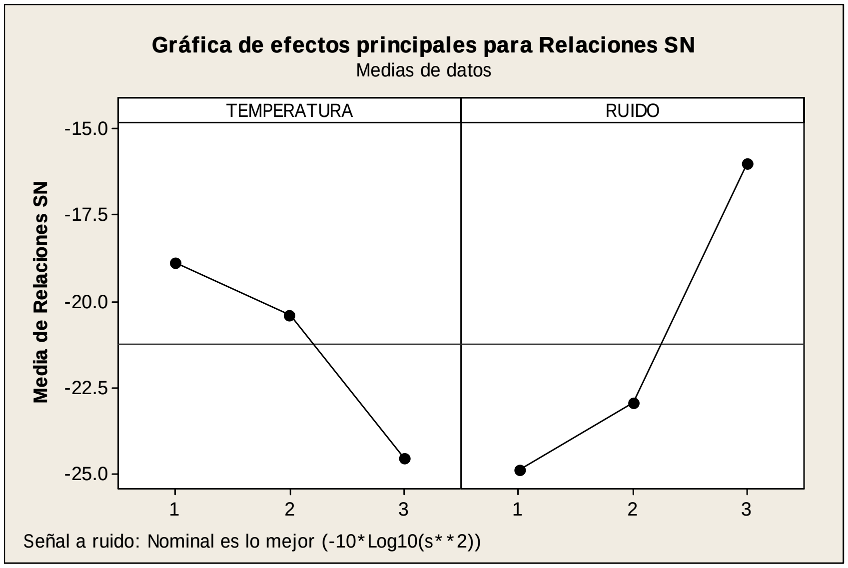


Table 9. Graphic variable effects on signal / noise (S / R) of FRC



As can be seen from the graph of the main effects (Table 7.8 and 9) and taking into account the "nominal is best" in this case would be considered nominal ranges of 70 to 90, average heart rate for graphic mean (Table 8) and plot of S / R (Table 9) is rated the best (closest to zero) we have a level 1 for temperature and noise level 3.

CONCLUSIONS

Based on the analysis of data obtained through Taguchi methodology, I conclude that the factors discussed above affect both production and heart rate of the women tested in the experimental field. These factors vary for each. Based on the results obtained that the most appropriate combination for greater production is labor at an average temperature of 20°C, with a noise> 70 dB <80.

If the company is interested in the quality of life of workers and this is not seen as a tool and take care of the health status of workers in terms of heart rate, making sure that the ranks of 70-90 to be considered a person working in good health, then levels of temperature should be 20°C on average, and the noise should be an average of> 60 db <70db.

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ERGONOMIC RISK ASSESSMENT WITH NIOSH AND JSI APPLICATION IN A FLOUR PROCESSING INDUSTRY IN THE STATE OF SONORA, MEXICO

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RESUMEN

En este trabajo se presenta la metodología y los resultados de un procedimiento de evaluación ergonómica en una estación de trabajo de la empresa Molino la Fama S.A.de C.V., el proyecto nace en base a las quejas de los mismos empleados al realizar la tarea de empaque en sacos de harina de 22 Kg., esto debido a que la estación está diseñada para realizar el empaque de sacos de 45 Kg., sin embargo se realizan las dos actividades, se aplican dos métodos para la evaluación, el método NIOSH para las cargas posturales y el método JSI para los riesgos ergonómicos en las extremidades superiores, siendo estos los principales objetos de estudios del trabajo, se obtuvieron resultados en los cuales se marca la necesidad de un rediseño del puesto de trabajo, y por ultimo en este articulo se mencionan algunas de las modificaciones que serian necesarias realizar para mejorar el área de empaque y la planta en general.

Palabras clave: Salud Ocupacional, fatiga, Ergonomía industrial

ABSTRACT

This article introduces the methodology and results of an ergonomic assessment procedure in a work station of a flour industry in the state of Sonora. The reason for this project is the inquiry of

the employees during the twenty two kilogram flour packing task, in a work station designed for a forty five kilogram packing, which provokes a negative impact in the employees´ occupational health. This work covers the application of two different tools, the NIOSH method which evaluates human capacity working loads, and the JSI method that evaluates ergonomic risks in the employees' upper limbs. The results of both applications show a redesign necessity of the work station, and advices the pertinent modifications needed to improve the packing activities.

The main objective of this article is to carry out an analysis and evaluation of the employees' ergonomic risks in the packing department of the company, as well as offering a framework explaining how the tasks should be done in order to prevent injuries and accidents in labor.

This study was developed in the twenty two kilogram flour packing which takes place in a work station designed for another capacity packing. This department plays a fundamental role between production and warehouse department.

This study is mainly focused in two factors the first one involve back problems generated by weight lifting and RWL (recommended weight limits) for the task, evaluated by the NIOSH equation, this technique is based on an equation involving seven variables which include distance, displacement, asymmetry, frequency and type of grip with the aim of providing the recommended weight limit and lifting index is obtained based on the recommended weight limits, and the second one evaluated by the Job Strain Index method, will analyze the exposure of the employees to generate injuries, product of repetitive movements in the upper limb. It will include an approach of hand, wrist, elbow, and forearm diagnose. The method is based on the measurement of six variables, which provides the Strain Index, value indicates the risk of upper limb disorders.

As a result of the NIOSH equation was a RWL of 2 kilograms which is smaller than the actual weight, the lifting rate is 20 which is more than the limit 3, that represents a risk for most workers, the recommendations are corrections in the type of grip and the vertical displacement factor, and for the JSI evaluation the results was 9.0 which means that the activity is potentially dangerous, the recommendation are adjustment in the intensity of effort and hand-wrist position. The adjustments can be corrected by a redesign of the workstation, then it have to be evaluated again whit the same methods, workers and operators have to be informed about the risk and diseases related to ergonomics and what working conditions can cause serious injury, prevent and detect the risk and do something about it.

Key Words: Occupational Health, Fatigue, Industrial Ergonomics.

Introduction

Low back pain and injuries attributed to manual lifting activities are one of the leading occupational health and safety issues, According to the Department of Labor of United States report, back injuries accounted for nearly 20% of all injuries and illnesses in the workplace, and nearly 25% of the annual workers compensation payments. A more recent report by the National Safety Council (1990) indicated that overexertion was the most common cause of occupational injury, accounting for 31% of all injuries. The back, moreover, was the body parts most frequently injured (22% of 1.7 million injuries) and the most costly to workers compensation systems. (Thomas, et al, 1994)

Cumulative trauma disorders due to performance of repetitive tasks account for more than 50% of all occupational illnesses in the United States today. Employees affected by these disorders frequently experience substantial pain and functional impairment that may require a change in occupation. For the employer, these injuries result in loss of productivity and increased costs in the form of higher medical expenses and disability payments for injured workers. Successful treatment of work-related repetitive tissue injuries depends on early diagnosis and appropriate therapy. Prevention requires identifying sites and tasks that place employees at risk of injury and supporting efforts to develop safer work environments. (Rempel, et al, 1992)

More than ten years ago, the National Institute for Occupational Safety and Health (NIOSH) recognized the growing problem of work-related back injuries and published the Work Practices Guide or Manual Lifting (NIOSH WPG, 1981). The NIOSH WPG (1981) contained a summary of the lifting-related literature before 1981; analytical procedures and a lifting equation for calculating a recommended weight for specified two-handed, symmetrical lifting tasks; and an approach for controlling the hazards of low back injury from manual lifting. The approach to hazard control was coupled to the Action Limit (AL), a resultant term that denoted the recommended weight derived from the lifting equation. (Thomas, et al, 1994)

The JIS method is based on existing knowledge and theory of the physiology, biomechanics, and epidemiology of distal upper extremity disorders, a semiquantitative job analysis methodology was developed. The methodology involves the measurement or estimation of six task variables (intensity of exertion, duration of exertion per cycle, efforts per minute, wrist posture, speed of exertion, and duration of task per day); assignment of an ordinal rating for each variable according to exposure data; then assignment of a multiplier value for each variable. The Strain Index is the product of these six multipliers. Preliminary testing suggests that the methodology accurately identifies jobs associated with distal upper extremity disorders versus jobs that are not; however, large-scale studies are needed to validate and update the proposed methodology. (Moore, Garg, 1995)

During a inquiry of different work stations in a flour industry of the state of Sonora we found one on the packing area to focus because the employees during the twenty two kilogram flour packing task, complain about pain and we found that the work station was designed for a forty five kilogram packing, which provokes a negative impact in the employees´ occupational health, also its important the safety and health of the employees on this department because they play a fundamental role between production and warehouse department.

ASSESSMENT AND RESULTS

Ergonomic Assessment: work postures

Nowadays there are some authors that in their publications indicates a big number of kilograms that an human can pick or carry. That is the shield of enterprises to tell their employs to work in those conditions. They don't consider the angles between the worker and the object to pick, number of repetitions of the activity in a day, and many other important factors that affect the work postures in workstations. We chose NIOSH method that involves psychophysics, physiology and biomechanics studies to measure the exposure of workers in their workstations.

The equation we used is this one:

LCR= LC*HM*VM*DM*AM*FM*MC

Figure 1. NIOSH values

LC = Load Constant	CC = 23 kg	--
HM = Horizontal Multiplier	MH = (25/H)	see Table 1
VM = Vertical Multiplier	MV = 1-(0.003(V-75))	see Table 2
DM = Distance Multiplier	MD = 0.82+(4.5/D)	see Table 3
AM = Asymmetry Multiplier	MA = 1-(0.0032*A)	see Table 4
FM = Frequency Multiplier	--	See Table 5
MC = Multiplier Coupling	--	See Table 6

Tabla 1. Multiplicador HM

HM =25/H	
H(cm)	HM
< 25	1.00
28	0.89
30	0.83
32	0.78
34	0.74
36	0.69
38	0.66
40	0.63
42	0.60
44	0.57
46	0.54
48	0.52
50	0.50
52	0.48
54	0.46
56	0.45
58	0.43
60	0.42
63	0.40
>63	0.00

Tabla 2. Multiplicador VM

VM =1-0,003 [V-75]	
V(cm)	VM
0	0.78
10	0.81
20	0.84
30	0.87
40	0.90
50	0.93
60	0.96
70	0.99
80	0.99
90	0.96
100	0.93
110	0.90
120	0.87
130	0.84
140	0.81
150	0.78
160	0.75
170	0.72
175	0.70
>175	0.00

Tabla 3. Multiplicador desplazamiento

DM =0,82 + 4,5 /D	
D(cm)	DM
<25	1.00
40	0.93
55	0.90
70	0.88
85	0.87
100	0.87
115	0.86
130	0.85
145	0.85
160	0.85
175	0.85
>175	0.00

Tabla 5. Multiplicador de Frecuencia (FM)

Frecuencia	t < 1 h		1 h < t < 2 h		2h < t < 8 h	
lev / min	V < 75 cm	V > 75	V < 75	V > 75	V < 75	V > 75
>0,2	1	1	0.95	0.95	0.85	0.85
0.5	0.97	0.97	0.92	0.92	0.81	0.81
1	0.94	0.94	0.88	0.88	0.75	0.75
2	0.91	0.91	0.84	0.84	0.65	0.65
3	0.88	0.88	0.79	0.79	0.55	0.55
4	0.84	0.84	0.72	0.72	0.45	0.45
5	0.8	0.8	0.6	0.6	0.35	0.35
6	0.75	0.75	0.5	0.5	0.27	0.27
7	0.7	0.7	0.42	0.42	0.22	0.22
8	0.6	0.6	0.35	0.35	0.18	0.18
9	0.52	0.52	0.3	0.3	0	0.15
10	0.45	0.45	0.26	0.26	0	0.13
11	0.41	0.41	0.23	0.23	0	0
12	0.37	0.37	0.21	0.21	0	0
13	0	0.34	0	0	0	0
14	0	0.31	0	0	0	0
15	0	0.28	0	0	0	0
16	0	0	0	0	0	0

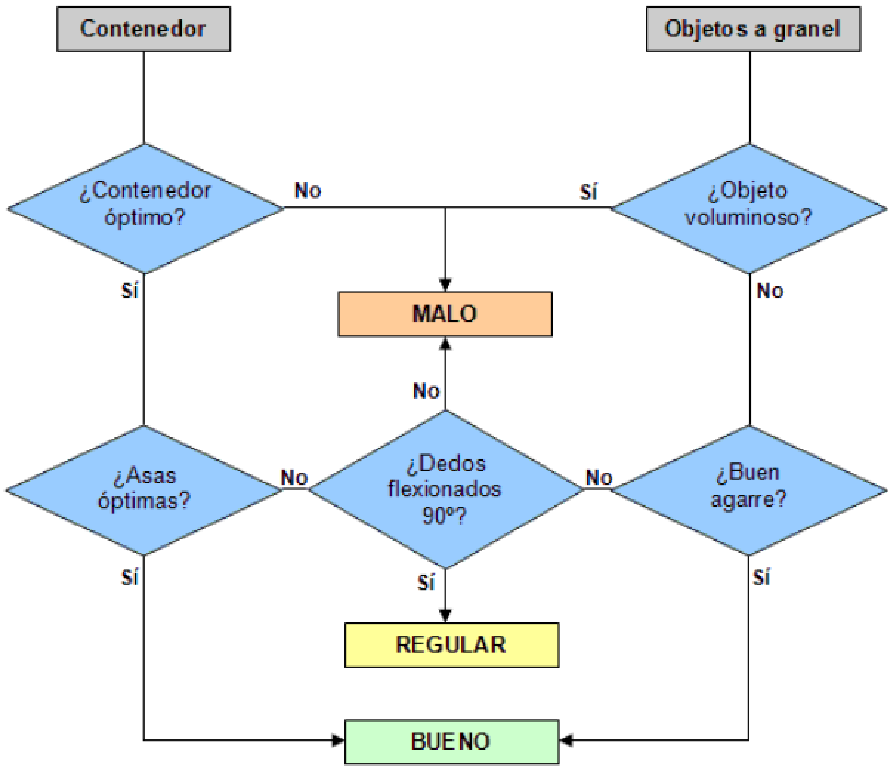
Tabla 4. Multiplicador de asimetría

AM =1 - 0,0032 A	
A (º)	AM
0	1.00
15	0.95
30	0.90
45	0.86
60	0.81
75	0.76
90	0.71
120	0.62
135	0.57
>135	0.00

Tabla 6. Multiplicador de Acoplamiento (CM)

Tipo de Acoplamiento	CM	
	V < 75 cm	V > 75 cm
BUENO	1.00	1.00
REGULAR	0.95	1.00
MALO	0.90	0.90

Figure 2. Decision three to determinate the type of grip



OBTAINED VALUES:

Table 7. Obtained values from the assessment.

LC	Load Constant	22 kg
HM	Horizontal Multiplier	57 cm
VM	Vertical Multiplier	136 cm
DM	Distance Multiplier	14 cm
AM	Asymmetry Multiplier	0 degrees
FM	Frequency Multiplier	8 picks/minute
CM	Multiplier Coupling	Bad

Results

Horizontal distance factor

$$HM = 25/H = 25/57 \mathbf{= 0.4385}$$

Vertical distance factor

$$VM = 1 - 0.003\ (V - 75) = 1 - 0.003\ (136 - 75) = \mathbf{0.817}$$

Vertical displacement factor

$$DM = 0.85 + (4.5/D) = 0.85 + 4.5/14 = \mathbf{1.17 = 1}$$

Asymmetry factor

AM= 1, there is no turns

Grip factor

CM= 0.90

Substituting in equation (1):

$$LCR = (22)\ (0.4385)\ (0.817)\ (1)\ (1)\ (0.18)\ (0.90) = \mathbf{1.334}$$

NIOSH propose a second equation, lifting index:

IL = WEIGHT OF LOAD / LCR

Substituting in equation

$$IL = 22 / 1.334 = \mathbf{20.66}$$

If IL > 3.0 represents a risk

Ergonomic Risk Assessment in the upper extremities

To determine if packing personnel is exposed to develop cumulative disorders we used the JSI method.

We fellow this steps to make the assessment:

- Determinate work cycles and watch the worker during a few cycles

- Determinate tasks to evaluate and determinate watching time
- Watch every task and give a value to each variable as the method propose
- Determinate a value to equation multipliers in accordance to the values of each variable
- Obtain JSI value and determinate risks menace
- Evaluate results to determinate changes that can minimize risks
- Redesign workstations and evaluate with JSI method one more time

Variable values were calculated with the tables of values of JSI method and calculating multipliers and the STRAIN INDEX.

Using table 7 we obtained the Intensity of effort.

Table 7. Intensity of effort

Intensidad del esfuerzo	%MS[2]	EB[1]	Esfuerzo percibido	Valoración
Ligero	<10%	<=2	Escasamente perceptible, esfuerzo relajado	1
Un poco duro	10%-29%	3	Esfuerzo perceptible	2
Duro	30%-49%	4-5	Esfuerzo obvio; sin cambio en la expresión facial	3
Muy duro	50%-79%	6-7	Esfuerzo importante; cambios en la expresión facial	4
Cercano al máximo	>=80%	>7	Uso de los hombros o tronco para generar fuerzas	5

[1] Comparación con la escala de Borg CR-10

[2] Comparación con el porcentaje de la fuerza máxima (Maximal Strength)

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 1. Intensidad del esfuerzo

The Intensity of effort in packing station is hard. The value obtained is 3

To determine the effort duration we used this equation:

% effort duration= 100* all efforts duration/ observation time

We obtained a 30%, using the next table we can see the value:

Table 8. Effort Duration Values

% Duración del esfuerzo	Valoración
<10%	1
10%-29%	2
30%-49	3
50%-79%	4
80%-100%	5

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 2. % de duración del esfuerzo

The corresponding value is 3.

To determinate the number of efforts per minute, its necessary determine the frequency, and number of efforts. And using the Table 9 we can obtain the value.

Table 9. Efforts per minute

Esfuerzos por minuto	Valoración
<4	1
4-8	2
9-14	3
15-19	4
>=20	5

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 3. Esfuerzos por minuto

To determinate the anatomic position of the hand voila Table 10.

Table 10. Anatomic position of hand

Postura muñeca	Extensión	Flexión	Desviación	Postura percibida	Valoración
Muy buena	0°-10°	0°-5°	0°-10°	Perfectamente neutral	1
Buena	11°-25°	6°-15°	11°-15°	Cercana a la neutral	2
Regular	26°-40°	16°-30°	16°-20°	No neutral	3
Mala	41°-55°	31°-50°	21°-25°	Desviación importante	4
Muy mala	>55°	>50°	>25°	Desviación extrema	5

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 4. Postura mano-muñeca

In function with work rhythm by us, we chose the value of table 11.

Table 11. Qualitative Velocity Estimation of worker performance

Ritmo de trabajo	Comparación con MTM-1[1]	Velocidad percibida	Valoración
Muy lento	<=80%	Ritmo extremadamente relajado	1
Lento	81%-90%	Ritmo lento	2
Regular	91%-100%	Velocidad de movimientos normal	3
Rápido	101%-115%	Ritmo impetuoso pero sostenible	4
Muy rápido	>115%	Ritmo impetuoso y prácticamente insostenible	5

[1] Ritmo observado dividido por el ritmo predicho por MTM-1 y expresado como porcentaje

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 5. Velocidad de trabajo

The multipliers values were obtained using table 12. Results of packing station showed here:

Effort (IE) = 2 during Effort (DE) = 1.5

Efforts per minute (EM) = 1 Hand work posture (HWP) = 2

Speed of worker (SW) = 1.5 during per day (DD) =1

Table 12. The multipliers values in JSI method.

Esfuerzos por minuto	
Valoración	EM
1	0,5
2	1
3	1,5
4	2
5	3

% postura mano-muñeca	
Valoración	HWP
1	1
2	1
3	1,5
4	2
5	3

Velocidad de trabajo	
Valoración	SW
1	1
2	1
3	1
4	1,5
5	2

Duración por día	
Valoración	DD
1	0,25
2	0,5
3	0,75
4	1
5	1,5

Fuente: MOORE, J.S. Y GARG, A., 1995, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, 56, pp 443-458.

Tabla 7. Cálculo de los factores multiplicadores

Obtaining Strain Index:

To obtain Strain Index value we replaced values using the next equation:

JSI = IE x DE x EM x HWP x SW x DD

JSI= 9.0

Interpretation of results

Under method JSI judgment, we consider that packing station in the enterprise is probably dangerous. We recommend some corrections in the work station. After redesign the workstation its required to make the assessment to assure the well practices in the facilities of the enterprise.

Conclusions and recommendations for further

Studying ergonomic risks in the workplace area is one of the most important part in the field of ergonomics. It is crucial to the enterprise to have the knowledge needed to develop the ability of auto evaluation and identification of ergonomic risk in our work stations. We consider that evaluating all the work stations is the safer way to identify the exposure of the workers into an ergonomic risk.

Enterprises could have consequences when they are exposed to an ergonomic risk; enterprise should consider ergonomics to improve productivity also quality. It is time to remove all the paradigms that enterprises think about ergonomics; it is not only another barrier to them.

Knowing the exposure of everyone in the workstations it is easier to develop efficiently preventive measures to risks. The knowledge of the cumulative trauma disorders, their causes and the symptoms in humans it is not a preventive measure, it is necessary to recognize every risk evaluating possible disorders in people, using ergonomic methods as we did in our research.

Ergonomic data and information must be shared to everyone, including symptoms and principal causes. That could help to prevent risks by acting before the exposure win the battle against the worker.

Once we finish the evaluation with both methods, we consider some aspects that we saw to enlist many recommendations to the enterprise to consider in future ergonomic evaluations in their facilities.

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CARPAL TUNNEL CAUSED BY COMPUTER USE

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RESUMEN

Hoy en día, muchos trabajos son altamente especializados y requieren el uso repetitivo de las manos. Con el aumento en el número de personas que utilizan computadoras, teclados y ratón, el STC es una o amenaza real para todos. El realizar una tarea, que implica ejecutar movimientos repetitivos con las manos genera desgaste de las mismas; si se diera más atención a este tipo de problemas se pudieran evitar enfermedades como esta y que cada vez se presenta con mayor frecuencia. El objetivo de aplicar el instrumento de estudio como lo es RULA, es evaluar el número de movimientos, el trabajo muscular estático, la fuerza que se aplica y la postura de trabajo, con el fin de detectar las malas posturas de trabajo o factores de riesgo de la actividad que se está ejecutando, para encontrar acciones tendientes a disminuir la posibilidad de desarrollar trastornos por trauma acumulativo. Así mismo se busca conocer los factores de riesgos en los trabajadores y su relación con la morbilidad reportada. El estudio se enfoca a datos obtenidos únicamente por personal que desarrollan sus actividades laborales haciendo uso principalmente de la computadora (actividades clericales). La investigación se basa en los resultados de un estudio descriptivo, en el cual se seleccionan las principales causas que originan el STC y se recolectan los datos necesarios que permitirán cuantificar la incidencia del mismo. Con la aplicación de este método se perciben tres tipos de factores de riesgo: los factores biomecánicos (movimientos repetitivos y/o posturas inadecuadas), los factores ambientales

(iluminación, calor, frio, ruido), organización en el trabajo (5S') y psicosociales (ritmo laboral, sedentarismo, falta de pausas, monotonía, estrés, horas extras de trabajo, etc.). De lo anterior, se encontró que los síntomas más comunes que se pueden presentar y que son fáciles de percibir por el usuario debido a malas posturas, son el dolor de hombro, del brazo, hormigueo y/o adormecimiento en la mano-muñeca y una mala posición que al sentarse ocasiona problemas en la espalda.

ABSTRACT

Today, many jobs are highly specialized and require using the hands in repetitive movements. With the increasing number of people using computers, keyboards and mice, STC is a concern or actual threat to all. Performing a task which involves repetitive movements with your hands can generate lea; paying more attention to this problems could help prevent such diseases and reduce the frequency it occurs. The objective of applying a method such as RULA is to assess the number of movements, static muscle work, the force applied and the working position, in order to identify poor working postures or risk factors, to reduce the possibility of developing accumulative trauma disorders. It also aims to find risk factors on workers and their relationship to the statistics reported. The research is limited to personal whose daily activities only involve the use of the computers (administrative activities). The research builds upon the results of a descriptive study in which you select the main causes or factors of the STC and collect the necessary data that will quantify the impact of it. With this method three different types of risk factors were identified: biomechanical factors (repetitive movements or awkward postures), environmental factors (lighting, heat, cold and noise), work organization (5S ') and psychosocial (employment rate, physical inactivity, lack of breaks, monotony, stress, overtime, etc.). From the

above, it was observed that the most common symptoms that may occur or are easily perceived by the user due to bad postures are shoulder pain, arm tingling or numbness in the hand-wrist and a poor seating position causing back problems.

INTRODUCTION

Some related disorders to human's body motor function have been known for a long time with terms like: "tennis or golfer's elbow ",etc. In the XVII century, Bernardino Ramazzini, performed actions, even in the forefront, that allowed in occupational health the recommendations such as : intertwine breaks in long last jobs, posture shifting and avoid vicious positions, condemned the lack of ventilations, the extreme temperatures, defended that in a dusty environment with the lack of a known extraction systems, workers should give their backs to the air flow and in spacious rooms, at last , evoke the need for the adequate cleanliness for each activity, the advisable clothing and its appropriate care. Ramazzini described the effects that appeared in the workers who made sudden and irregular movements and took on unnatural postures when doing their job, likewise alerted about the possible appearance of these disorders on office employees, believing that these effects were caused by the repeatedly hand movement, by the physical contraction of assuming some forced posture and the excessive mental stress .

Nowadays technology contributes in a substantial and critical way to man's well-being , however breakthroughs almost always go hand-in-hand of new risks and their possible short and medium term consequences. The incidence of labor accidents is directly proportional to the extent of the industrial plant growth settled on each region, execution times that are assigned to the tasks, like risk training, depending of the work area.

OBJETIVE

The objective of applying RULA method is to evaluate the number of movements , the static muscle work, the applied force and posture of work, with the purpose of detecting bad work postures or risk factors of the executed activity and require being closely observed, to decrease the possibility of developing disorders of accumulative trauma.

Is not the objective of this study to expose the working environment in which companies work presently, but to express the lack of knowledge to properly develop office tasks.

METHODOLOGY

Assumes that the RULA method is reliable. This is, the reason why several privet companies use it, VISTEON, JABIL, HONEYWELL can be cited among others, all these established companies in Chihuahua city. Therefore its assumed that is functional and the results that this study provides are useful for future studies. This study refers only to those, health problems associated to the intensive use (repetitive movements) of the computer mouse, with emphasis in those that affect superior extremities and where the task are developed in a sitting position throughout a labor day. As a precedent of the study that was made using the Sue Rodgers method and showed the levels of strong effort due to repetitive movements as a result. However, this is a broad topic since there are also other types of health problems that are brought up by the use of the key board, monitor, a bad sitting positions along other factors that affect professional performance such as stress, excessive working periods, work environment, etc.

Problem Definition

In this last years, several new professional osteomuscular diseases were generated, many of them are caused by the fast-pace of demands of work and combine with stress, fatigue, bad postures y long last repetitions. CTS (Carpal tunnel syndrome) is a disease that is connected to repetitions and mouse use. Numerous articles have been written about this illness that afflict thousands of people in the world, but in many occasions the individual is not aware of the damage that is doing to itself; several titles that talk about CTS were checked and analyzed, the next was found: 40% of the discomfort is caused by repetitive movements, the with a 36.66% are bad postures due to working place and 23% is the stress that the work groups are put under.

The problems of the CTS are characterized by:

- The results of a continuous action and the slow effect, meaning, they are not coincidental injuries, sudden or spontaneous.
- They derive from excessive strength, stretching, extreme postures and highly repetitive movements.

There are multiple analysis tools to solve the problems that can help us study the reason why CTS appears: we can mention some of them: Cause-Effect Diagram or Ishikawa, 5 Whys, QFD (Quality Function Deployment), flowcharts, Paretto Diagram, Review Sheets, etc. Taking the last into consideration we can analyze the CTS problem by Ishikawa's fish diagram. (Figure 1)

This tool will allow us to visualize, in one figure, all causes related to one dysfunction and their possible connection, besides it allows analyzing the concatenation of events.

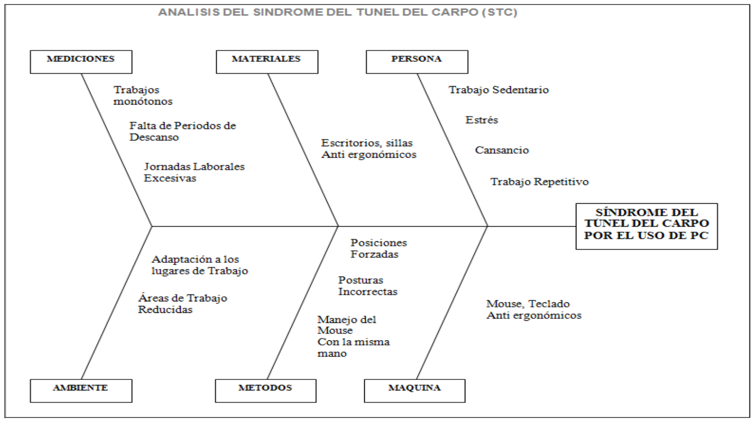

Figure 1. CTS Analysis

As a result of analyzing the CTS with the Ishikawa diagram and the 5 Why's technique, is that one of the main factors that lead to de development or appearance of the disease, is the repetitive continuous work with few or none breaks, the bad postures taken by the user, combine to this, the need of spaces in work areas and also being short of ergonomic equipment.

This analysis fundaments that the continuous use of the mouse might cause a problem due the repetitive movements.

Another tool that can be use as well is the QDF. Is a formal mechanism to assure that the "consumer's voice" is heard and taken into consideration in every stage of the process or service of a product. This time the tool will be analyze to observe the need of the mouse user. (Figure 2) The characteristics of a product to satisfy the needs of consumer are determined through the QDF, that is, the hand's positioning according to the right angle; and at the same time to inform of the correct positions that should be taken when using the device. It was found that the most important demands refer to prevention, information and CTS' symptoms spreading as well another diseases cause by the prolonged mouse use, likewise, is the way the mouse is handle

DEMANDAS	CARACTERÍSTICAS	Cronómetro de uso del mouse	Angulo mano-mesa correcto	Angulo mano-teclado correcto	Posición horizontal común	Distancia del teclado <= 10 cm.	Asociación de enfermedades	Precauciones por uso del mouse	Manual de instrucciones de uso del mouse	Peso solicitado	Tasa de importancia (TI)	Situación actual (SA)	Competidor X	Plan (PL)	Tasa de mejora (TM)	Importancia para ventas (IV)	Peso absoluto	Peso solicitado
		↓	↓	↓	↓	↓	↓	↑	↑									
Modo de uso del mouse	Reducir el tiempo de uso del mouse	9 / 11.9	0	0	0	0	9 / 11.9	3 / 3.96	3 / 3.96	1.32	3	2	2	1	0.50	1	1.50	1.32%
	Reducir la fatiga por uso del mouse	3 / 3.96	9 / 99	9 / 11.9	3 / 3.96	3 / 3.96	0	0	9 / 11.9	11.00	5	3	3	5	1.67	1.5	12.50	11.00%
	Mouse fácil de sostener	0	0	0	3 / 9.51	1 / 3.17	0	0	0	3.17	4	4	4	3	0.75	1.2	3.60	3.17%
Posición de uso del mouse	Posición de la mano correcta	0	9 / 149	9 / 149	3 / 49.5	9 / 149	9 / 149	1 / 16.5	9 / 149	16.51	5	2	2	5	2.50	1.5	18.75	16.51%
	Distancia corta del teclado	0	0	1 / 1.98	0	9 / 17.8	0	0	9 / 17.8	1.98	3	4	4	3	0.75	1	2.25	1.98%
Accesibilidad a la información	Enfermedades por uso del mouse	0	9 / 17.8	9 / 149	0	3 / 5.94	3 / 5.94	9 / 17.8	9 / 17.8	16.51	5	2	2	5	2.50	1.5	18.75	16.51%
	Síntomas asociados por el uso del mouse	0	9 / 17.8	9 / 17.8	3 / 5.94	3 / 5.94	0	9 / 17.8	9 / 17.8	16.51	5	2	2	5	2.50	1.5	18.75	16.51%
	Prevención de síntomas.	0	9 / 17.8	9 / 17.8	0	3 / 5.94	0	9 / 17.8	9 / 17.8	33.01	5	1	1	5	5.00	1.5	37.50	33.01%
	Total	16	301	347	69	191	166	74	236	1399.8							113.60	100%
	%	1.13%	21.51%	24.76%	4.92%	13.67%	11.89%	5.28%	16.84%	100%								

Figure 2. QFD of the CTS for the use of mouse

according to the hand's correct position. We can see that there is also a demand that is concerned in reducing the fatigue given by the use of the mouse.

Justification

In past years there has been an increase in the professional diseases called by physical agents and more specific diseases that are by fatigue, as tendinitis. According to Ministry of Labor and social Affairs' published data, the diseases caused by fatigue (tendinitis) declared in Spain in 2001 were 15575 from total of 18991 professional illnesses, this equals the 82.01%. In 2006 it raised to 22228 out of 26833 professional diseases, this represents 82.83%. The situation Spain seems the reflex of other countries, being coined the term, repetitive stress illnesses or accumulative trauma. Currently in the U.S there are multimillionaire proceedings that are after the recognition of these diseases as the cause of different productive processes, specially the computer. The NIOSH (National Institute of Occupational Safety and Health) and accordingly to the Bureau of Labor Statistics (BLS) "the disorders associated to repetitive traumas" represent around 60% of occupational illnesses. Amid all these disorders, the carpal tunnel syndrome is the most frequently reported. In Mexico, the IMSS classifies the illness according to the injury's nature that is the synovial capsule, synovial and tendon disorders went from 0.8% in 2001 and by 2006 increased to 1%.

Based on the above, evaluations of the work stations, postures and the presence of CTS by computer use can be done besides of being the foundation for this study, the exposed investigation in the article called "CARPAL TUNNEL AND THE LACK OF INFORMATION BY THE USER INTRODUCTIÓN".

According to an article published by IMSS in 2006, points out that administrative workers predispose the development of the carpal tunnel syndrome in relation to the workers that don't perform administrative tasks. With this reference, the statistic information published by IMSS and given data by the department of Security and Hygiene of the plant, there is a platform to start the study of the carpal tunnel caused by computer use in Chihuahua City.

Prolonged Computer Use

A computer can be defined as: means of communication, entertainment and work tool. There is no doubt, by its multiple uses, the computer has become man's right hand and we can say that nowadays we cannot do without it. Despite of the number of articles, books, interviews, etc.; nobody dares to assure that computers might cause problems, either long or short term, not to mention the sedentary condition that has been forming.

This is a broad research topic, because not only can produce musculoskeletal ailment but also visual, headaches, stress problems, etc. All this caused by the prolonged and excessive computer use.

Diseases caused by Accumulative Trauma Disorders

Hand and Wrist

- CTS (Carpal Tunnel Syndrome).- compression in the medium nerve that goes through the Carpal Tunnel.
- Tendinitis.- Inflammation of a tendon
- DeQuervain's disease. - Thumb Tendinitis, generally in the base of the thumb.
- Digital Neuritis. - Inflammation of the finger's nerves caused by repetition or constant pressure.
- Lymph. - Synovitis in the tendons, causing swelling below the skin in back part of the hand.
- Guyon Syndrome. – Ulnar Nerve Compression, that passes through the Guvon Tunnel.
- Synovitis. – Inflammation of the tendon sheath.
- Trigger Finger. – Finger Tendinitis, it is observable that the tendon sheaths break.

Elbow and Shoulder

- Bursitis. –Inflammation of a Bursa. They are small liquid bags in shoulders and elbows which help tendons to slip.
- Epicondylitis. – Elbow Tendinitis, "Tennis Elbow".
- Tendinitis of the Rotator Cuff. - Shoulder Tendinitis.
- Thoracic Outlet Syndrome. – Compression of nerves and blood vessels located between neck and shoulder.

Back and Neck

- Degenerative Disk Disease. - Chronic Degeneration, narrowing and hardening of spine disk, which generally cracks the disk surface.
- Slipped Disk. – Rupture or bulge out of the spine. Sprained ligaments. Tear or stretch of the ligaments.
- Mechanical Low-Back Pain. -Degeneration of the spinal joints.
- Muscular Tension. - Excessive use of a muscle.
- Stressful Position. - Excessive stretching of the neck muscles or related to the soft tissue.
- Neck Stressed Syndrome. - Neck pain, mainly related to static load, or tension in the neck muscle.

RULA

RULA was created in 1993, by Dr. Lynn McAtamney and the professor E. Nigel Corlett, from the University of Nottingham in England. It was design to research in workers exposed to musculoskeletal overcharged, prolonged or awkward postures, repetitive movements and excessive strength, are likely to cause disorders in the upper extremities. RULA is based in the direct observation of the positions taken during the job, by the upper extremities, neck, back and legs. RULA divides the body in two groups: Group A, which includes upper limbs (arms, forearm and wrists). Group B, includes legs, back and neck. Using the charts associated to this method, a score is assigned to each body zone (legs, wrists, arms and back) and depending on each score, a general punctuation is assigned to each Group A and B. The procedure for the application of the method is the following:

A) To determine and observe the worker in some of the “working cycles”.

B) To select the postures to be evaluated.

C) Determine, for each posture, if the right or left side of the body is going to be evaluated. (If any doubt, evaluate both).

D) Determine the score for each body part.

E) Get the final score from the method and The Action Level to determine if there are any risks.

F) Check the scores from the different body parts to determine where is necessarily to apply any corrections.

G) If it is necessarily redesign or introduce changes to improve the posture.

H) If changes are introduced, evaluate with the RULA method again to prove the effectiveness of this changes.

The next charts give the scores for the Group A (Table 1).

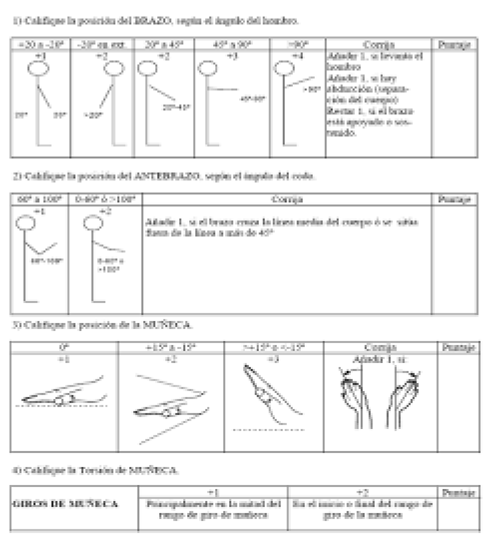

Table 1. Group A: Analysis of Arm, Forearm and Wrist

We use a second chart to observe the relation on an awkward posture and its consequences on Group A.

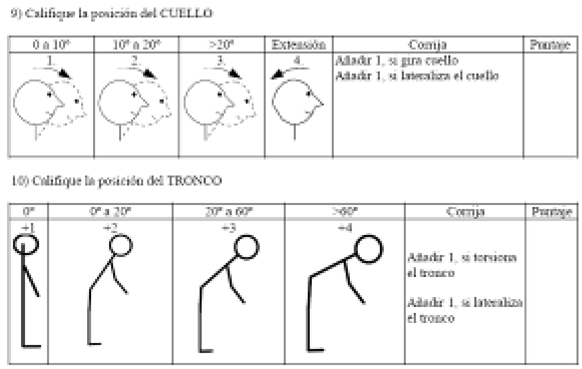

Table 2. Group B: Analysis of Neck, Back and legs

Then, the general scores from Group A and B are modified depending on the function of the muscular realized activity, as well as strength applied during the realization of the job. At last, get the final score from these modified general scores.

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Risk and Action Levels

Action Level 1: score 1 or 2: indicates that the posture is acceptable, not repetitive or stays in the same position for long periods. Action Level 2: score 3 or 4: indicates the need of a more detailed evaluation and the possibility for a change. Action Level 3: score 5 or 6: indicates the need to do a deep study and to correct the posture as soon as possible. Action Level 4: score 7 or above: indicates the need to correct the posture immediately.

Application of RULA Method

As we mentioned before, this method is based on the observation and uses body posture diagrams in which gives a score that show the exposure to the risk factors. It focuses mainly in the task analysis realized with the upper limbs of the body. This method allows the evaluation without any special equipment, due to the fact that is based on the personal observation, is easy and does not interfere in the normal activity of the worker.

The objective of applying this method is to evaluate the number of movements, the static muscular work, the strength applied and the work posture, to detect awkward postures of work or risk factors of the activity that is running and which requires to be well observed, to reduce the possibility to develop disorders caused by accumulative trauma.

This study is developed in the evaluation of the postures taken in jobs, where they use computers. It will evaluate only groups from the administrative area. It will realize a postural analysis from the jobs by the application of the RULA method. This study was applied to 112 people from different offices in Chihuahua.

During the normal activities of different employees, we proceeded to take photographs; the purpose was to identify the different angles on each movement and to realize an analysis.

It is necessary to mention, that all the angles taken may correspond to the same posture. In the below section, we exemplify the following images in the way the study was done in a job using the computer which is done in a wrong way due to an awkward posture.

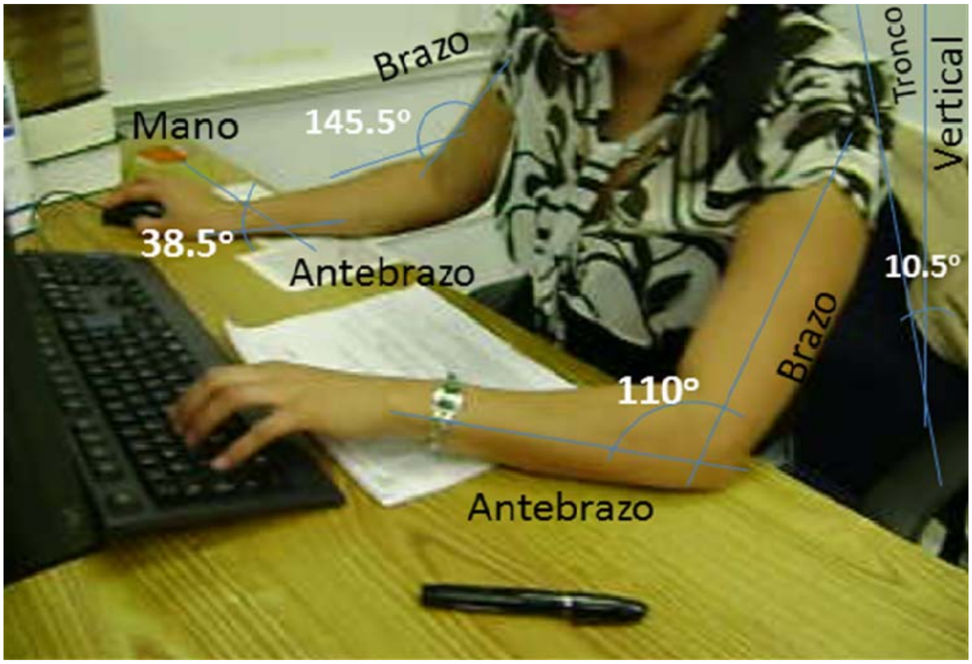


Image 1. Zenith Plane

Image 1. Sagittal Plane

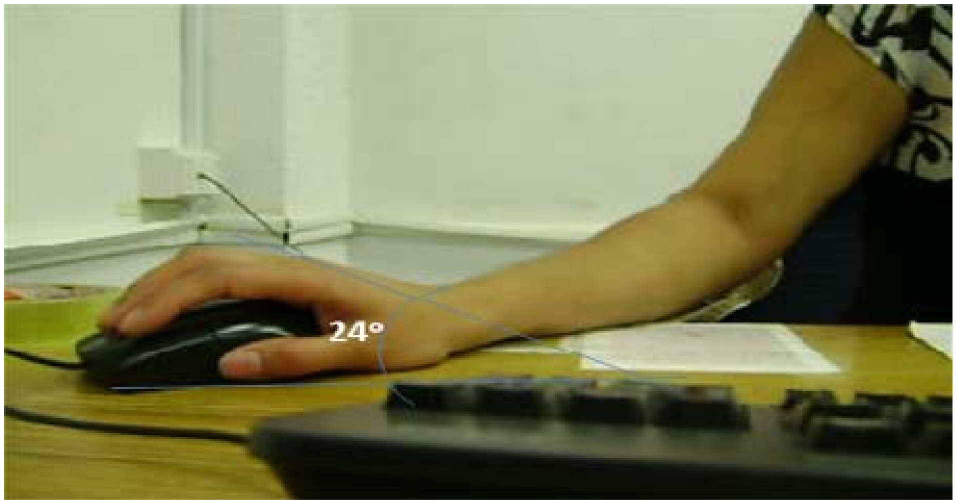


Image 2. Frontal Plane

With the application of this method shows the Biomechanical risk factor, (repetitive movements and/or inadequate postures) besides we can mention other different factors: environmental (lighting, heat, cold, noise) job organization factors (5S´) and psychosocial (employment rate, sedentary, lack of breaks, monotony, stress and overtime) these risk factors with over time can provoke muscular atrophy, or injuries with the time.

Every risk situation may be evaluated and may apply the adequate measures to change postures, avoid the employee adaptation to the job and even to incorporate brakes in the working places.

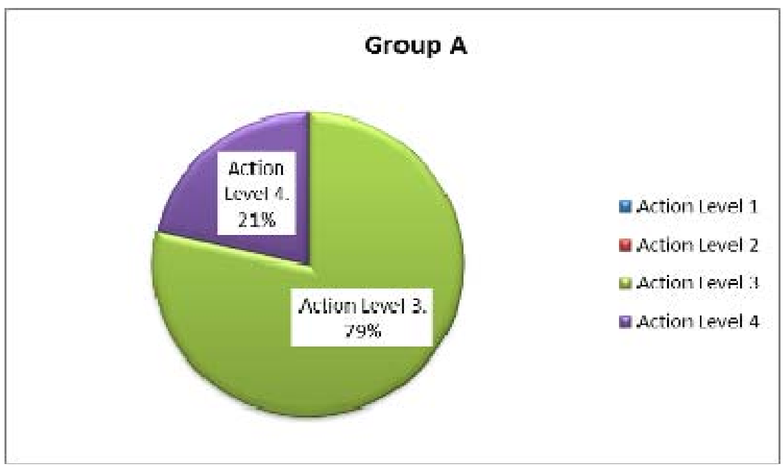
RESULTS FROM RULA METHOD

The RULA method was applied to 112 people from different offices in Chihuahua. Taking into consideration that RULA analyzes the body in two Groups, one for the upper limbs (arm, forearm and wrists) another for neck, back and legs. When applying the correspondent scores to each group we got these results: in Group A 78.57% from the examined people and it shows an Action Level of 2, this means that they have to correct the posture as soon as possible and

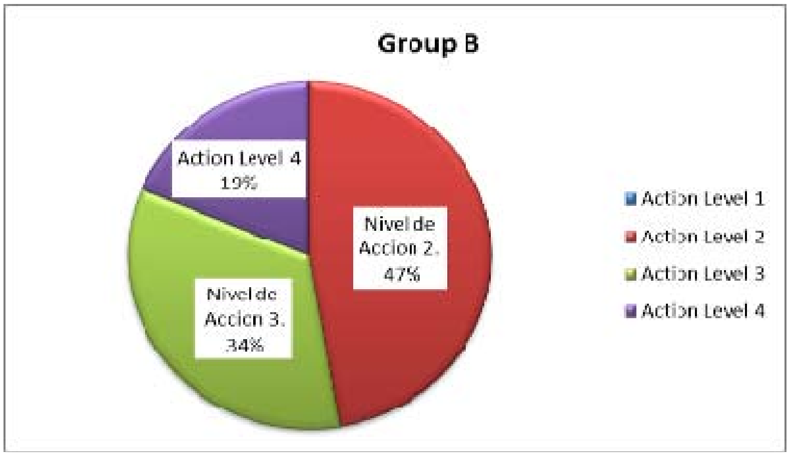
21.43% requires an Action Level of 4, which means that there must be immediate changes in the manner of realizing tasks (Graphic 1); Group B shows 47% with an Action Level of 2, 34% for the Action Level of 3 and 19% for the Action Level of 4: this means, that they require immediate changes (Graphic 2). Analyzing jobs: 45.54% require correctness as soon as possible, and 53.57% indicates the necessity to correct immediately (Graphic 3).

The more common symptoms that can be presented or are easy to perceive by the user due to the wrong postures are pain in shoulders, arms, tingling and/or numbness in hand-wrist and an awkward posture when sitting can cause back problems.

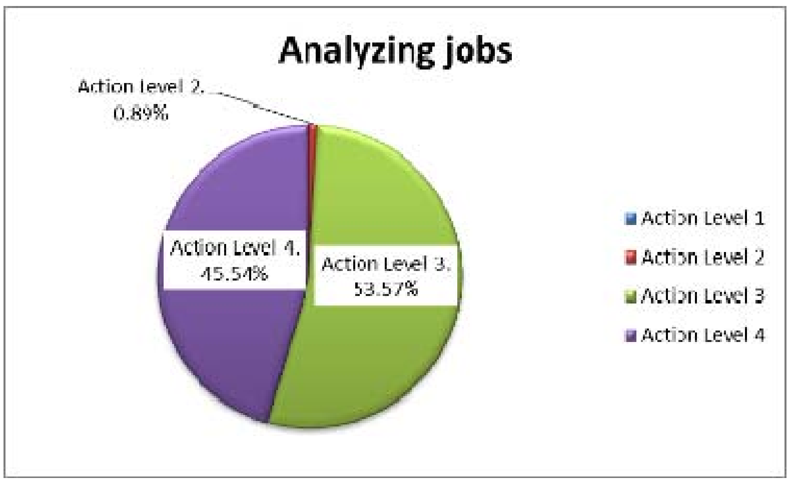
As we have mentioned before, the task with repetitive movements are common in offices.



Graphic 1. Group A



Graphic 2. Group B



Graphic 3. Analyzing jobs

CONCLUSIONS

These types of conditions are caused by the wrong use of the computers, due to the lack of information for the user. In several cases the employee is not only affected in health but also in several occasions there have been disability extensions for several days, this implies extra expenses for the company.

This situation encourage to reflect and rethink, and undoubtedly demonstrates that there must be a national strategy established to promote in the medical units in the three attention levels IMSS (Job Accidents, Commuting Accidents, and Occupational Diseases) give special attention to the different diseases related to work, to offer a diagnosis and an early treatment, to avoid or slow the presence of irreversible complications and squeals, frolicking simultaneously the health promotional measures and the prevention of these conditions at workplaces.

It might be indispensable that the companies take into consideration these types of methods to avoid any occupational hazards due to these repetitive movements.

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ERGONOMIC ANALYSIS IN THE AREA OF PHYSICAL THERAPY

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Resumen: Este documento presenta el estudio ergonómico del área de terapia física que se encuentra en un hospital de Ciudad Juárez. Esta investigación analiza el área de trabajo y los trabajadores en la aplicación de la terapia de masajes. El formato del mapa del cuerpo de Marley y Kumar (1996) fue realizado por 7 trabajadores para evaluar los niveles de dolor o malestar y el método REBA (Hignett y Mc Atamney 2000) se utilizó para la evaluación ergonómica. Se identificaron problemas en espalda media, espalda baja, tobillos, hombros y dolor en los brazos. Según los resultados de la evaluación con REBA se observa que en esta tarea hay un nivel de riesgo medio por lo que se presentan recomendaciones para cambios en los componentes del equipo. También se encuentro que estos modelos ayudarían a identificar y evaluar los aspectos ergonómicos relacionados con terapia física y son recomendables para salvaguardar la salud de los trabajadores y para proporcionar los mejores servicios a los pacientes.

Palabras Clave: Fisioterapia, Área de Trabajo, Masaje, Incomodidad, evaluación.

Abstract: This paper presents the ergonomic study of the area of Physical therapy that is located at a hospital in Ciudad Juarez. This investigation analyzed the work area and workers in the task of the massage therapy implementation. The Marley and Kumar (1996) Body Map format among 7 workers was conducted for pain in discomfort study and Hignett and Mc Atamney (2000) REBA method was used for ergonomic evaluation. Middle back, low back, ankles, shoulders and arm pain were identified. The evaluation results indicated that in this task there is a medium risk level according to REBA. Recommendations for changes in the equipment components are presented. It is also found that models that would help identify and evaluate ergonomic aspects related to Physical therapy are recommendable to safeguard the health of the workers and to provide the best services to the patients.

Keywords: Physiotherapy, Work Area, Massage, Discomfort, Evaluation.

INTRODUCTION

This project considered the area of work and workers engaged the physiotherapies patients in a hospital located in Ciudad Juárez, Chihuahua. This study focused on a proposal for the improvement of the working area and the tasks that develop physiotherapists in search of greater efficiency, comfort and security**.**

Problem Description

This study took into consideration the massage therapy and its working area. This consideration was a consequence of the application of the Marley and Kumar (1996) Body Format among 7 physiatrists; the massage therapy had resulted as the more stressful activity for the physical therapists.

In addition, complains and discomfort's levels of the different therapist's body parts are shown in Figure 1.

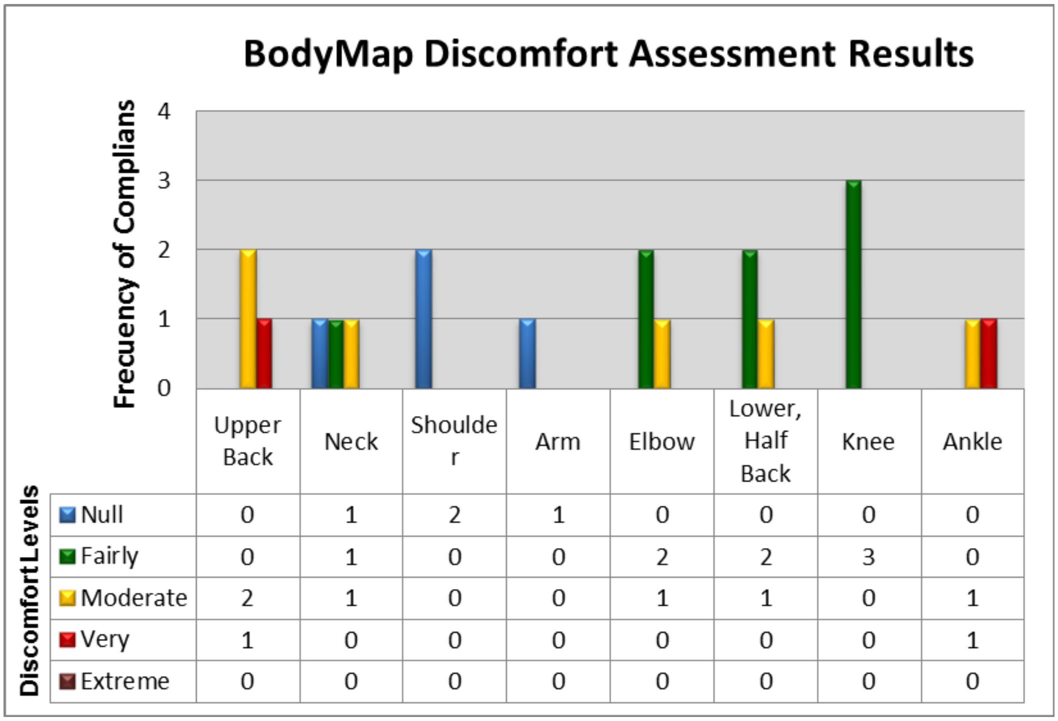

Figure 1. BodyMap Discomfort Assessment Results

As it is noted, the indicator of discomfort level classified as “Very” is found only on the upper back and ankles; also evidence of the discomfort level “Moderate” is mostly found on the upper back, neck, elbow, lower and half back, and ankles. Likewise the manifestation of the discomfort level named as “Fairly” was generally originated on the elbows, knees, and lower and half back.

Consequently, the presence of theses complains of pain among the physical therapists is evidenced when the therapists applied the massage therapy. Moreover, stressful body postures and repetitive movements of hands and arms were identified. Therefore, an ergonomic assessment in this situation is proposed.

Objectives

This project presents an overall objective and five individuals, which are explained below.

General Objective

Apply ergonomic and anthropometric principles to the design of the work area and the postural evaluation of the worker, in this case the physical therapist.

Specific Objectives

1. Establish the area and the different tasks to study.
2. Use methodologies accepted in the literature to assess the positions of the worker.
3. Assess the degree of discomfort experienced in performing the tasks by means of the questionnaire of Marley and Kumar (1996).
4. Propose improvements and/or changes in the design of the working area and working methods.
5. Propose changes or redesigns of the devices and tools.

Justification and Scope

The potential benefits to get with this project are:

- A greater efficiency in the working area by promoting a better manipulation of instruments, facilities and techniques.
- The prevention of injuries among physiotherapists by improving the positions taken during their work.
- Provide a better service to patients.
- Learn different risks which the physiotherapists are exposed.
- Optimizing and saving space where these tasks are performed.

The results obtained by this project can be applied to the area of physiotherapy, to analyzed tasks and the problems identified.

LITERATURE REVIEW

To address the problem, theoretical evidence for ergonomic problems are presented, where various studies indicate that cervicalgias, backche, low back pain and muscle aches are common within this group and have been associated to stressful postures, manual handling of heavy loads, inclinations in carrying out tasks and poor facilities (Briseño, 2005). Some conclusions from these studies are shown.

Bork and collaborators (Bork, 1996) have found that most common musculoskeletal disorders among physiotherapists are found in back, wrists and hands. The factor that causes most likely occupational hazard of these ailments is lifting and/or the transfer of patients. This study found that injuries more frequent and in order of importance were: low back and neck, Middle back, shoulders, hands, knees, feet, hips and elbows.

On the other hand, Hildebrandt (Hildebrandt, 1997) found that the position, strength and movement are the risk factors for the appearance of musculoskeletal pain in the lower part of the back in these same workers.

In addition, Viikari and partners (Viikari, 1996) have statistically demonstrated a correlation between the strength and the posture with back pain. This study was conducted with practitioners of physical therapy which in a working day they care an average of 3 patients per hour, and where their activity forced them to perform repetitive motions and sometimes carrying weight. Likewise, some rehabilitation techniques that are applied to patients require that the physical therapist bends over repeatedly doing large loads of weight. Kumar (Kumar, 2001), States that these activities, postures, movements and repetitions are biomechanical risk factors causing damage to the tissues, resulting in recurring pain that eventually results in musculoskeletal injuries.

According to the use of these studies and history, this project will expand the information with the application of ergonomic principles, methodologies of evaluation and the application of questionnaires to physiotherapists to identify and study the problems that they suffer during their work.

METHODOLOGY

Methods and materials used in this study are presented in this section; first a description of the materials used and then the applied methodology.

A digital camera was used to take video and pictures of the physiotherapist as he performed the massage therapy with the purpose of identify possible stressful positions. On the other hand, a measurement tape was used to measure the physiotherapist’s dimensions and finally a laptop computer to run the REBA’s software.

Definition of the Relevant Human Body Dimensions

The measurement tape was used for the measure of the different dimensions of the therapists towards determine and analyze those human body dimensions which are relevant, define the best anthropometric principles, and the percentiles suitable for our study.

Registration on Videotape and Photographs of the Physiotherapist’s Activities

A digital camera was used to observe and record the massage therapy given by the physiotherapist to a patient. These video and photographs both were taken in the angle that is require by the REBA's software in order to make an objective study; also the video helped to evaluate the different positions that the physiotherapist adopts and the duration of them while the therapy is in progress.

Description of the Task

Work task consist in the application of the massage through the hands of the physical therapist to the patient. This is done with the patient lying on a table especially designed for this task. On the other hand, the massage cannot last more than 10 minutes otherwise it reduces its effectiveness.

The physical therapist moves around the table to perform the massage in different parts of the patient's body by applying pressure, tension, motion, or vibration.

There are different types of massages that the therapists can execute. Some applied massages are:

- Medical massage: Combination of manual technical movements and maneuvers that are made in a harmonious and methodical way with therapeutic purposes; this massage is applied with the hands and allows assessing the status of the treated tissues.
- Deep tissue massage: This type of massage focuses on the muscles located below the surface of the top muscles. Deep tissue massage is often recommended for individuals who experience consistent pain, are involved in heavy physical activity (such as athletes), and patients who have sustained physical injury.
- Myofascial release massage: Myofascial release refers to the manual massage technique for stretching the fascia and releasing bonds between fascia, integument, and muscles with the goal of eliminating pain, increasing range of motion and equilibrioception. Myofascial

release usually involves applying shear compression or tension in various directions, or by skin rolling.

Description of the Working Area

The working area is located in gymnasium from the department of physical therapy. It consists of two massage tables.

Application of the REBA Method

Pictures and both sides' results of REBA for the most critical operations in massage therapy are exposed underneath.

Figure 2. Physiotherapist.

Figure 3. Physiotherapist's left side close up.

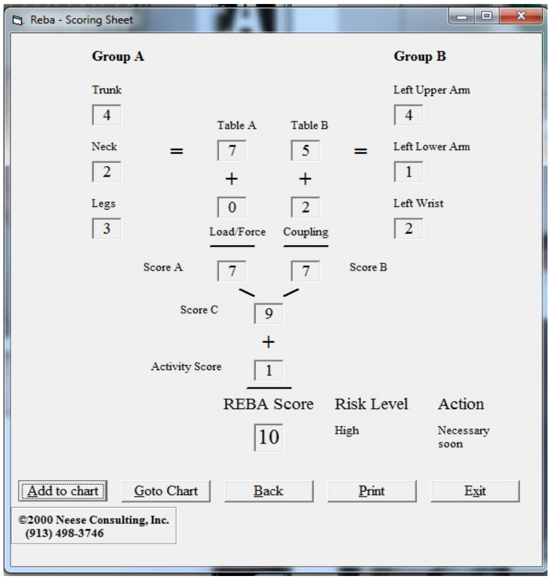

Figure 4. Scores of REBA (left side).

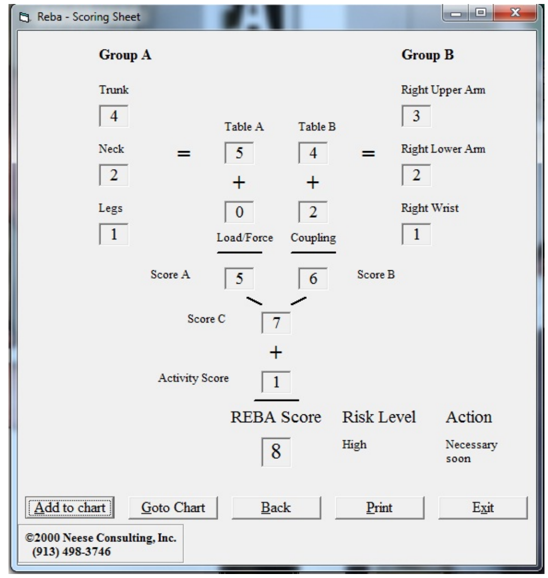

Figure 5. Scores of REBA (right side).

RESULTS

This section presents the results achieved in this assessment.

Anthropometric Results: Relevant Human Body Dimensions, Anthropometric Principles, and Suitable Percentiles

As a result of the analysis of the mentioned activity, the relevant measurements of the massage table for this study are:

1. Height: 67 centimeters
2. Width: 60 centimeters
3. Length: 200 centimeters

According with the table's height measurement, difficulties for tall persons are observed due to the constant bending of the torso that result in back and neck discomfort.

On the other hand, body dimensions, suitable percentiles and anthropometric principles were identified for each relevant dimension of the massage table. The results are presented in the following tables.

1. Height: 67 centimeters

Table 1. Body dimensions, suitable percentiles and anthropometric principles for the table's height.

Body Dimensions	**Anthropometric Principles**	**Percentiles**
Stature	Design for Extreme Individuals. Design for Adjustable Range.	95
Elbow Height	Design for Extreme Individuals. Design for Adjustable Range.	95

1. Width: 60 centimeters

Table 2. Body dimensions, suitable percentiles and anthropometric principles for the table's width.

Body Dimensions	**Anthropometric Principles**	**Percentiles**
Forward Functional Reach with Body Depth at shoulder	Design for Extreme Individuals.	5

REBA Results

The REBA score sheets presented a High risk level for both sides; this means that an ergonomic intervention is required as soon as possible.

According with REBA scoring sheet, the trunk is extremely affected and it has a score of 4 since the physical therapist has to bend repetitively in order to perform the therapy; this produce mechanical stress.

Likewise, the left upper arm has a score of 4 due to the massage table's height and an ergonomic assessment and redesign is necessary.

CONCLUSIONS AND RECOMMENDATIONS

This section concludes about the results obtained, and contrast the goals outlined in this work.

This ergonomic analysis was performed in those body dimensions which are relevant to the execution of the task. Moreover, the application of ergonomic principles was essential to determine if the work areas, machinery or tools were correctly adapted to the worker. In this case, REBA method was effective in the identification of high level risks that the physiotherapists are exposed to.

Recommended ergonomic interventions due to the analysis of the work area, the application of the REBA method, and the definition of the relevant body dimensions, suitable percentiles and anthropometric principles are listed underneath.

1. The acquisition of a new massage table with adjustable height in order to enhance the adaptation to the different stature of the physiotherapists and the prevention of injuries.

2. The Purchase of anti-fatigue mats to surround the table in order to reduce fatigue and stress within therapists.

Furthermore, the effective design and redesign of workstations and the application of ergonomic principles would encourage productivity, but mostly help therapists to be comfortable and secure.

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ERGONOMIC DESIGN OF A SMELTING FURNACE OF METALS

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Resumen:

Los métodos actuales en que se realizan los procesos de fundición carecen de condiciones seguras y ergonómicas. Típicamente los hornos se encuentran a nivel del suelo y el vaciado del material fundido es sumamente peligroso, situación que provoca molestias musculo esqueléticas derivadas de las posturas que deben adoptar los trabajadores. Este artículo presenta el diseño de un horno de fundición considerando principios ergonómicos, que disminuye significativamente los riesgos de seguridad y ergonómicos en los trabajos de fundición.

Palabras clave: Diseño ergonómico, fundición, metales

Abstract:

Current methods of metal casting have not safe and ergonomic conditions. Furnaces are typically at ground level and discharge of molten material is a very dangerous situation that causes musculoskeletal discomfort derived from positions to be taken the workers, also the risk of burns. This article presents the design of a smelting furnace considering ergonomic principles, which significantly reduces security risks and ergonomic in smelting works.

Keywords: ergonomic design, smelting furnace, metals.

INTRODUCTION

Ergonomics aims to guarantee that the environment is appropriate for the activities of the worker, so his goal is to achieve efficiency in any activity carried out to achieve the desired result without wasting resources, without errors and without damage to the worker (Singleton, 1982).

Ergonomics prospective means, look for alternative work design to avoid fatigue and exhaustion in the worker, in order to improve productivity (Rivas, 2007). This comprehensive approach includes prospective ergonomics to equipment design and workplace.

The poor design of a machine causes the user to adopt inappropriate postures, which can increase the risk of accidents and result in cumulative musculoskeletal injuries, for example, back pain, neck and back pain, tendinitis, carpal-tunnel syndrome, among others.

This research proposes an ergonomic design aluminum smelting for commercial use. The proposed design determines how to adapt the material melting process in a safe for the user. Through the previous study of the biometrics, environmental, cognitive and preventive, that is, the design includes the analysis of the risks of operating the melting furnace metal and hand tools in order to avoid fatigue and injury .

METHODOLOGY

Anthropometric and environmental characteristics.

Today, in the blacksmith workshops, there are still metal smelters with unsafe designs. Regularly, is low-rise which creates risks of accidents and operator fatigue and a slow casting process.

In the process of casting cast metal clips are used to carry the pot to where the mold is, this situation increases the risk of burns.

The current design of the furnace does not include the human factor which must be one of the most important components of the machine. Based on the study design was developed, which looks a safe way to empty the material into the mold, it was noted that the current method causes fatigue, risk of injury and the possible serious accident if the worker has direct contact with the material cast. Figure 1 shows this situation.

a b

Figure1. a) Proceso de fundición, b) Proceso de vaciado.

Cognitive and preventive characteristics

Ergonomically designed for smelter considered the following characteristics:

- Optimum height of the machine-operator interface.
- Operator Control Systems.
- Safety considerations.
- Visibility.

- Handling.
- Maintenance.

RESULTS

Furnace Specifications

Preparation for gas inlet and discharge device, which are described below:

- The pot consists of a tube 6"de diameter x 7 "long, cap weld of the same diameter, round rod 3 / 4" and angle of 2 "x ¼".
- The melting furnace is made of insulating refractory bricks and heavy duty for approximately 1982 ° C, was used refractory cement high-alumina and outdoor setting. The bricks are covered by a sheet of ¼" box.
- The basis of the smelting furnace is PTR 1 ½ "X 1 ½", forming a structure where it is possible set the oven and angle of 1 "x1"to fix the motor and centrifugal fan.
- The centrifugal fan consists of an electric motor of 110 hp ¾, a pulley mechanism 5 "and 3 " arrow ½ ", 2 bearings ½" hose and 4 "to drive air to the combustion chamber.
- Preparation for gas inlet includes a Regulator, flexible hose with ½ "diameter, reduced to ½ ¾ bell, bell reduction valve with copper line ¼" tube and 3 / 4 "x 11 ½ "NPT at both ends.
- The emptying device consists of a tube of Schedule 40, rigid 2 "x ¼" and ¾" tuve.

Ergonomic planes

As part of the design process is required to simulate the human ergonomic interaction of the furnace.Figures 3 and 4 show device human interaction.

a b

Figure 3. a) Ergonomic plane prototype; b) Human interaction

a b

Figure 4.a) Two persons Eegnomic chart; b) Human interaction of dispositivo de vaciado.

Furnace operation

The oven can produce temperatures ranging from 482 ° C to 750 ° C, with an ideal temperature for melting of tin (240 ° C), Lead (340 ° C), Zinc (420 ° C), magnesium (650 ° C), and finally aluminum (657 ° C) material that was designed this machine.

CONCLUSION

We developed a smelting furnace of metals that allows the process safely and with less fatigue. The machine can be used by almost anyone, as required by melting metal for a project.

With the ergonomic design of the furnace for smelting, it was possible to demonstrate how anthropometry helps increase individual productivity, reduce fatigue and probability of injury. The movements performed by the worker no longer produce risks, achieving a better quality of life of the person during their workday.

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PROPOSAL FOR AN INTEGRATIVE METHODOLOGY FOR THE ERGONOMIC PROGRAM

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Resumen:

Este documento recoge la experiencia para ambos, la práctica académica y profesional, y hacer frente a las etapas y el nivel de participación de los diferentes elementos de la organización. El trabajo se centra en algún tipo de ciclos concéntricos, el mismo fuera son los que interactúan en un período de un año, los ciclos internos son los que actúa de una intervención diaria o semanal. El éxito del programa que sigue dependiendo de la voluntad de los gerentes, pero cualquier acción dirigida en beneficio de la gente en el trabajo, permitirá a la moral, así como los indicadores de salud y seguridad.

Palabras clave: Programa de Ergonomía, herramientas de evaluación, diseño de trabajo

Abstract

This paper collects the experience for both, academic and professional practice, and deal with the stages and level of involvement from different elements on the organization. The work is focused in some kind of concentric cycles, the very outside are those that interact in a year period, the inner cycles are those that acts in a daily or weekly intervention. The success of the program still depending on the will of the managers but any action directed on benefit of the people at work, enable the moral as well as the indicators for health and safety.

Keywords: Ergonomic program, assessment tools, work design

INTRODUCTION.

Industrial grow in twenty century become on a engine for the world economy, is relatively easy to see how it was, just take a look on automotive or electronics, for instance, and will perceive a big quantity of models, colors, styles, technologies, etc. This growing has not been easy; it has some negative consequences, environmental and occupational health had been affected negatively.

Automotive industry generate a lot on jobs, directly and indirectly way, and from the sixties decade and until present time, and its growing could consider constant, with some crisis periods. According with data from the International Organization of Motor Vehicle Manufacturer (2011) from 1997 to 2010, world production of automobiles has been in more than 50,000,000 cars each year, in 2010 and 2008, production reach more than 70 million cars. The ILO (2000) present a model for jobs created by the automobile industry, using the French Industry as a example, and data are impressive; for 182,000 jobs in manufacturing cars, there are 313,000 jobs related directly with it, manufacturing industry demands 773,000 jobs, that means almost 50% of manufacturing labor is in automobile industry. In world terms, the automobile industry generates (OICA, 2011) in 2010 about 8 million jobs, in México, 137, 000 people worked for automobile industry. INEGI (2010) registered 436,851 manufacturing jobs. The data shows a picture about the magnitude of people working in manufacturing jobs, locally and wide world.

Occupational health has been abundantly studied; risks factors, illnesses, disorders and much more. The benefits of occupational health or occupational ergonomics programs has been probed so many times, just for instance, the detailed of research on the field is shown in Ismail et al (2008), going to the relationship between the work station design and the discomfort of the people. But the point is how the occupational ergonomics program should be design. Chengalur et al

(2004), mention a six sigma approach, it is basically a problem solving methodology, of course it is a very useful tool, but mainly deals with engineering controls and covers efficiently the proactive approach. There is a important amount of societies and organisms, like OSHA, that provide very good guidelines to structuring an ergonomics program, but remain the same, are general guidelines.

Method

Is relevant to point that having an ergonomic program is a good sign and the results of it should be good, that is due to the work in ergonomics. Is important delimitate the use of this method to industrial work design. The layers are all important too and they all interact constantly. The next figure shows the model:

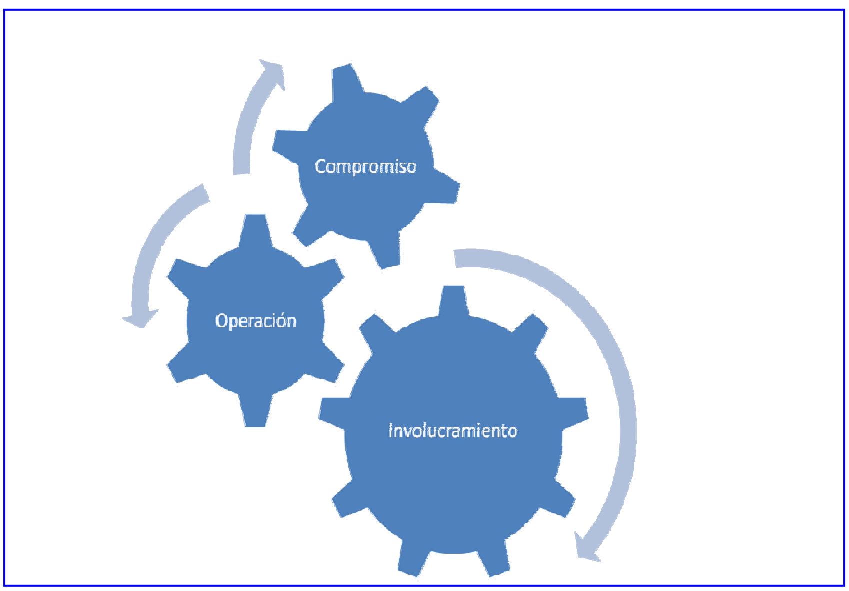

Figure 1. The model

First layer, ¿where is the beginning?

It was mentioned that all the parts or layers interact, but it is required to point on a start, and it should be the commitment of high level managers and it should be translated to a written policy, assigning responsibility program and assigning an annual budget, following by the conforming of a group to design the ergonomic general program or evaluate the current program, tuition by an ergonomic certified consultant, the program has to became on the ergonomic operating system. It is relevant to propose an ergo day as a component on the ergonomics program, which is a highly effective strategy to create or improve the feeling for the ergonomics. The ergo day could be every three or four years and is good to use some allusive promotional items like t shirts or buttons. But, ¿what is an ergo day? Simply, is a specific day when all administrative personnel in the plant works like labor, a complete shift. Say all means; plant manager, areas managers, support people and so on. They will be assigned to a work station; they will receive the correspondent training on manufacturing process, safety and quality. At the end of the ergo day, is recommended write all opinions down focused in perception about how good, or no good, direct work is. Ergo day promotes the eye on the process, opening the chances to get feedback about the ergonomics and detecting potentials issues.

Ergonomics operating system engaged the second layer; it is how the program works like a process. The commitment this time goes to form or support a local ergonomics committee (LEC). The Occupational Health Clinics for Ontario Workers (2011) Ergonomics Committee Workbook is a very useful guide.

As a fundamental element of the Ergonomics Program (EP) it is anthropometrics, this tool is so relevant for ergonomics language, it is the way to really match the ergonomics proposals and achieve the human centered design mentioned in the International Ergonomics Association (IEA) definition. Bustillos et al (2010) shows how anthropometrics can be used to design or redesign workstations.

The second layer includes mapping the risk of occupational injuries or disorders. Mapping is one of the main activities for the LEC. Usually a color code is helpful and the standard is green, yellow, red and black associated with the low, moderate, high and very high risk of occurrence an occupational injury. The question is ¿how to map? There are a wide variety of assessment ergonomics methods, one of the most simply and effective is the Fatigue Muscular Analysis (FMA), better known as Sue Rodgers method, Chengalur et al (2004). It provides a result in a color code form. Complementary analysis could be measurement of energy expenditure, especially when walking conditions is part of the job.

From risk mapping has to pass to an action plan, the final target is only green code workstations. That is, yellow and red code workstations should become green code workstations and black code, needs to get an immediately action to lower the level risk. It is important to establish additional criteria to code workstation, for instance, a medical complain should be a red code until root cause is determined, it implied a complete assessment of workstation. No matter a green code, if a person remains in the same workstation for more than six months doing the same job, it should be code as yellow. The 8 D´s method is a useful tool to contain and prevent the same risk occurrence.

Additional assessment may be required depending on the kind of issue found, if static postures are the problem, it could be evaluated with 3D SSPP™ tool, if exist manual material handling, NIOSH revised equation or Liberty Mutual Tables could be helpful.

The second layer includes standardization. Standards are for:

- Force limits,

- Time on awkward postures, over shoulder or overhead for instance,
- Workloads efficiency and recovery time.
- Weights for tools and materials,
- Heights for tools and materials,
- Periodicity for updating the risk map,
- Excel templates for assessments,
- Medical records related to occupational complains,
- Training and
- Success history.

Standardization may require:

- Some research methods (psycho-physicals)
- Basic measurement equipment (portable force gauge, accelerometers)
- Anthropometric data,
- Anthropometrics criteria to assign people to workstations
- Buy-off procedures for tool weights,
- Buy-off procedures to re-design workstations,
- Buy-off procedures to re-balance and allocate work activities,
- A LEC (with an agenda and coordinator, and established roles for participate),
- A responsible for ergonomics,
- Training program, subjects and refresh periods for LEC participants.
- Record every intervention on ergonomics.

The third layer deals on work level. That is, how the people participate on work and workstation design and how team leaders are encouraged to take care of people. Is so important that every time that a process part is modified, ask to people about the changes, take opinions about the way they feel on new tools, about how they feel at the end of the shift; so tired, painful, stiffness or numbness. A good strategy is teach people to care themselves on ergonomics as usually in safety does.

Promote cross-assessments between work areas people. Promote people to buying processes; tools, mechanical aids, workstation design and work design. Recognize good practices, feed back constantly on good and bad ergonomic practices. Respect point of views from operators and group leaders.

Conclusion

There is, may be, no much new findings on this proposal, but it is an exercise going to put in some order the experience of several years on ergonomics practice and can be trust that it works. While ergonomics remain on job designers mind, we can be sure that people heal is going on right direction.

When people notes that industrial engineering goes to the production line not just to give them more work, instead they are going to ask about ergonomics improvements, people moral rises as well the involvement.

When an ergonomic program works well, managers trust increases, especially when morale people and safety goes up and health costs go down, every year.

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USES AND CHARACTERISTICS OF THE HUMAN MODELING SOFTWARE ManneQuinPRO™V10.2 IN ERGONOMIC STUDIES

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Resumen:

Este documento presenta una investigación sobre las características del software ManneQuinPRO™ V10.2 y su uso en análisis ergonómicos. Pretende facilitar el conocimiento y el empleo de este software de modelación humano. Este software ayuda a realizar análisis básicos durante el diseño, validación y comunicación en cualquier etapa de un proyecto de diseño. Se utilizaron varias fuentes de información, incluidos sitios de internet, manual del software y el sitio oficial del software. Dentro de sus características incluyen varias herramientas biomecánicas como la ecuación revisada de levantamiento NIOSH 1991, bases variadas de datos antropométricos y múltiples cálculos biomecánicos como masas de segmento, volúmenes, ubicaciones de centro de masas, fuerzas conjuntas, momentos y momentos de inercia. Otro propósito de esta investigación es mejorar las actividades educativas y promover el uso de esta herramienta de diseño de proyectos ergonómicos.

Palabras Clave: MannequinPro™, Maniquí, Software, Opción, Espacio de Trabajo.

Abstract:

This paper presents a research about the characteristics of the ManneQuinPRO™ V10.2 software and its use in ergonomic analyses. It pretends to facilitate the knowledge and employment of this human modeling software. This software helps to perform basic analysis during the design, validation, and communication on any stage of a design project. Several information sources were used, including internet sites, the software's manual and the official software site. Within its characteristics includes several biomechanical tools such as the Revised NIOSH 1991 Lifting Equation, varied anthropometric databases and multiple biomechanical calculations including segment masses, volumes, center of mass locations, joint forces, moments and moments of inertia. Other purpose of this research is to enhance educational activities and promote the use of this design tool in ergonomic projects.

Keywords: MannequinPro™, Mannequin, Software, Option, Workspace.

INTRODUCTION

This project presents important characteristics and utilities of the digital human modeling software named MannequinPro™ using its last version 10.2; also, it pretends to give an objective introduction of some functions, components and tools of the software in order to facilitate the knowledge and use for ergonomic analysis.

In addition, this study pretends to introduce this software into educational activities and to encourage the use of MannequinPro™ tools to execute basic analysis on any phase of a design and ergonomic projects among students.

Objectives

The objectives that arise in this work are divided into one general goal and two specific objectives which are presented below:

General Objective

To give an objective introduction of all the important functions, components and tools of the software in order to facilitate the knowledge and its use in an ergonomic analysis.

Specific Objectives

- Introduce this software into educational activities.
- Encourage the use of MannequinPro™ tools to execute basic analysis on any phase of a design and ergonomic projects among students.

Justification and Scope

This research will provide information to researches and students about the characteristics of a Human Modeling software named MannequinPro™ and its advantages to design a work area due to its useful to simulate a certain condition. The scope of this investigation is applied to any kind of investigation which requires Human Modeling.

LITERATURE REVIEW

Computer Aided Design (CAD) became available for aerospace and automotive manufacturers in the early 1960's (Hickey, 1985). The development and implementation of the CAD resulted in the construction of design in less time than usual; also allowed the search of a broader range of design solutions (Porter, 1990).

Main advantages of human modeling are reducing the time of the design process and optimize the human machine interface, automotive and aviation industries recognized its potential and started to use this tool since the late 1960's (Das, 1995).

On the other hand, traditional way to evaluate the design of a workspace has different approaches. First, the utilization of two-dimensional drafts mannequins in order to evaluate the workspace in the early stages of the design. Typically, these mannequins only represent a single view of the human, however more and different types of the human's view are also use in the assessment (Roebuck, 1995). Likewise, with the purpose of guarantee the proper view of most of the humans, and the totally reach of the controls, it is common to represent the 5th and 95th percentile statures in transparent mannequins to overlaid them on the drawings of the work area and evaluate them.

To assess a workspace in later stages of the design, the construction of a model and the use of mannequins based on anthropometric databases it's needed. These models give the researches the opportunity to recreate, simulate or analyze movements like walking, running, jumping or stepping over obstacles (Baritz, 2008), so Human Modeling is a useful tool in ergonomics due to it incorporates human body in the design of a wide range of products, facilities and equipment.

Modern Human Modeling Tools

There are many models proposed to study the human body biomechanical behavior. All those models require elaborated analysis. The most important software description for this investigation is encouraged to MannequinPro™.

Human Modeling Software

Between the most common software for Human Modeling it can be found SafeWork™, Jack™ and Mannequin Pro™ (Elliot, 2002).

SafeWork™

This software has a mannequin with more than 100 anthropometric variables and 148 degrees of freedom. It contains modules for postural analysis, ergonomic analysis, clothing, animation and collision detection and vision.

Jack™

Jack™ is a Human Modeling and simulation software that helps varies industries to improve the ergonomics of product designs and refine workplaces task. It has additional toolkits for workplace task analysis, motion and capture playback.

MannequinPro™

This software is a PC-based, 3 dimensional human factors, and human modeling software. MannequinPro™ has been available since 1990 and its price is around US$1000 (Laws, 1997). This software package helps you perform basic analysis during the different stages of any space design project. Some examples of a design project could be an office, the inside of a vehicle, or any manufacturing floor.

Within its characteristics consist of numerous biomechanical tools that are used to evaluate and authorize human interfaced designs. Several of these tools embrace the Revised NIOSH 1991 Lifting Equation, multiple biomechanical calculations including segment masses, volumes, center of mass locations, joint forces, moments and moments of inertia, and varied anthropometric databases.

In order to generate adult and child mannequins, MannequinPro™ uses multiple anthropometric databases. With this application the manipulation of a mannequin into the precise position that the design needs and includes a broad posture library with pre-defined postures. A mannequin can be created with following characteristics:

- Male or Female
- Adult or child
- From the 2.5, 5, 50, 95, 97.5 percentiles
- Of any size, when manual dimensions are entered

Furthermore, with MannequinPro™ the import of CAD sketches of any kind of spaces with or without mannequins (if necessary, the addition of new mannequins to the design) it is possible. The importation of CAD sketches allows the performances of several tasks to test mannequin's ability to reach an object or point, walking a mannequin along a prearranged path, and the use of a range of viewing angles and alternatives to determine whether or not peoples are compatible with the space. MannequinPro™ with all it features and applications helps to adapt the design space to the wanted population characteristics, counting those who are physically challenged.

MannequinPro™ Case Studies

This human modeling software has been effectively applied to different and extended range of problems. MannequinPro™ benefits Engineers, industrial designers, safety practitioners, and a variety of professionals to assess the human body dynamics in the design process of any facility, equipment or product. Two examples of this software tools are presented below.

Prevention of Occupational Hazards Onboard Fishing Vessel Using Ergonomic Digital Human Modeling

This study presents the methods to improving the occupational health and safety of Spanish fishermen and the redesigning the work area onboard small fishing vessels. By used of ergonomic human modeling MannequinPro™ software, all fishermen's postures were computer-generated and evaluated. Moreover, risk factors on board fishing containers were founded and solutions for redesigning the work area on board in order to prevent occupational hazards in fishing activities were also established.

Ergonomics Wheelchair Design for the Aging People

Among aging people are the diseases at the lower part that make difficult or impossible to walk or run. Therefore, a wheel-chair is needed for those aging people who have some disability in the lower part of their body. This study pretended to improve or redesign the wheel-chair in order to benefit aging people.

With MannequinPro™, product dimension and seating position were considered. An improvement resulted since the force needed to move the recommended wheelchair is smaller than the current design. Another benefit is that gives an enhanced movement control and seating position. Likewise, product dimensions have improved and presented a better fit with the standard anthropometric dimension.

MANNEQUINPRO™ OVERVIEW

This section provides an introduction of the principal characteristics and tasks of the software along with pictures to facilitate its understanding.

Introduction to Main Screen and Menus

Main Screen

This software's main screen was designed with the purpose to be compatible with Microsoft Windows. This means that primary sections, hot keys, menu items, toolbars and project windows stay very similar to other Windows applications and software.

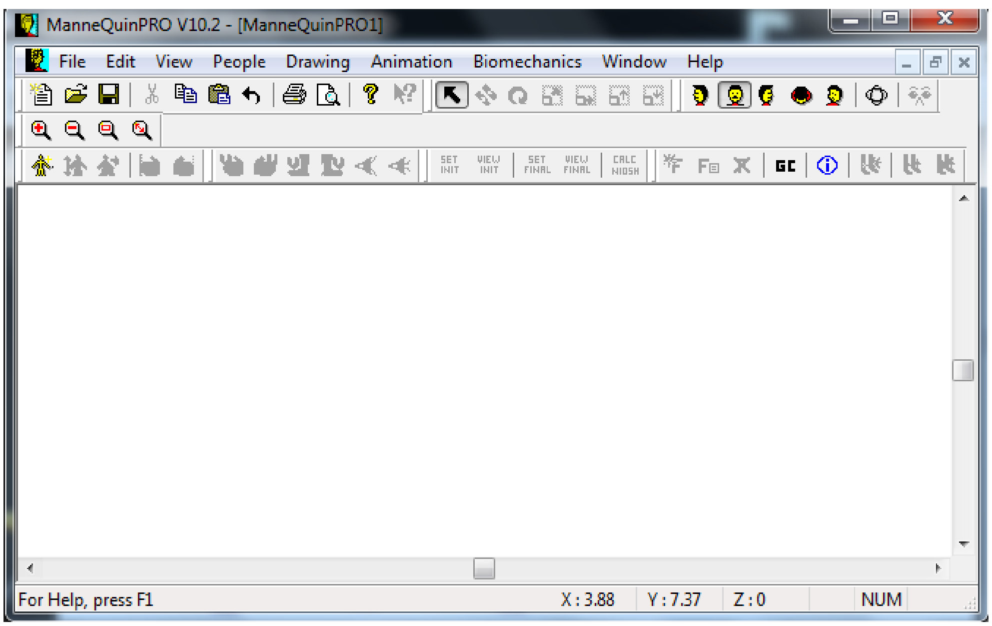

Figure 1. MannequinPro™ Main Screen.

Menu Items

MannequinPro™'s menu items are organized into nine categories and each category has its list of functions and subcategories. The nine categories are: FILE, EDIT, VIEW, PEOPLE, PEOPLE, DRAWING, ANIMATION, BIOMECHANICS, WINDOWS, and HELP.

MannequinPro™ Features and Tasks

This section focuses in the description of the different tasks and features that this human modeling software offers. This description would include the import of 3D CAD drawings, the creation of mannequins, and the performance of different analyses along with other functions.

Importing a CAD Drawing

MannequinPro™ allows importing 2D or 3D models from any CAD program such as AutoCAD. The formats that this software supports are .DXF format (Drawing Exchange Format) and .3DS format (3D Studio). This software is compatible with the early mentioned format in AutoCAD™ versions 11, 12, 13, 14, 2000 and 2002; also the importation of .MQP (MannquinPro™ format) files is possible.

The instructions to import any file are:

1. Go to File menu and select import.
2. Select the file format (.DXF, .3DS or .MQP)
3. Find and select the file from the directory
4. Set the units (inches, feet, millimeters, centimeters, or meters)

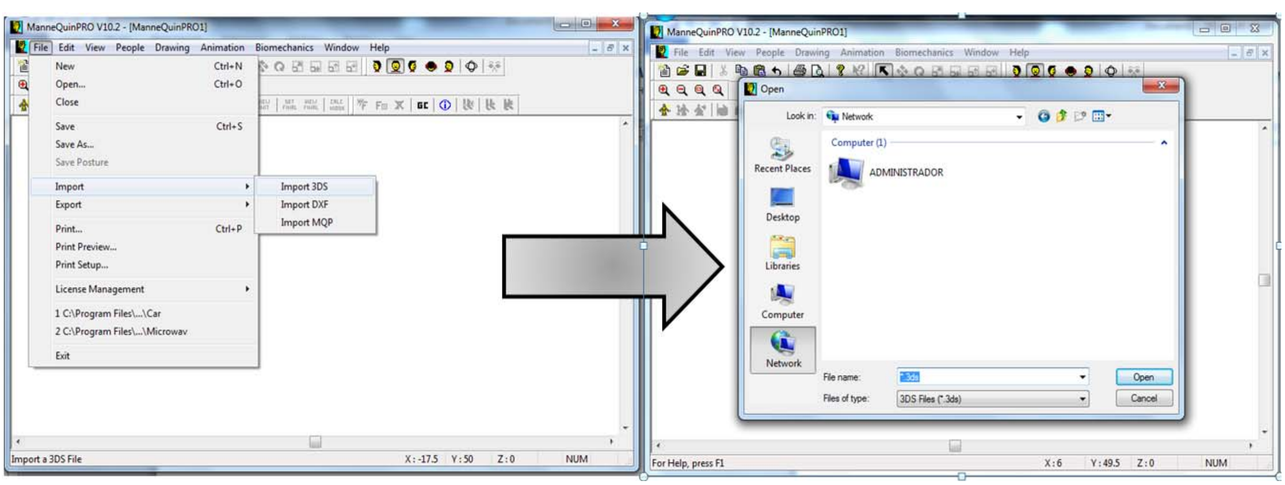

Figure 2. File menu and Open Dialog Box.

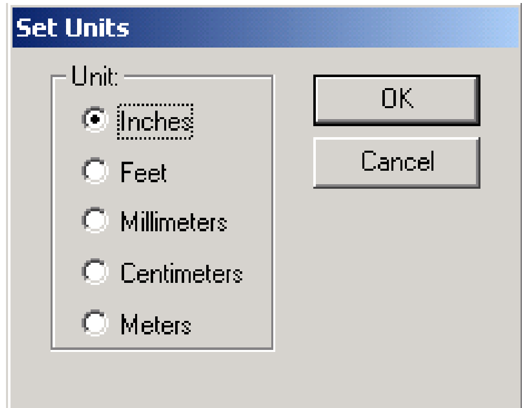

Figure 3. Set Units Dialog Box.

<u>Creating a new mannequin</u>

Once the importation of a drawing into MannequinPro™ has been completed, the next step is creating a new mannequin or mannequins to interact in the workspace. This software allows creating a three-dimensional mannequin with different anthropometric characteristic that were mentioned earlier (section 2.1.1.3).

The steps to create a new mannequin are:

1. Chose People menu and select New Mannequin or click on the New Mannequin icon.
2. The Anthropometric customization dialog box appears. This dialog box gives the options to create the mannequin with the require characteristics for the analysis. These characteristics are described underneath.

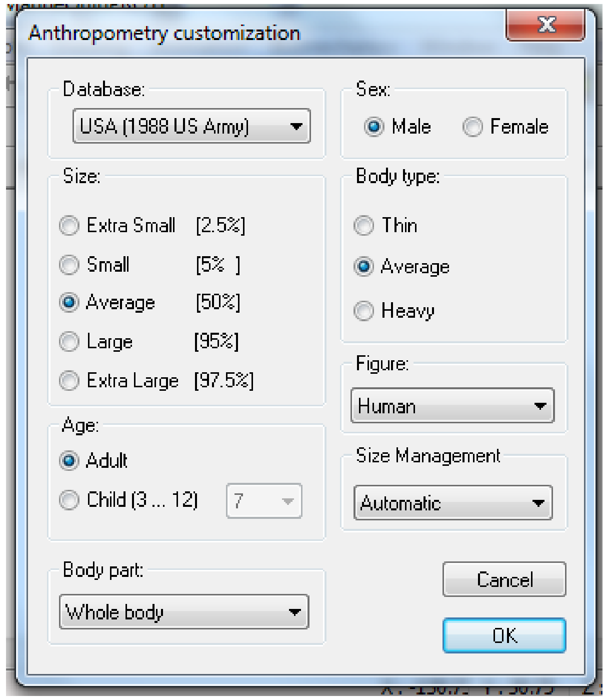

Figure 4. Anthropometric Customization Dialog Box.

- Database: this option is to select the applicable population for the asses. The population databases included in this software are: USA(1988 US Army), Britain, Germany, France, Sweden, Poland, Honk Kong, India, Switzerland, Japan, South China, North Europe, and NASA STD-3000.
- Sex: select Male or Female.
- Size: the statistical percentile for the mannequin that has the appropriate fit for the analysis is in this point.
- Body Type: Thin, Average and Heavy are the options.
- Age: this option indicates the selection of adult or child is made. If the child option is selected, is necessary to choose the child's age from 3 to 12 years.

- Figure: Human, Robot, Stick Figure, Skeleton or Human Form are mannequin models that are available.

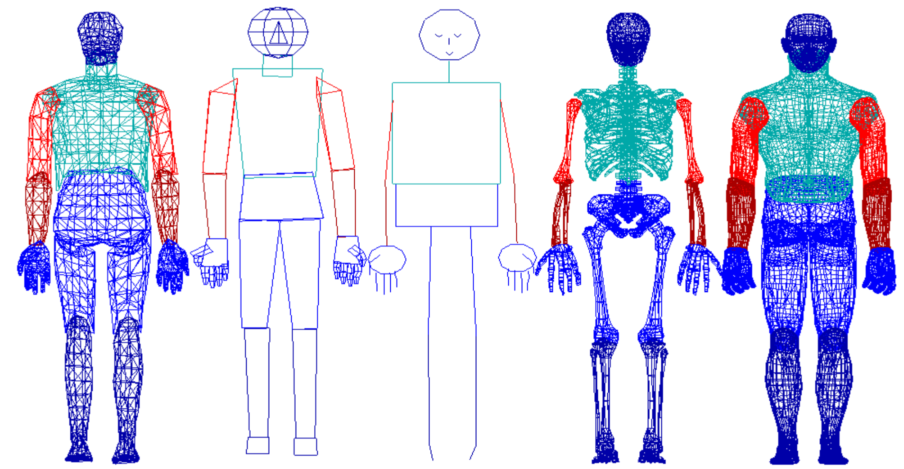

Figure 5. The five Mannequin Models Available

- Size Management: this option allows to create a new mannequin with the specifications that the assess needs.
    - Automatic: creates the mannequin automatically.
    - Semi-Automatic: creates the mannequin based on height and weight.
    - Manual: creates the mannequin with the anthropometric data for each part of the body.

3. When the anthropometric customization has been completed, the next step is to select the body posture that the analysis requires.

Figure 6. Body Postures Dialog Box.

<u>Changing mannequin's posture</u>

MannequinPro™ gives the opportunity to change the mannequin's posture. This is done by going into the People menu and selecting the New Posture option. In addition, the selection of a new hand posture is possible. This option is located below the New Posture option and by click on it; the Hand Postures dialog box appears.

<u>Presenting mannequin's field of view and view through the mannequin's eyes</u>

This software presents the mannequin's field of view and the objects that are covered underneath that field in order to analyze interaction of mannequin in its environment. This option is selected by click on View Cone from People menu.

Figure 7. Hand Postures Dialog Box.

The View Cone option allows choosing from two alternatives. The first is the Optimum View Cone which is shown in magenta rays and the second is the Maximum Viewing Cone that is represented by the green rays.

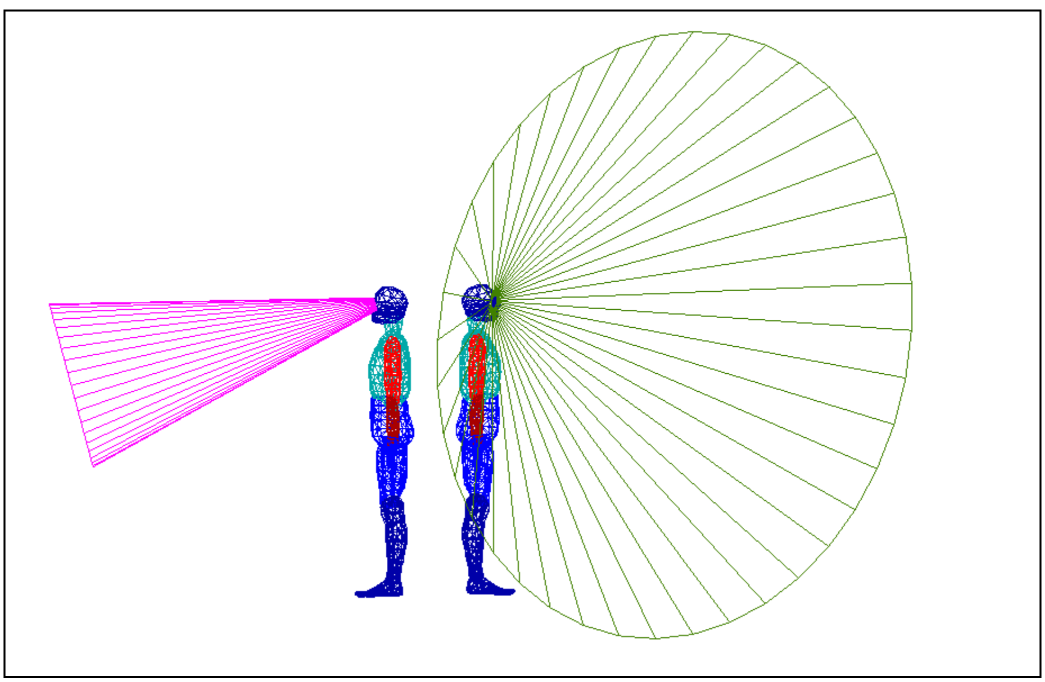

Figure 8. Optimum View Cone and Maximum Viewing Cone Example.

View through mannequin's eyes helps to determine if the mannequin is seeing every object of the workspace that needs to be seen. This option is accessed by choosing Eye View from the Viewpoint submenu under the View menu; also another way to access this option is by clicking on the Eye view icon.

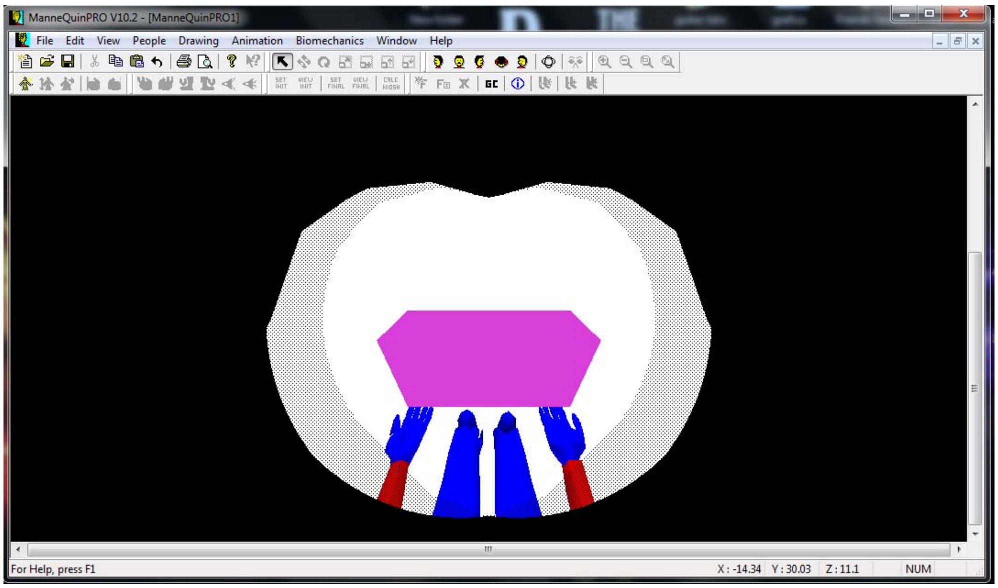

Figure 9. Eye View Example.

<u>Mannequin's reach zones</u>

Other feature of this human modeling software is the option that allows observing the functional reach zone capabilities of the mannequin's hands and feet. This helps to determine whether an object or workspaces is within the mannequin's reach. This command can be access by selecting the Range Volume option from the People menu

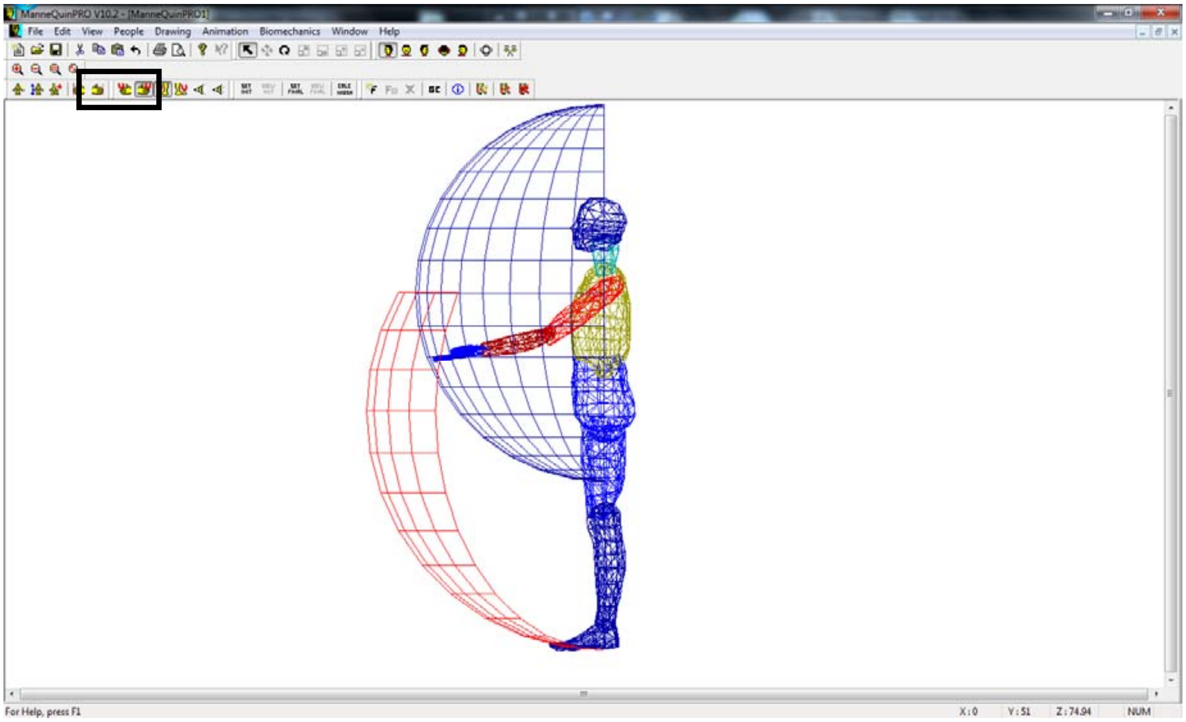

Figure 10. Mannequin's Reach Zones Example.

NIOSH lifting task

This command allows the calculation of the Recommended Weight Limit (RWL) as determined by the NIOSH 1991 lifting equation. Three steps are necessary to perform this task.

1. Adjust the mannequin to the initial posture of the lifting task and click on the Set Initial button.
2. Change the mannequin to the final posture and select the Set Final button.
3. From the Biomechanics menu, select Compute NIOSH and the NIOSH Revised Lifting Equation dialog box appears. It is required to introduce the weight, frequency, duration and the hand to object coupling data and click on recompute. Results will appear instantly.

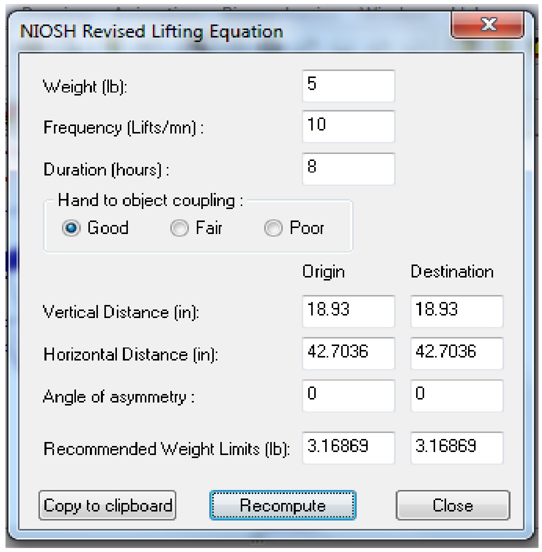

Figure 11. NIOSH Revised Lifting Equation Dialog Box.

Biomechanical summary

Two methods to view the biomechanics are shown in MannequinPro™. One method displays the individual body segment properties by selecting a particular body part, followed by clicking on the Segment Properties Floating Panel located in the toolbar. The other one displays a summary of the rotations, forces and moments of all joints by highlighting the entire body and selecting Summary from the Biomechanics menu.

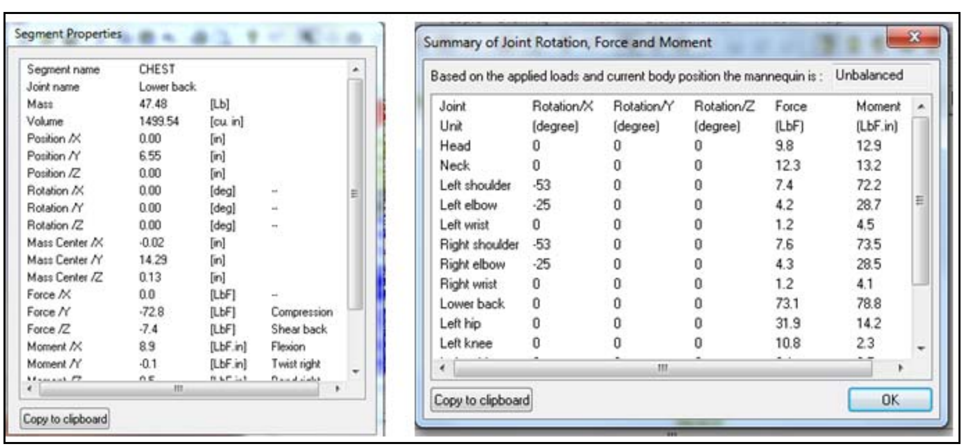

Figure 12. Segment Properties and Summary of Joint Rotation, Force and Movement Dialog Boxes.

External forces

Adding an external force to a mannequin's body part is easy with MannequinPro™. The utilization of the features Add External Force and Edit External Force in order to add, edit or delete any external forces.

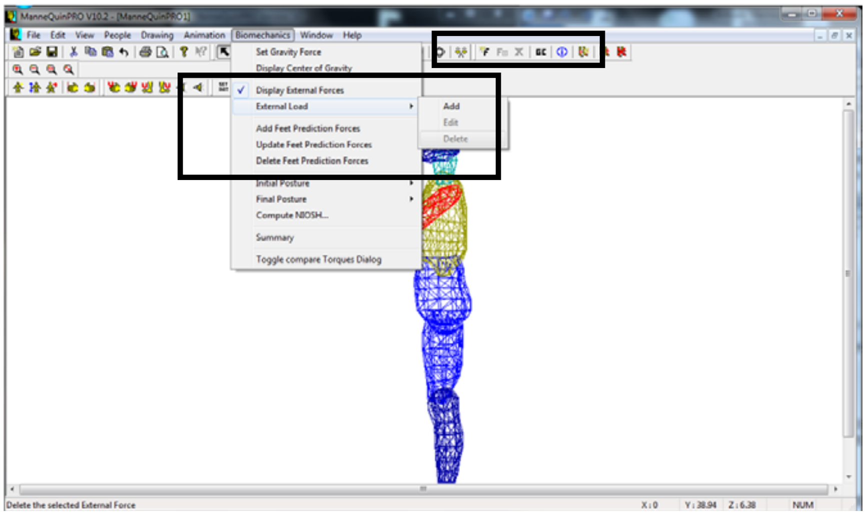

Figure 13. Biomechanics menu, submenus and icons.

DISCUSSION

Some previous studies mentioned that MannequinPro™ software has been one of the most successful human modeling programs because of its ergonomically human figures based in very specific anthropometric databases, functions that are simple to control like reaching, walking, and posing and the simulation of lifting, pushing and pulling by adding forces on any part of the body in any possible direction. Furthermore, other advantages are that mannequin's joints have convincing ranges of motion. Likewise, provides a needed and effective assessment tools for a modest price and offers a good performances ratio with moderate graphics requiring only a single computer to run.

On the other hand, some disadvantages have been also mentioned in relation with the limitations and problems of the software. The limited formats of CAD files that support the difficulty to import files correctly, the correct positioning of the mannequin on the work area and the interpretation of some of the task results are mentioned as the most common problems. Additionally, other software like JACK™ and RAMSIS™ are considered as more efficient and specialized due to their extended number of tools and features.

CONCLUSIONS

This paper showed that the characteristics and tools of the MannequinPro™ software are easy to understand and use in basic ergonomic assess. Also gives an extensive background and introduction of the software that facilitates the knowledge of the software capabilities, so it is concluded that MannequinPro™ is flexible and usable software which have components and tools that are friendly and can be used during any phase of a design process.

This investigation presented some of the modern Human Modeling Tools and its characteristics. Oh the other hand, it was showed two case studies where risk factors were founded thanks to modeling in MannequinPro™, so it is concluded the importance of this software while design or redesign a work area.

Also, it was presented an overview of the software where it was briefly explained some menus, features and tasks to understand the functions. Therefore, students are able to use this Human Modeling software in order to increase their ergonomic evaluation into educational activities and to enhance their projects and papers.

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ERGONOMIC ANALYSIS AND IMPROVEMENTS PROPOSAL IN THE LABOR ENVIRONMENT ON C346 AREA IN A AUTOMOTIVE INDUSTRY ENTERPRISE IN HERMOSILLO SONORA.

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RESUMEN

El propósito de este trabajo es identificar los riesgos ergonómicos se presentan en las estaciones de trabajo C346 área dentro de una empresa del ramo automotriz. Una vez que los posibles riesgos han sido identificados y analizados en el sitio, se presentarán las mejoras para disminuir y contribuir a una mejor adaptación a los seres humanos en su trabajo, que incluyen el cuidado de la salud, reducción de las cargas y perfección de las condiciones de trabajo, entre otras. El propósito de este trabajo es la seguridad en el lugar de trabajo en el momento de llevar a cabo sus actividades. La necesidad de realizar un análisis ergonómico es esencial para definir los elementos representativos en el desarrollo de los trabajos y recoger la mayor información posible las actividades que se llevan a cabo. Con el desarrollo del análisis ergonómico dentro de la empresa está prevista para conocer los principales peligros ergonómicos asociados con estaciones de trabajo e identificar cuáles son los puestos de trabajo que debe ser analizado en detalle, también dar prioridad a los planes de acción para contribuir en las mejoras de una vez se mencionó antes.

Palabras clave: Evaluación Ergonómica, ambiente de trabajo

ABSTRACT

The purpose of this work is to identify ergonomic hazards presented in the workstations on C346 area inside a automotive industry. Once possible risks are identified and analyzed in site, will be presented improvements to decrease them and contribute in a better adaptation to humans in their work, which include the care of health, loads reduction and perfection of the labor conditions, among others. The main purpose of this work is the safety work into the work place, in which is covered at the time when carrying out their activities. The necessity to realize an ergonomic analysis is essential to define those representative elements in the progress of work and collect as much possible information about activities realized. With the development of the ergonomic analysis inside the company is planned to know the main ergonomic hazards associated with workstations and identify which are the jobs that must be analyzed in detail, also prioritize the action plans to contribute in the improvements on once mentioned before. The issues into this document give information about the necessities and workers' requirements to make their operations, which provides basis for analyze the stations and to know the current situations. It describes the used methods along ergonomic assessment, the developed processes and the criteria used to determine the ergonomic hazard level. Finally are presented the results from the research to the activities realized, the risk from each workstation prioritizing, proposing and arguing improvements to the founded troubles.

Keywords: Ergonomic evaluation, work environment

INTRODUCTION

This company with the purpose of carry out with the necessities and market requirements has extended its production areas, by this has been implemented a new area called C346 in which was necessary to made an ergonomic analysis for its new line of production. Is really important to do an ergonomic analysis which allows us to detect the main factors of hazards presented on the workstations before mentioned took as a result ofa lot of injuries and occupational diseases. According to (Oborn de David, 1987) whose propose direct observation, is decided to use this method to detect the principal factors of occupational risk into labor areas. To achieve this objective, ergonomics criteria, occupational safety and health will be followed. With the implementation of ergonomic analysis will be possible to detect the risks to which workers are exposed and look for administrative and engineering options to support a comfortable environment between workers and processes. Each time the processes demand to be more specific and with higher quality, the human factor and security are important to achieve.By that is necessary to make an ergonomic analysis on workstations, in order to contribute to get better labor conditions, know the possible illness, risk that may occur and propose solutions or improvements to such problems. This is a company specialized in design, production and distribution of exhaust system with engineering and production of autogroups. It has placed as a world leader of car’s equipment. Its goal is to create and provide innovate products such as services and techniques solutions that provides quality, competitiveness and value added to constructors. In recent years has increased the importance of implementing an ergonomic analysis into the organizations, using a set of methods that help to know the conditions under workers operate, based on the systematic and specific description of current operations. As in many other companies on this company processes previously registered injuries and occupational diseases caused by wrong positions, erroneous lifts and unfit machinery for the work done, by this is necessary to do an ergonomic analysis because the human factor is crucial in each process and is really important that do the work in an environment that ensures the physical, psychological and social wellness. With that implementation, the company hopes to achieve better optimization in its production and reduce the level of hazards for employees at the time they perform their duties.

General Objective

The objective of this project is to do an ergonomic analysis to know the main risk factors in C346 area to measure the impact these will have on operators and then reduce occupational risks.

Specific Objectives

- Observe each one of the movements, positions and left of operators.
- Detect the ergonomic hazards of each workstation.
- Analyze the ergonomic hazards presented on workstations.
- Detect if exist a kind of relation between ergonomic hazards that have been presented and those that may occur according to the ergonomic hazard analysis.
- Propose administrative and engineering controls to ergonomic hazards and possible occupational illnesses that could be presented.

METHODS AND MATERIALS

The development of the Ergonomic Analysis project was divided in two steps:

1. Evaluation of the workstations by the Ergonomic Analysis.
2. Proposed improvements to the problems presented in the Ergonomic Analysis on C346 area workstations.

The First step was the evaluation on workstations, on the progress of the ergonomic analysis was used a company's software which has the intention of reduce the risk of accidents, help the employees work achieving with this the efficiency and do available stations to most possible number of operators. This software is basically based on produced hazard by repetitive movements, lifts and positions adopted at the time of doing an operation.

Second step are proposed solutions to improve workstations by administrative and engineering techniques. The software is formed by many elements which give a general vision of each workstation and their critical aspects.

RESULTS AND DISCUSSIONS

At the end of the ergonomic analysis development in which was planned identify the ergonomic hazards to which staff are exposed in C346 area, was obtained the results presented next and the proposals to the found problems during the project development: Shown below the results with the purpose of write down the ergonomic hazard level of each workstation.

Puesto de trabajo	Surtidor de corte de Bender Addison C346
Tarea	Cargar Bender Addison

PARTE POSTERIOR Y HOMBROS

a) Esfuerzo

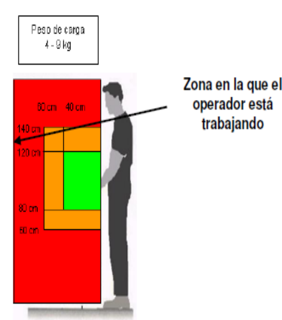
Peso real de la carga	4,40 Kg.
Frecuencia por hora	60 piezas
Nivel de riesgo	BAJO

Load's weight 4,9 Kg.

Working Area

b) Punto de apretón

Peso	4,40 Kg.
Distancia vertical	1.50 m.
Distancia horizontal	1.25 m.
Nivel de riesgo	**ALTO**



c) Postura

Postura	Frecuencia por hora
	120
	0
	0
	120
Nivel de riesgo	ALTO

Comentarios:

En la primera operación al cargar la máquina:

El esfuerzo que realiza con la parte posterior del cuerpo y hombros esta dentro de los límites permitidos, el riesgo radica en la zona en la que se realizan las operaciones la cual está fuera de la zona de manipulación recomendada, en cuanto a la postura adoptada por el operador se encuentra en un alto nivel de riesgo ya que se encoge para recoger la materia prima a 60° y estira su brazo para posicionarla en la máquina.

CUELLO

Based on station found risks is intended to get better the conditions according to the following arguments:

General situation of the station: The Ergonomic Hazard level on the station of Supplier cutting and formed in robotic cells is Medium and Effort level is high based on the guide to the election of manipulation’s helps.

Unsafe condition: at time to place the raw materials the operator has to lift 1.50 m and stretch the arm 1 meter to fits perfect as the incitement of tube holder is 5 cm and doesn’t reach to trapping point.

Current condition: Tube holder is so high and inclination is so little.

Injure risk: Tendinitis shoulder.

Condition required:

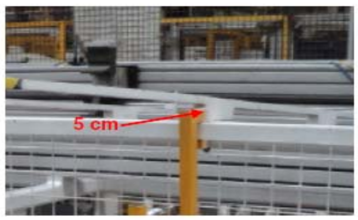
1. Lower machinery 30 cm. to operator works in the grip point safe area.
2. Reduce 60 cm. tube holder avoiding the operator is hit.

3. Rise the tube holder inclination then raw material would slide without requiring the operator stretch to place it.

Base de la máquina cargador de tubos

Porta tubo

Base of the machine
Tube holder



Inclinación del porta tubo

Addison C346 Cutting Supplier with the Requested Chenges

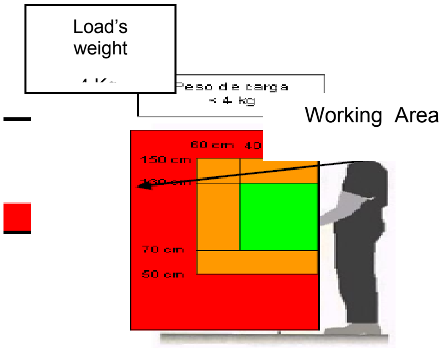
Workstation	**Pipe form & cutting of C346 Bender**
TaskLoad cell robot	

BACK AND SHOULDERS

a) Effort

Real weight of load	0.26 kg.
Frequency by hour	60 pcs.
Risk level	**L O W**

b) Grip	ón
Weight	0.26 Kg.
Vertical distance	1.18 m.
Horizontal distance	1.10 m.
Risk level	**HIGH** G H



Zona en la que el operador está trabajando

c) Postura

Postura	**Frecuencia por hora**
	180
	60
	0
	120
Nivel de riesgo	**ALTO**

Comentarios: En esta actividad de cargar la celda robótica el esfuerzo que realiza el operador es muy poco ya que las piezas son muy pequeñas, el nivel de riesgo radica en el punto de apretón y la postura, por que el operador está trabajando fuera de la zona segura ya que la distancia horizontal es muy grande. La postura que toma el operador es muy forzada y esto implica que la operación se considere de alto riesgo ergonómico.

Level of	**HIGH**

EXTREMIDADES SUPERIORES

Position	Frecuency by
	0
	0
	0
	0
	0
Nivel de riesgo	BAJO

Comments: With upper extremities is not made any repetitive or inappropriate movement by what this activity is without ergonomic hazards.

Based on station found risks is intended to get better the conditions according to the following arguments:

General situation of the station: The Ergonomic Hazard level is medium into activities mentioned before as activities are so simple the risk is mainly at time to place the piece because the horizontal distance is 1.10 meters and the operator at time to put the piece introduces practically the top of his body to the robot cell.

Unsafe condition: To put the piece the operator gets his body into the robot cell, what can cause an accident if the on button is press by mistake and cause an injury on the back by the position in which is working for the robotic cell doesn't have light curtains to prevent this.

Current condition: Horizontal distance between operator and machine is 1.50 m.

Injure risk: Cervical spasm.

Condition required:

1. Install light curtains in the robotic cell to not activate the security guard when operator is putting the piece and occur an accident.
2. Use the tools to place the piece inside the robotic cell, be inserted into the cell and then prevent a hit or an accident by entrapment.
3. Reduce the distance between the guard and machine to avoid the operator to enter the upper body.

Figure 2. Formed & Cut of Pipe C346 Bender with Requested Changes

Workstation	Robotic cell 1 fixture 1 Manifold
TaskLoad robotic cell	

BACK AND SHOULDERS

a) Effort

Real weight of load	1.42 kg.
Frequency by hour	60 pcs.
Risk level	L O W

b) Grip

Weight Kg.	1.42
Vertical distance m.	1.25
Horizontal distance m	63.5 c

Load's weight

Working Area

c)

d) Postura

Position	Frecuency by
	60
	0
	0
	0
Level of	**MEDIUM**

Comments: The level risk is medium based on fundamental positions as inclination the upper part of the body to pick up the piece on standby, this may cause back injuries.

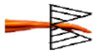
Neck

Position	Frecuency by
	120
	0
	0
	0
Level of	**L O W**

Comments: The operator tilts his head at time to place the piece as time to remove it from the robotic cell.

UPPER EXTREMITIES

EXTREMIDADES SUPERIORES

Position	Frecuency by
	0
	0
	240
	0
	0
Level of	HIGH

Comments: To fits the piece, the operator takes the handle which has to be taken by two hands repeating this movement with each piece by the station is a high ergonomic hazard.

Based on station found risks is intended to get better the conditions according to the following arguments:

General situation: The operations on the station written before show that they are in a medium level risk, with an exception with the pressure that operator performs at time to take the piece and the repetitive movements made by the neck, the effort level is accepted.

Unsafe condition: The operator has to hold the piece at time to place it and do repetitive movements with the left hand.

Current condition: The operator makes constant movements which can damage his arms.

Injure risk: Wrist tendinitis.

Condition required:

1. Place sensors to detect and hold the piece to keep away from such moments in operator.
2. Put light curtains for operator safety as operator or someone can press the on bottom by mistake and cause an accident.
3. At time to do the first activity and not to do constant movements the operator may place the first piece with the right hand and hold it with left hand, at time to place the second piece do it with the left hand and hold it with the right hand.

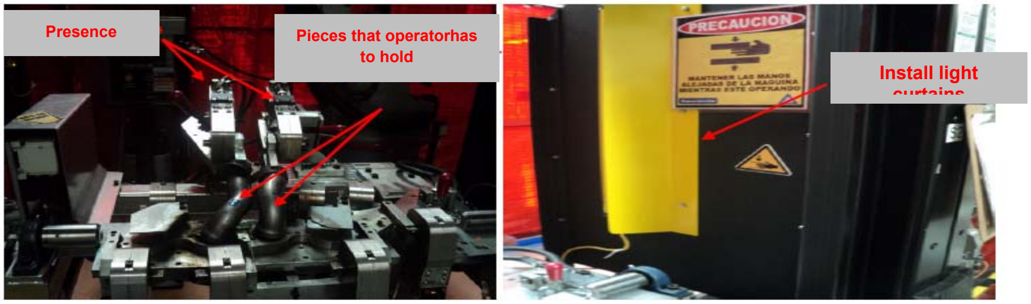


Figure 3. Robotic Cell 1 Fixture 1 Manifold with Changes Required

Workstation	Leak and Inspection Maniverter test
TaskLoad robotic cell	

PARTE POSTERIOR Y HOMBROS

a) Esfuerzo

Peso real de la carga	6, 27Kg.
Frecuencia por hora	60 piezas
Nivel de riesgo	BAJO

BACK AND SHOULDERS

b) Grip

Weight Kg.	6.27
Vertical distance m.	48 c
Horizontal distance m	27 c

Load's weight

4 Kg.

a) Effort

Real weight of load	6.27 kg.
Freq	pcs.
Risk Working Area	O W

c)

c) Postura

Position	Frecuency by
	120
	120
	0
	120
Level of	H I G H

Comments: In this process is made the leak test, at the same time the operator has to inspect 8 points of the piece which are behind it and has to incline to have access at these points because the base where the piece is placed is fixed.

tener acceso a estos puntos de inspeccion, ya que la

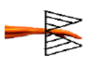
base donde se coloca la pieza es fija.

Neck

Position	Frecuency by
	240
	0
	0
	240
Level of	HIGH

Comments: The movements made with neck are many by the manner to place the piece is inadequate, taken by this a bad position may cause hurt or back and neck injuries.

UPPER EXTREMITIES

Position	Frecuency by
	60
	0
	60
	240
	240
Level of	HIGH

Comments: The operator has movements with his upper extremities which can have repercussions in his health accumulating over time, representing an activity of high ergonomic hazard to the worker.

Based on station found risks is intended to get better the conditions according to the following arguments:

General situation: The leak test station has a really bad design; the operator has to do a big effort to inspect each one of the required points, representing a high ergonomic hazard area.

Unsafe condition: The position taken by the operator can cause big back and hands problems by movements and positions.

Current condition: Bad design of machine.

Injure risk: Low back pain.

Condition required:

The machine can't boost by the weight of the machine (6, 27 kg.) it should be.

• Add 30 degrees of inclination of the machine, by this the piece doesn't be horizontal but tilted and the operator wouldn't have to duck to make the inspection.

• Move the security guard throw the left approximately 1 meter like counterweight to best security of the operator.

• Place a piston to put the piece by horizontal manner and at time to do the inspection when the machine goes up, avoiding with that any unsecure position.

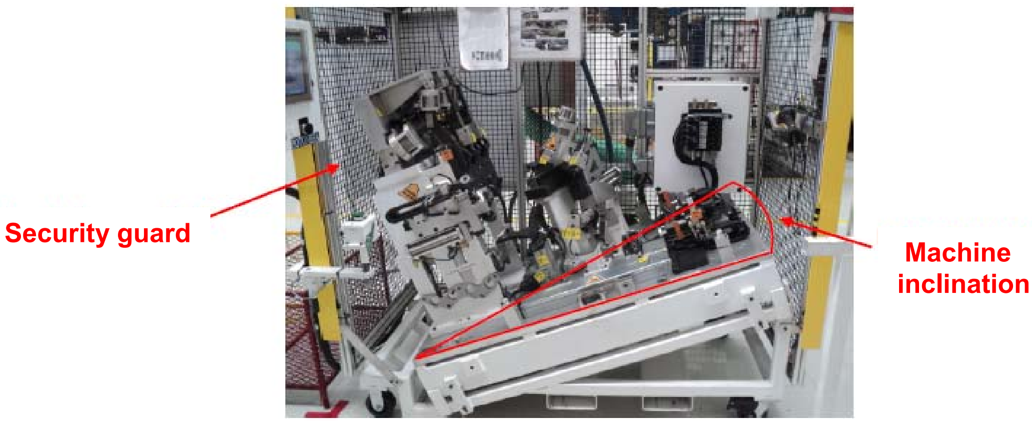
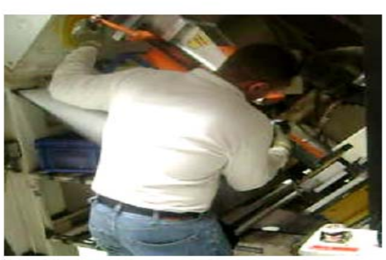


Figure 4. Leak and Maniverter Inspection Test with the Changes Requested

Puesto de trabajo	Soldado de convertidor con cono
Tarea	Cargar la celda robótica



PARTE POSTERIOR Y HOMBROS

a) Esfuerzo

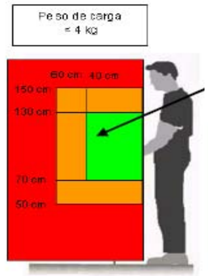
Peso real de la carga	1,36 Kg.
Frecuencia por hora	60 piezas
Nivel de riesgo	BAJO

Load's weight

b) Punto de apretón

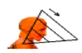
Peso	1,36 Kg.
Distancia vertical	1,15 m.
Distancia horizontal	37.6 cm
Nivel de riesgo	BAJO

L O W



Working Area

CUELLO

Position	Frecuency by
	60
	0
	0
	120
Level of	MEDIUM

Comments: The movements made by neck are medium level of risk by the frequency which is made.

c) Position

c) Postura

Position	Frecuency by
	120
	60
	0
	120
Level of	H I G H

Comments: The position taken by the worker at time to place the piece is so anti-ergonomic and is a high risk inside the workstation as the position taken to place the piece is so forced.

UPPER EXTREMITIES

Position	Frecuency by
	0
	0
	0
	0
	240
Level of	HIGH

Comments: The operator makes repetitive movements with the waist that can cause an injury.

Based on station found risks is intended to get better the conditions according to the following arguments:

General situation: The level of risk in where is the station is high by the position in which the operator has to work which several anti-ergonomic motions resulting therefore as difficult to the operator work here in the station.

Unsafe condition: At time to work on this station the operator has to flex to one side, place the piece with the right hand and with left hand take a handle to secure the piece.

Current condition: The machinery is in an inappropriate position.

Injure risk: Contraction of column, low back.

Condition required: Machinery currently at a height of 1.70 meters with an inclination of 45 degrees, what is necessary to low the machinery at a height of 1.30 meters and placed at 180 degrees so the machinery should be horizontal.

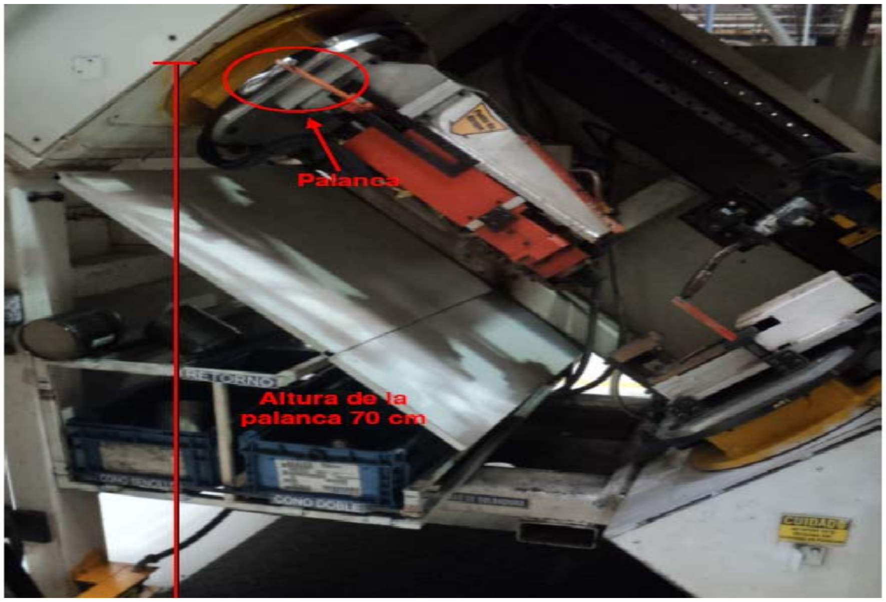


Figure 5. Inverter Welding Cone with Changes Requested

Puesto de trabajo	Inspección final Maniverter
Tarea	Realizar la inspección final

BACK AND SHOULDERS

PARTE PC

a) Esfuerz

Peso real d	
Frecuencia	
Nivel de ries	

a) Effort

Real weight of load	6.87 kg.
Frequency by hour	60 pcs.
Risk level	L O W

b) Punto de apretón

Peso	6,87 Kg.
Distancia vertical	1,20 m.
Distancia horizontal	68.4 cm
Nivel de riesgo	**MEDIO**

Based on station found risks is intended to get better the conditions according to the following arguments:

General situation: The station has a high index of dangers to operator who is doing the final inspection of the piece, considered a high ergonomic hazard station by the tasks performed.

Unsafe condition: The position taken by the worker at time to inspect each one of the points of the piece, the repetitive movements made and the interaction between the operator and the tools used (inspection table, tools, manual to check inspect points) impact directly on worker's labor conditions.

Current condition: The forced position of the worker and repetitive movements during 8 hours at day affects directly to operator, having as consequence muscle aches and labor injuries.

Injure risk: Wrist tendinitis, neck contracture.

Condition required:

1. Put a device to the final inspection table that is adaptable according to each height's operator, avoiding with this the operator takes forced and anti-ergonomic position.
2. Install guides to the table so the piece is fixed and the operator doesn't have to hold the piece whit his hands to make the inspection.
3. Use of tire tools with die controlled to detect the possible burrs on the nut.
4. To not repeat the operation on inspected points, install solid copper into the nut using this device could reduce 360 to 180 wrist turns by piece.

Figure 6. Final Maniverter Inspection with Changes Requested

CONCLUSIONS AND RECOMMENDATIONS

Based on data obtained during the advance of the ergonomic analysis project was found that the stations of C346 area inside the company, represent an ergonomic hazard to workers, the results given by the analysis helped as the beginning to give improvements to found problems, which are expected be useful to the company in obtain more safety on employees.

Is important to say that with the labor environment improvement will be benefited other situations inside the company such as the productivity grows thanks to reduce absenteeism, at the same time increase the quality on work and products.

The method used to develop the ergonomic analysis satisfy all planned expectations as is based on main aspects in which may affect operators giving the risk of each activity, is highly recommended as the same manner where studied the ergonomic hazards and where looked the improvements to founded problems, monitoring the ergonomic hazards in other areas of the company to guarantee the wellness and security of all workers, could be simple solutions and give a lot of benefits to the company.

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ERGONOMIC ACCESSORY FOR EXERCISE "UPRIGHT BARBEL ROW" OF TRAPEZIUS MUSCLE

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RESUMEN:

Para conservar una buena salud física, las personas caminan, corren, pasean en bicicleta o visitan gimnasios; esto ayuda a una buena calidad de vida para nuestro futuro, al mismo tiempo que también trae beneficios estéticos como pérdida de peso y tonificación muscular.

Dentro de un gimnasio de pesas existen diferentes formas de ejercitar cada músculo, sin embargo, lo importante es desarrollar el ejercicio de la manera correcta utilizando los accesorios adecuados con el peso apropiado para evitar lesiones. Muchas de las personas que ejercitan el musculo trapecio, realizan el ejercicio "Remo Vertical al Cuello (Upright Barbel Row)" el cual utiliza como accesorios, tanto La barra z en modo cerrado como la barra recta.

Al ejercitar el músculo trapecio con estos accesorios, las muñecas son sometidas a esfuerzos que provocan incomodidad o dolor, ya que el ejercicio se realiza en una posición no-natural de trabajo. Esto predice un potencial riesgo de lesión para el deportista.

Actualmente el ejercicio Remo Vertical al Cuello no cuenta con un accesorio ergonómico que mantenga las muñecas en una posición natural durante el desarrollo del ejercicio.

En el desarrollo del artículo se describe la opinión de un experto en el tema y se propone un prototipo de accesorio diseñado para este tipo de ejercicio guardando posiciones ergonómicas de trabajo para las muñecas tratando de evitar lesiones.

El articulo lleva a cabo una simulación de pruebas de esfuerzos de tensión con un software especializado en análisis de esfuerzos para determinar materiales, grosores, y características de diseño que necesiten ser tomadas en cuenta simulando un comportamiento real del accesorio en condiciones reales de trabajo. Se realiza el esquema del accesorio en tercera dimensión; se selecciona el material adecuado y comercial; se procede a simular esfuerzos con cargas en los sitios de soporte.

Palabras clave: Diseño ergonómico, Salud Física, Muñeca.

ABSTRACT:

To maintain good physical health, people walk, run, ride bikes or visit gyms, it helps to maintain a good quality life for our future, while also brings cosmetic benefits such as weight loss and muscle toning.

In a gym, there are different ways to exercise each muscle; however, the important thing is to develop the practice of a correct execution using the right accessories with the proper weight to avoid injury. Many people who exercise the trapezius muscle execute the exercise "Vertical Barbel Row" in which they use as fittings, z bar in its open and closed modes as well as the straight bar. In exercising the trapezius muscle with these accessories, wrists are subject to an effort that causes discomfort or pain, since the exercise is performed in an unnatural position. This predicts a potential risk of injury to the athlete.

Currently, the upright row exercise does not have an ergonomic accessory to keep your wrists in a natural position for the exercise.

Into the article it describes an expert opinion on the issue and proposes a prototype accessory designed for this type of exercise keeping an ergonomic working position for your wrists trying to avoid injury.

The paper conducts a simulation of tensile stress testing with a specialized software in stress analysis to determine material thickness, and design features that will help simulating the real behavior of the accessory under real conditions of performance. A three-dimensional scheme of the accessory is performed; the selection of the appropriate material and commercial is done; the procedures of simulating loads on the support spots are made.

Key words: Ergonomic Design, Physics Health, Wrist.

INTRODUCTION

For the development of exercise "Remo Vertical to Neck (Upright Barbel Row)"are used as fittings, z bar in its open and closed modes as well as the straight bar. Through exercising the trapezius muscle with these accessories, wrists are subject to an effort that causes discomfort or pain, since the exercise is performed in a unnatural position. This predicts a potential risk of injury to the athlete.

Tools are as old as the human race itself. The hands and feet could be considered tools given to humans by nature. However, tools as we know them were developed as extensions of the hands and feet to reinforce the range, strength, and effectiveness of these limbs.

There are few stresses which the body is exposed to that even nearly approaches to the extreme stresses of a heavy exercise. In fact, if some of the extreme exercises were continued for even moderately prolonged periods, they might be lethal. Therefore, sports physiology is a discussion of the ultimate limits to which several of the bodily mechanisms can be stressed.

The human hand has 27 bones divided into three groups: 8 *carpal* bones in the wrist, 5 *metacarpal* bones, and 14 *phalanges* of the fingers. The *carpal* bones are arranged in two rows and have names reflecting their shapes (Figure 1). The bones of the distal row, from the lateral side to the medial side, include the *trapezium* (four sided with two parallel sides), *the trapezoid* (four sided), the *capitate* (the central bone), and the *hamate* (hook shaped). These four bones fit together tightly bound by interosseous ligaments to form a relatively immobile unit that articulates with the metacarpals to form the *carpometacarpal* (CMC) joint.

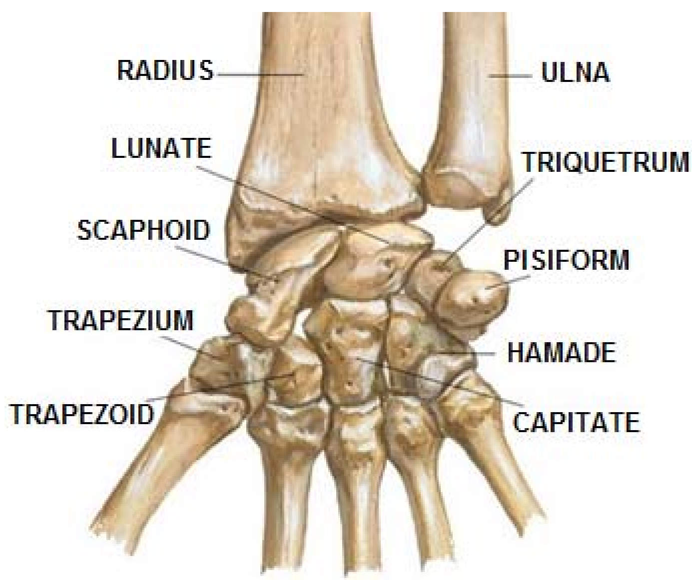

Figure 1. Bones of the wrist.

The bones of the proximal row include the *scaphoid* (boat shaped), the *lunate* (half-moon shaped), *the triquetrum* (triangle shaped), and the *pisiform* (pea shaped). The proximal surfaces of the scaphoid, lunate, and triquetrum form a biconvex elliptical surface, which articulates with the biconcave surface of the distal extremity of the radius. The articulation between the proximal and distal rows is termed the midcarpal joint while articulations between adjacent bones are called intercarpal joints.

The human hand is a complex structure of bones, arteries, nerves, ligaments, and tendons. The fingers are controlled by the extensor carpi and flexor carpi muscles in the forearm.

The neutral position is one in which the hand is in the same level with the forearm. The reference position for measuring the amplitude of movement, occurs when the axis of the hand, embodied by the third metacarpal and third finger, is located in the prolongation of the axis of the forearm. The neutral position of the hand is also called natural position.

The trapezius shown in Figure 2, is one of the most important muscles of the trunk and its contribution to the movement is critical because the link works the arms and the torso, extending to the skull. It is located in the trunk, specifically in the upper back, and gives shape to this area to belong to the outermost layer and superficial muscles, thus lining the posterior neck muscles and the entire upper back that is between the shoulders and head as well as the area between the shoulder blades.

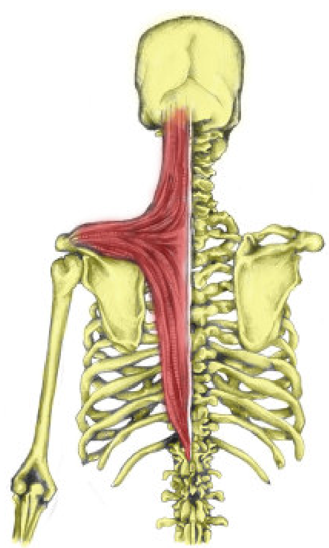

Figure 2. Trapezius muscle.

The trapezius is the muscle that connects the scapula to the spine. It controls all movements that tend to bring the scapula to the spine. By combining their action with the serratus muscle, it gets all the movements of rotation of the scapula, which extends the range of arm movements. Moreover, the trapeze set the shoulder blades with the trunk getting good support for the muscular actions that move the arms compensating the force exerted by large muscles such as the dorsal or pectoral, and is primarily responsible for the shoulders to remain in position and to not give in when they are loaded with weight, this is the reason why the trapeze works quite a bit of when it supports weights with arms, either below or above the head. (F. Molano, 2008).

The purpose of this project is to provide practitioners of the sport of weightlifting an ergonomic accessory that eliminates almost entirely the efforts of an unnatural positions wrist work to develop the Upright Barbel Row exercise.

OBJECTIVES

Contribute to the efficient performance of the exercise "Remo Vertical to neck" used to train the trapezius muscle by an ergonomic accessory proposed to decrease or avoid the risk of further injury due to efforts by anti ergonomic work positions in both wrists and secondary muscles used in the exercise.

Every work tool is designed to be subjected to an effort provided by the nature of work, this tool requires testing of behavior during the application of such efforts to determine the efficiency of its design. These tests can be destructive or nondestructive. Tests on the tools that are subject to tensile stresses, as it’s the case of the proposed attachment, are called stress tests; and by the nature of the stress analysis, these tests tend to be destructive tests. This leads to the forced development of several models with different design features to determine the mix of appropriate materials and dimensions that result in increased efficiency at the lowest cost.

Make this whole process is very expensive and it consumes a lot of time. However, today there is a wide range of software to simulate the destructive tests mentioned in the comfort of your computer and testing at no additional cost.

To develop the fitting model with three-dimensional views, displaying thicknesses and depths, it’s used as fundamental tool the software Solidworks 2010. It is possible to model and display with this software; as well we can analyze the efforts of different types: tensile, compression, bending, etc.. This will help to represent the actual behavior of the fixture and find the best materials and dimensions to be put into production.

METODOLOGY

The completion of this exercise according to the Guide of muscular movements - anatomical description of Delavier F (2004) is shown in Figure 3 and described as follows:

Standing, legs slightly apart, back straight, hold bar with overhand, hands a foot apart (20.873cm) or so.

This exercise requires the traps, especially its upper portion, and deltoids, the angle of the scapula, biceps, forearm muscles, abdominals, buttocks and lumbosacral. Note that larger the separation of the hands, the greater the requiere of deltoid and reduced that work traps.

To model the fixture on Solidworks 2010 is used readily available commercial materials, which are presented below:

- PTR Square Tube 1" Schedule 40 steel 1045 (stainless steel), folded and processed to serve as sliding angle.

• 4 model 607 SKF brand bearings inserted into the angular slider. The design of the bearing inner diameter is 9mm, 24mm exterior diameter and 7mm wide.

• Cuts of stainless steel plate 1045 of ½" thick.

• 1” circular bar of 1045 stainless steel.

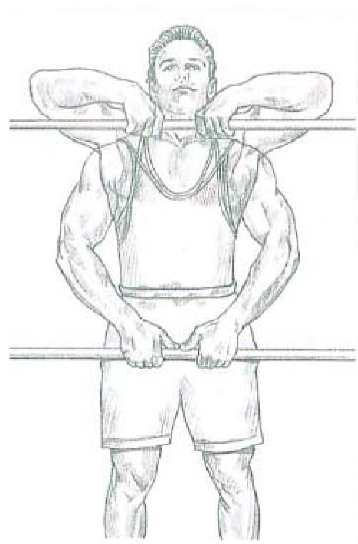

Figure 3. Enforcement of the movement

The project begins by carrying out a simulation of tensile stress tests with Solidworks 2010 software specializes in modeling and stress analysis. For the final design of the fixture, were carried out several sketches with high visual quality designs in marketing issues. However, we should not lose the primary objective which is to model a design accessory easy to prepare, with a high efficiency of labor, increased user safety, light, and above all, as economical as possible. As shown in Figure 4.

Fixture design consists of two sliding half circle that are free to make an angular motion (circular) as the wrists needs during the execution of the exercise "Remo Vertical to neck." These sliding angles are designed to maintain the natural working position of the wrists to prevent future injuries. These slides are attached to their respective carrier via bearings that allows the free semicircular movement that this exercise requires for its development.

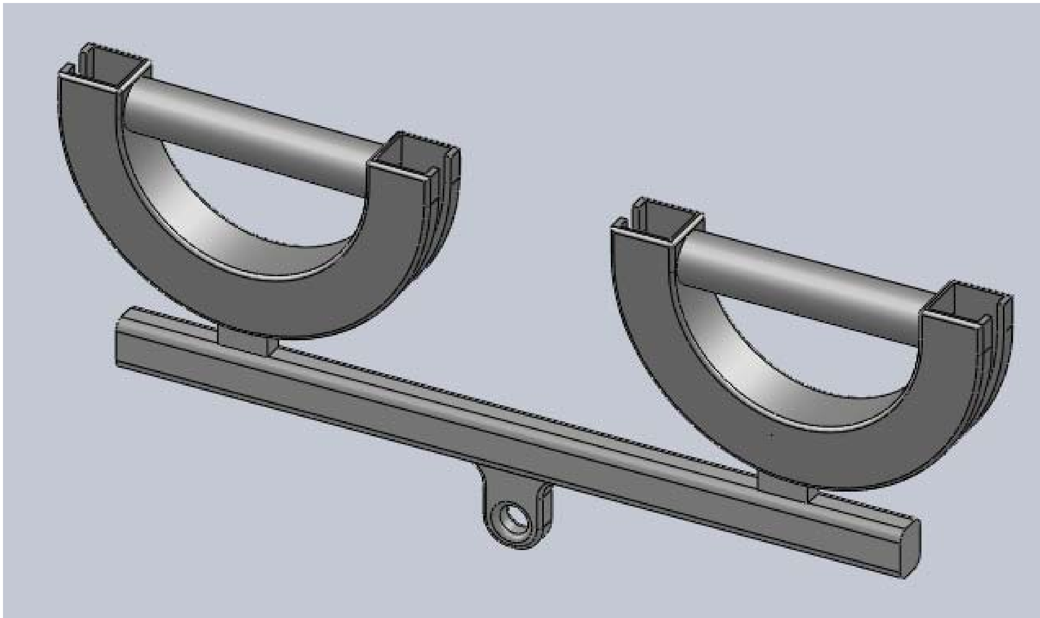

Figure 4. Isometric of the accessory.

The software is used in this project to determine the type of material needed for the development of attachment and the secure specific measures of thickness in the main parts to support the stresses applied.

In the stress test done in the software, a proposed tensile force was applied; this force which the fixture is subjected to, it’s a figure a bit unrealistic for most users. The software also calculated minimum and maximum displacement and the points that have the greatest displacement. Similarly we calculated the safety factor thrown by the designs of different parties. All this by applying 120kg tensile strength.

As a fundamental part of the article, at the end, an interview of an expert is shown. His general view of the topic and particular opinion on the proposed solution it's a point to be considered.

RESULTS

In the simulation of tensile stress by the software Solidworks 2010, satisfactory results were obtained that indicates that the tool is designed with proper materials and measures to perform its function with safety for the user, and the person who recommended.

Table 1. Results of the simulation of efforts.

Fuerza de tensión aplicada (kg)	**Desplazamiento máximo (mm)**	**Factor de Seguridad**	
		Correderas	**Soporte**
120 kg	0.6mm	16.89	2.21

The simulation of forces showed positive results in terms of design resistance. Full accessory was analyzed with forces of 120 kg, where the minimum safety factor is at 2.21. This means that the designed accessory can be subjected to loads of work with little more than twice the applied load (just over 240 kg) before reaching the elastic limit where there occurred a permanent deformation of the support, where greater stresses were obtained. All this is shown in Figures 5, 6, 7 and 8.

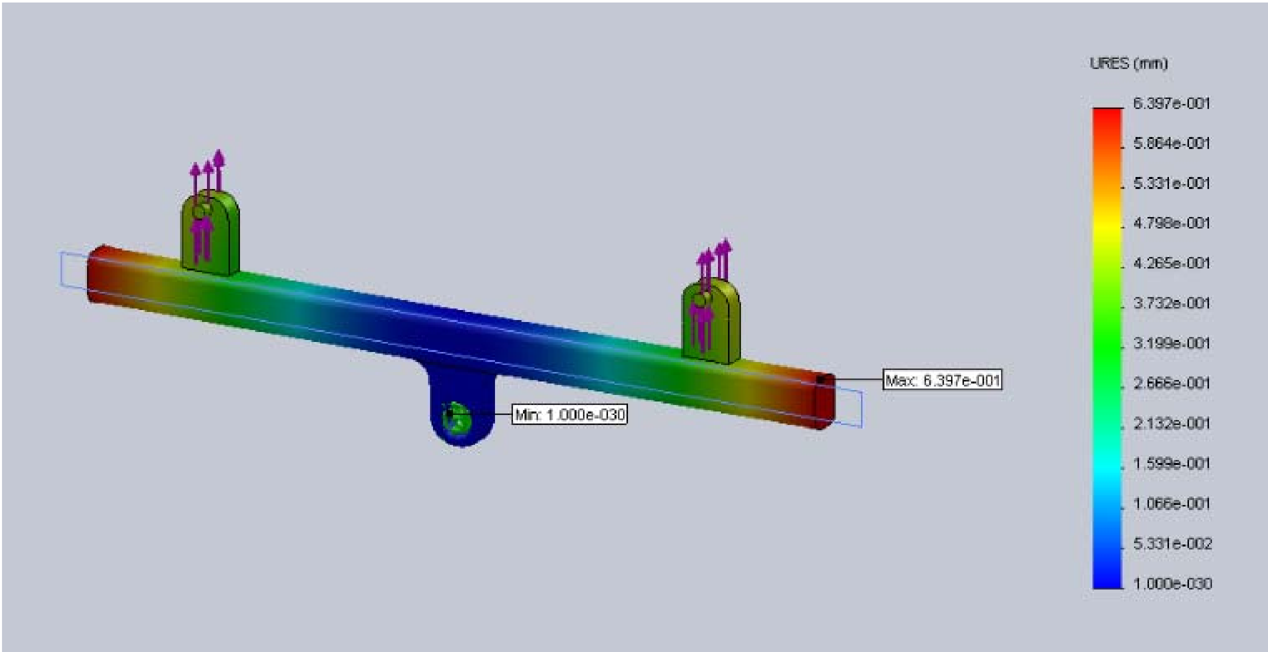

Figure 5. Minimum and maximum displacements (mm).

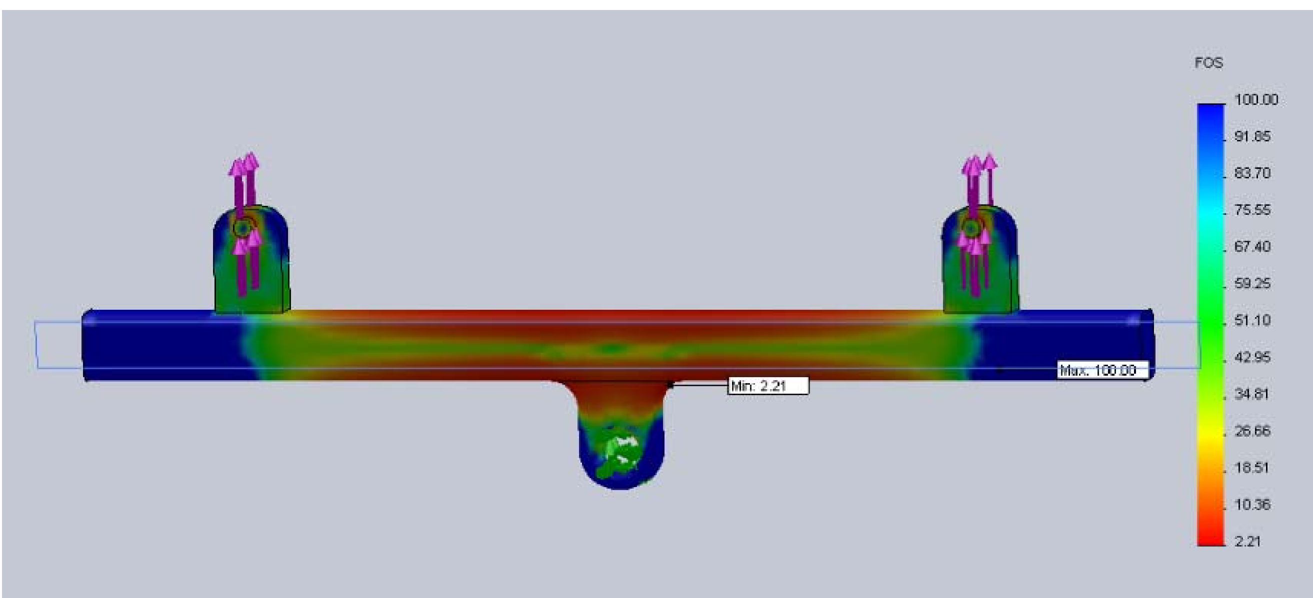

Figure 6. Factor of security of the support.

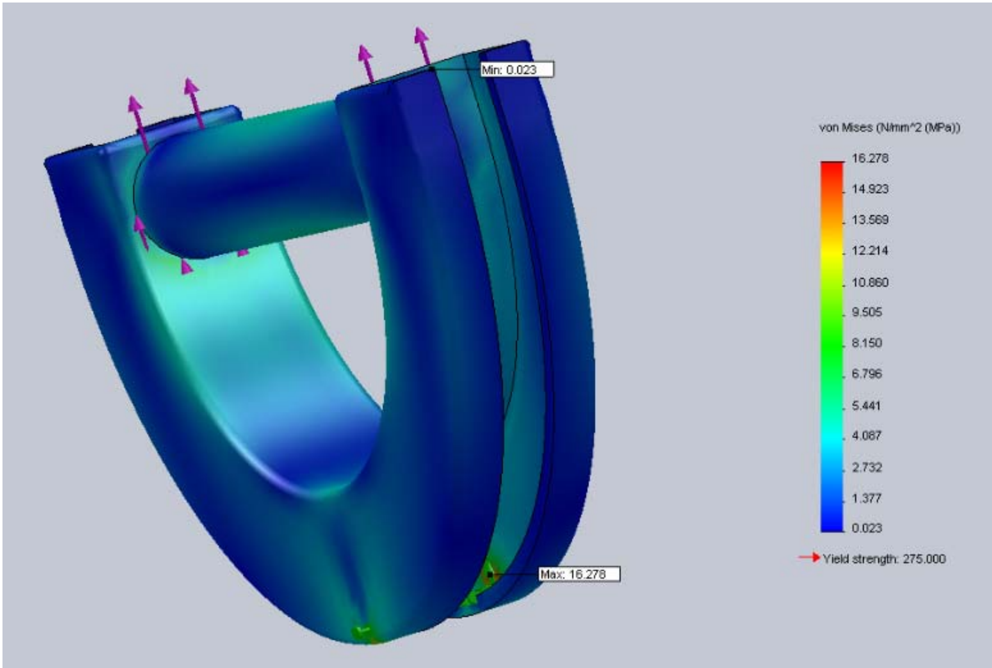

Figure 7. Analysis of the efforts in the circular sliders.

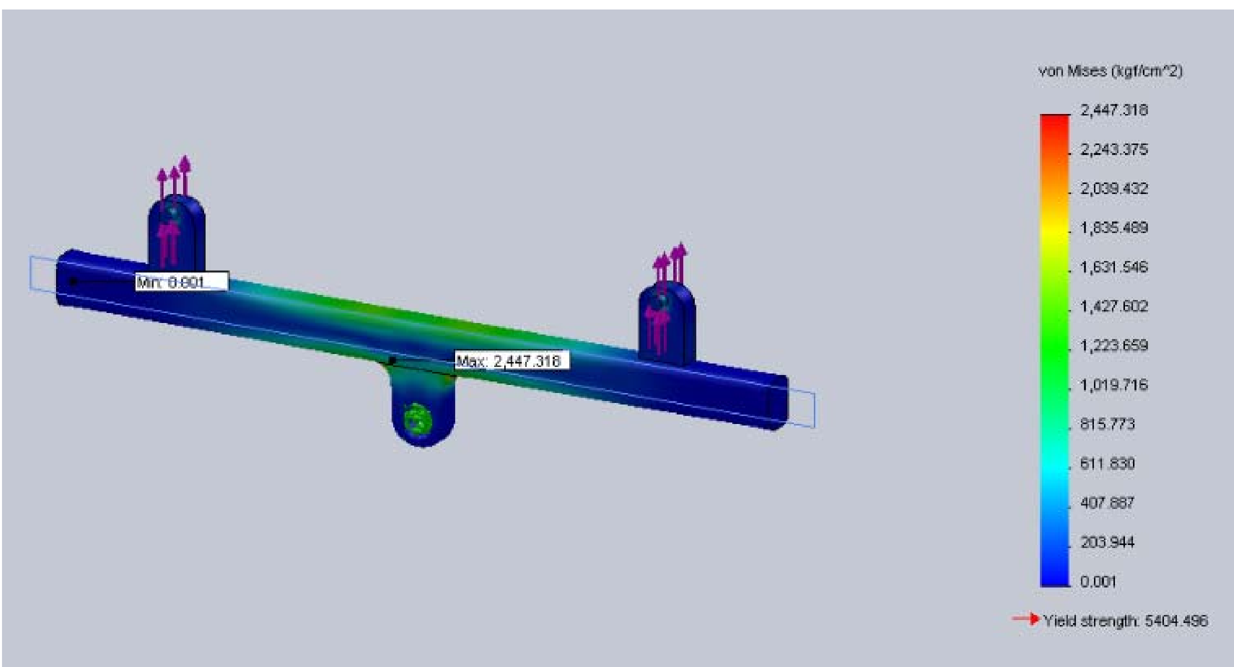

Figure 8. Analysis of efforts in the support.

DISCUSSION AND CONCLUSION

We collected positive comments from enthusiasts of the sport of weights that have been in contact with this type of problem. There are even some other areas in the same field that could be improved.

In relation to the analysis of fixture design, the favorable effects to begin developing the prototype and promote weightlifting in gyms as a solution to the problems in wrists when performing upright row exercise to the neck for the trapezius muscle. The tensile stress analysis showed that the design of accessory is favorable for execution of the exercise in a safe manner with regard to the accessory.

Dalke K. (2005), said that the Structured interviewing of subject matter experts is the most often used technique to render key tacit knowledge of an individual into more explicit forms.

As mentioned above, is included in this section the opinion of an expert in the field, coach Israel Rodriguez Valenzuela. He is certified by the Mexican Federation of Bodybuilding and Fitness (FMFF).

Below are the comments collected from the expert in the interview on April 15, 2011:

"The trapeze is the support for the back and shoulders. The trapeze acts as support in the execution of many exercises, exercises for biceps and even with triceps when you're making an exercise like Press Cup, or even whether to work the shoulder the trapezius is weak this tends to take a serious shoulder injury. So I think that if you have strength in the traps, this has a direct bearing on the strength of the muscles that work together with the trapezoid, as in the case of the shoulder.

Many people work indirectly the trapeze when exercising the back muscles, this is because the trapezius is involved in a support that reaches the middle of the back. The trapezius is a large muscle, but many do not see it that way, for the area covered on the back. So it happens that many people exercise the trapezius muscle after the workout done to the back muscles.

The exercises I execute to train the trapezius are: the upright row, either with a straight bar z bar, depending on how I can best accommodate my hands, I do crunches with a barbell or dumbbell by pulling the shoulders back, or sometimes I put the bar behind my body and pulled my shoulders forward stretching the trapezius, for me this last exercise is more efficient for the trapezius than the upright row.

The specific position I take to make the exercise Remo Vertical Neck is described as follows: it all starts from the legs, start with a good squat for better support on the lower back, took the z bar either closed or open, depending on how I want to work out the trapezius, if I do a close grip I put my elbows a little up as if I'm trying to pull with my elbows, not the wrist itself, I mean you pull the elbows up to work out well and pull the trapezoid well, if you keep your elbows below all you do is to work only the biceps and shoulder, not the trapezius directly as the primary muscle but as secondary, and the purpose here is to work directly, to contract the muscle and that it receives a most generous blood circulation.

In executing the exercise there are parts of the body that function as support and become fatigued. These parts are, in my opinion, the forearm (for the grip) and wrist often resent the efforts by the weight applied, also depending on the weight and the grip you use, if it's z bar or straight bar, with "Z" work better because the wrist is tilted slightly and is less tense, and straight bar forearms get tired because I have to do a lot more pressure on the grip to maintain position over.

Many people feel a sharp pain in the wrists when they perform the exercise because it is not the same to lift with the muscle than with a joint, then many times when you put your weight up, your muscle itself can lift but the joints or the wrists are a little weak for obvious reasons, you never strengthens bones, strengthening the muscles around the biceps, triceps and forearm muscles can be strengthened because they are, but there is nothing for the wrists. This also occurs in other joints, like when you do other exercises such as the Press Cup, shoulder hurts, that means you have weakness in the shoulder and the shoulder joint itself. Then I say that the wrist suffers more by weight and it is not a muscle but a joint. Following that, the second part of the body that suffers the effort in this exercise is the the forearm, as a result of the strength used by the fingers to do the grip.

The accessory presented in this paper can greatly improve exercise technique of the Upright Barbel Row. Sometimes you think that the reason of going to the gym is to get a lot of strength, in my case I'm going to get a good look and what it seeks to have a good psychical is to congest the muscle to grow it with better muscle quality and better muscle tone, then the better you develop a technique is to build better muscle. If you compare this with the old grip (with straight bar bar zo), wrist bothered you looking for a slightly different technique developed to avoid that pain. I hope with this attachment technique is improved so you can use your full weight without any trouble as it would have a better efficiency.

I would recommend the use of this equipment with my colleagues who are in the field of weightlifting and gyms where I work or will work in the future.

I think that this accessory is very well done and I don’t have any recommendations for its improvement. The comment I want to do about it is that I'm glad you care about the improvement accessories found in a gym and make them more ergonomic, for all this is focused on improving the quality of the sport and is good that someone cares about that. "

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STRUCTURAL EQUATION MODELING FOR WORKLOAD, FATIGUE AND PERFORMANCE IN AMT OPERATORS, THEORETICAL MODEL.

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Resumen:

Este artículo presenta la propuesta de un Modelo de Ecuaciones Estructurales (SEM, por su siglas en inglés) para cuantificar las relaciones entre los constructos carga de trabajo, fatiga y desempeño para el caso de operadores de maquinaria considerada como Tecnología de Manufactura Avanzada (TMA). El modelo se construyó considerando la secuencia "estimulo, almacenamiento, procesamiento, respuesta" descrita por farrer (1994) y que ha sido adaptada a la secuencia "carga de trabajo, fatiga, desempeño". Con este modelo se identificarán las variables que más afectan a la fatiga y al desempeño de los trabajadores.

Palabras Clave: Modelo de ecuación estructural, Carga de trabajo, fatiga, ejecución, TMA

Abstract:

This article shows the proposed Structural Equation Modeling (SEM) to quantify the relationships between constructs workload, fatigue and performance in machinery operators considered as Advanced Manufacturing Technology (AMT). The model was built considering the sequence "stimulus, storage, processing, response" described by Farrer (1994) and has been adapted to the

sequence "workload, fatigue, performance". This model will identify the variables that most affect fatigue and human performance.

Keywords: Structural equation model, workload, fatigue, performance, AMT.

INTRODUCTION

Evolution, the way it works, where some years ago physical effort and manual work predominated, has now changed and in some cases, mental effort with little or null physical effort predominates. It has created the necessity to assess the workload and mental fatigue taking greater importance day by day (Farrer, 1994; Móndelo, 1996).

SEM require the measurement/assessment of constructs using statistically validated instruments. In the case of the model proposed in this article, is necessary to assessment workload, fatigue and human performance. Model presented has been based on the sequence proposed by Farrer (1994) presented in Figure 1.

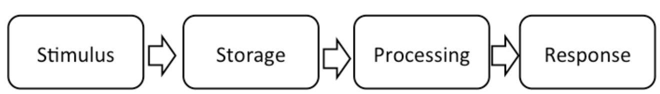

Figure 1. Farrer´s (1994) sequence.

The sequence mentioned has been adapted to the process is shown in figure 2:

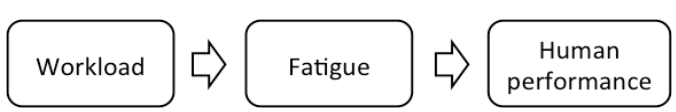

Figure 2. Proposed sequence

Because the model proposed by Layer (2009) associated the workload factors to human performance and Marinn (2009) associated the fatigue with human performance and, it is necessary to analyze the workload, fatigue and its effect on workers' performance in AMT environments.

Workload

Workload is a construct defined as the cost incurred by an individual, given their capabilities, while making a particular level of performance on a task with specific demands (Hart and Staveland, 1998).

DiDomenico (2003) postulates that the workload is derived from from the interaction between the demands of a task, the conditions under which it is carried out, and the skills, behaviors and perceptions of the individual. The demands of a task or combination of tasks may include maintaining postural stability, perform physical actions and / or cognitive tasks. The impact of these demands is directly proportional to the abilities of the individual performing the task. The workload has two components: the physical and mental demands. This classification is determined according to the required response or capacity utilization.

Fatigue

The construct fatigue is defined as a decrease in the capacity to perform a specific activity levels that may occur are: normal, acute, chronic and pathological (Farrer er al, 1994). Juarez-Garcia (2009) postulates there are few methods of fatigue assessment, especially in Spanish-speaking countries. Existing methods have been developed in countries with different languages, cultures and beliefs from Latin American Countries.

Human Performance

Human performance is critical in any work system and is generally considered to be a function of the speed and accuracy a human maintains while working on a task (Sanders, 1993). Performance can be measured as the results, achievements, etc.., made by a person, team, a group or a company. A simple definition is the result of conduct as the means to get an achievement .

SEM applications in ergonomics

The application of SEM in occupational ergonomics is limited, specially in manufacturing environments. The next three models show SEM applications in ergonomics.

Cognitive Demands, Quality Work Life and Human Performance SEM

Layer (2009) proposes a model to quantify the effect of the constructs "mental demands" and "quality of work life" on " human performance" in manufacturing environments. According to the authors, the cognitive demands are explained by complexity, adaptability, workload, and motivation. The quality of work life is explained by learning, job satisfaction, empowerment, and supervision. The human performance was explained by the quality and schedule.

The results (figure 3) show no significant correlation between the mental demands and quality of work life. Load factors of the independent variables (mental demands and quality of life) to the dependent variable (performance) are significant.

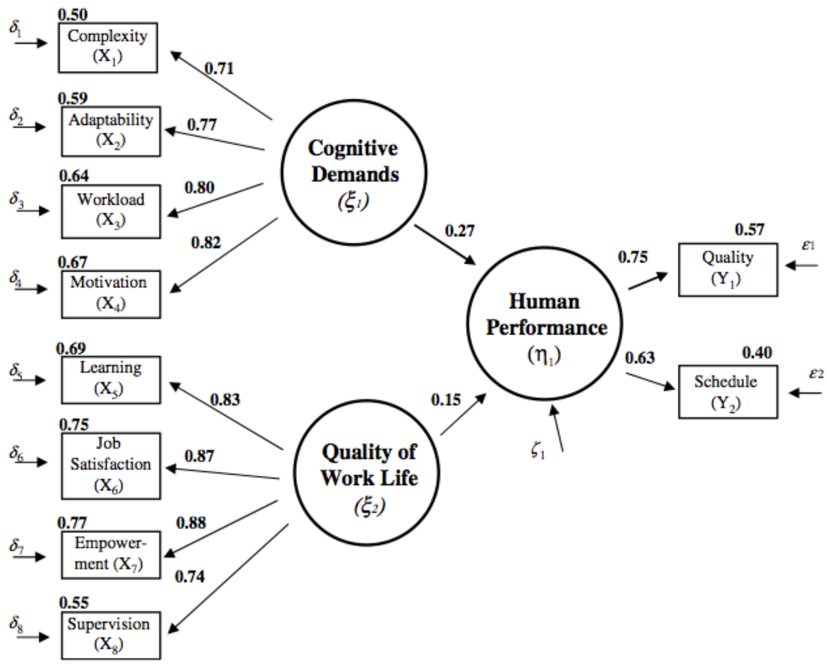

Figure 3. Proposed model by Layer (2009)

Fatigue and Performance SEM

A model related to fatigue and performance is proposed by Marinn (2009), which obtained the causal relationships between "fatigue" (mental and physical) and "performance" (mental and physical) in the work of nurses including fatigue total in the center of the model. In order to assessment fatigue, the autor applied the Swedish Occupational Fatigue Inventory (SOFI) (Ahsberg,1997) and F-RSQ (Yoshitake, 1978). In order to assesment performance, author created the Nurse Performance Instrument (NPI). Figure 4 shows the final model.

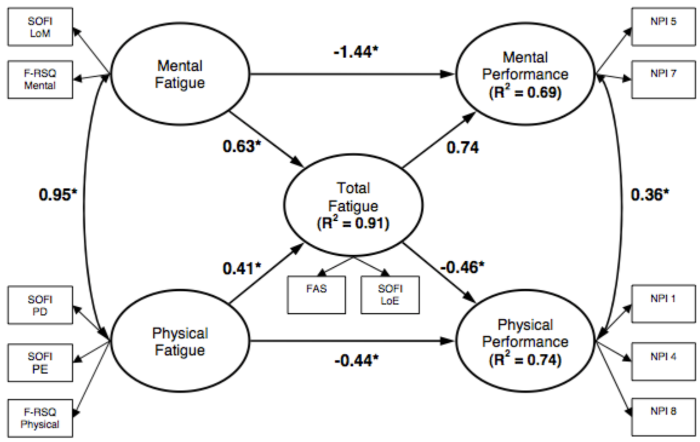

Figure 4. Proposed model by Marinn (2009)

Ride Comfort SEM

A model created as part of the design process is proposed by Lee (2009), in which independent variables are considered as environmental factors, seat, the tunnel effect and movement. As dependent variables were considered: comfort and fatigue, both related to the trip on the train.

The results (figure 5) show that if improved seat width and seat pitch, significantly increases the ride comfort.

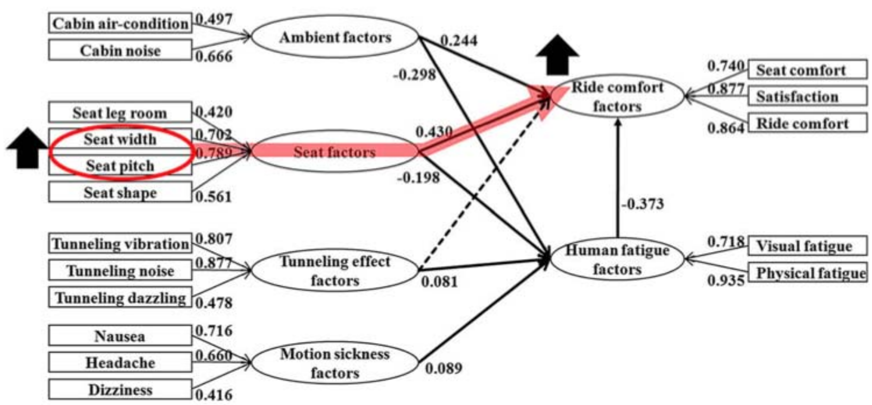

Figure 5. Proposed model by Lee (2009)

PROPOSED MODEL

Following the sequence shown in figure 2 (workload, fatigue, and performance), figure 6 shows the proposed SEM. In the first column, the constructs workload are shown, ie, mental load, physical load, physical environment and psychosocial demands. The second column shows that fatigue is composed of mental fatigue, physical fatigue and total fatigue. The right column shows mental performance and physical performance.

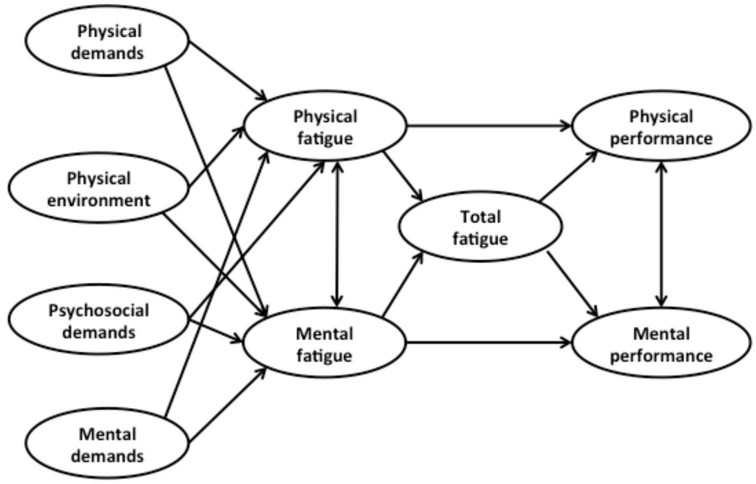

Figure 4. Proposed of workload, fatigue and performance SEM.

CONCLUSION

The proposed model aims to quantify the relationships between the workload, fatigue and performance for operators of machinery considered as AMT. The quantification of load factors, variances, covariances and correlations will define the actions to create a methodology to design the work environment for operators of AMT considering ergonomic principles.

At this moment is performing the assessment of the constructs using a statistically validated survey.

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APPLICATION OF CORLETT & BISHOP METHOD TO DETERMINE POSSIBLE CTDS IN WORKERS OF DONUTS MODULE IN A BAKERY AT LOS MOCHIS, SINALOA.

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Resumen:

Dentro de la gastronomía mexicana, la panadería tiene un lugar muy importante. La mayoría de los panaderos de la vieja escuela de la panificación elaboran su producto de manera artesanal, por lo que sus herramientas también lo son. La mayoría de ellas, por no decir todas, no son ergonómicas, y las personas que las usan pueden verse afectadas en su salud, ya que la utilización de estas herramientas les puede ocasionar, sin saberlo, problemas de salud conocidos como Desordenes Traumáticos Acumulativos (DTA´s). Objetivo. Determinar si se han desarrollado DTA´s en trabajadores del módulo de donas, aplicando el método Corlett & Bishop. Delimitación. Este trabajo se limita al análisis de trabajadores del módulo de donas de una panadería de la ciudad de Los Mochis, Sinaloa, y las recomendaciones respectivas para evitar la aparición de nuevos DTA's. Metodología. En el módulo de donas laboran 8 trabajadores del sexo masculino, de los cuales 5 se encargan de la elaboración y 3 del freído de las mismas. Se aplica entre ellos un cuestionario en base al mapa de molestias de Corlett & Bishop. Cada trabajador menciona su malestar o dolor, según la zona del cuerpo en que lo siente. Se toma en cuenta su semana laboral, la cual comprende del día domingo al día viernes. Resultados. En base a los resultados del cuestionario del método Corlett & Bishop, se determina que si existen DTA´s en los trabajadores del módulo de donas de la panadería, ya que el resultado de dolor es mayor que el de molestia. Conclusiones. Tomando en cuenta los resultados obtenidos, se concluye que existen DTA´s en los trabajadores del módulo de donas, por lo que se recomienda utilizar los resultados de esta investigación para evaluar, mediante el método de RULA, la situación y las condiciones de trabajo en las que operan dichos trabajadores, a fin de establecer una propuesta de mejora para estos obreros, ya sea modificando el método de trabajo o las herramientas que utilizan.

Palabras Clave: Herramientas no ergonómicas, Molestia, Dolor, Desordenes Traumáticos Acumulativos.

Abstract:

Into Mexican Gastronomy, bakery takes a very important place. Most of the old fashion bakers make their products with craft methods, so their tools are crafts too. Most of those tools, if not all of them, are not ergonomic, and the people who use them can be affected in their health, because the utilization of those tools can cause , even if they don't know it, health problems known as Cumulative Trauma Disorders (CTD). Objective. Determine if Cumulative Trauma Disorders (CTDs) have been developed by donuts module workers, applying Corlett & Bishop Method. Delimitation. This research is limited to analyze the donuts module workers of a bakery at Los Mochis, Sinaloa, and the recommendations to avoid the appearance of new CTDs. Methodology. At the donuts module work 8 workers, male, which 5 are in charge of donuts elaboration, and 3 are in charge to fry the donuts. Corlett & Bishop questionnaire is applied to them. Every worker talks about the part of the body where he feels discomfort or pain. Workweek is taken in count, which includes Sunday thru Friday. Results. According to Corlett & Bishop method, is determined that exist CTDs in donuts module workers at the bakery, due to pain results are higher than discomfort results. Conclusions. Due to the obtained results, the conclusion is that exist CTDs in donuts module workers, so it is recommendable to use the results of this investigation to evaluate, using the RULA Method, the situation and the work conditions in which these workers are developing their activities, so it can be possible to establish a proposal to get better work conditions for these workers, modifying the work methods or the tools they use.

Keywords: Not ergonomic tools, Discomfort, Pain, Cumulative Trauma Disorders.

INTRODUCTION.

Actual situation.

Today, work is the main earnings source to have everything a person needs. As the time passes, human being look for the way to make work better, in order to get more and better benefits.

Some machines has been developed to help, automate and make faster production processes, generating bigger earnings to enterprises, all of this due to technology and the time and dedication that men have invest to adapt these machines to look for his own benefit.

This situation has as result the constant interaction of men with machines and work tools. However, human factor is the puzzle’s main piece in a work center, and the reason why it’s necessary to take care of the way every person develops the activities. One way to do it is to look for the adaptation of the work place to the needs of the persons who work in it. At this point, ergonomics plays a very important roll, because it’s based in the concept that laboral activity is not only the machine or the man, but the combination of both parts, so it’s necessary to find the concordance between physical machine characteristics and psychophysiological man characteristics, defining it as “*the study of the human being in his work environment*” (Murell 1967).

The center of this investigation is the application of one of the ergonomics tools, the Corlett & Bishop Method, in the donuts elaboration line of a bakery. Thru the application of this method it’s possible to determine if the workers of this line have been developing Cumulative Trauma Disorders.

Based in the ergonomics basic concepts and the idea that man is the main study object of ergonomics, it’s very important to know and understand the work risks present at work.

The bakery under study is located at the city of Los Mochis, Sinaloa, and his main activity is the elaboration and sale of bread in different varieties. At the donuts module work 8 persons, male, which 5 are in charge of donuts elaboration, and 3 are in charge to fry the donuts.

Physical and mental effects caused by this work to those workers bring a number of diseases and fatigue symptoms that can cause CTDs, decreasing their performance and affecting their health, so it’s necessary to know their actual situation about the symptoms they can actually have. It’s important to mention that there are very few investigations about similar environment work.

OBJECTIVES.

Particular.

Determine if Cumulative Trauma Disorders (CTDs) have been developed by donuts module workers of a bakery in the city of Los Mochis, Sin., applying the Corlett & Bishop Method.

Specifics.

Apply the Corlett & Bishop questionnaire to the workers of the bakery.

Analyze the obtained results.

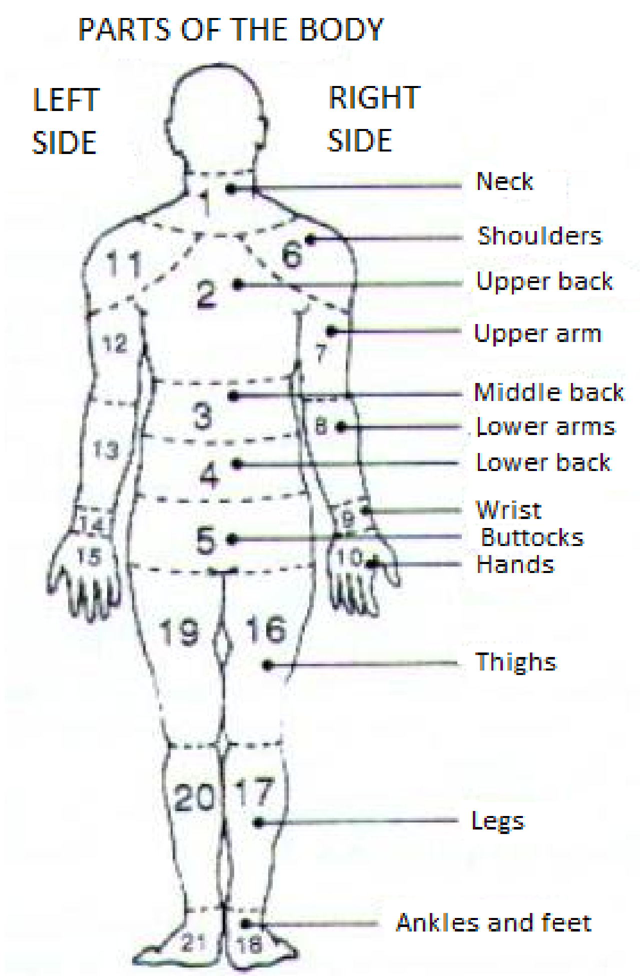
If there are CTDs, make an improvement proposal to avoid new CTDs in the workers in the future.

METHODOLOGY.

First thing is to apply Corlett & Bishop questionnaire shown in Figure 1 to the workers at the bakery. Write in the table the correspondent letter depending if you feel: D = Discomfort, P = Pain

In this questionnaire, the workers answered depending of the symptom they felt the day and the time they were interviewed. Table 1 shows as example the answers of one of these workers.

As can be seen in Table 1, the questions are made at the beginning of the workday, about 6:00 in the moorning, and at the end of the workday, between 2:00 and 3:00 afternoon. Is just then when every worker mentions about his discomfort or pain, depending the part of the body where he feels it. The whole workweek is taken into account, which begins on Sunday and finish on Friday.



Part of the body	Time of registry		D	L	M	M	J	V
Head	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Neck	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Shoulders	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Upper back	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Upper arms	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Lower arms	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Middle back	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Lower back	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Wrist-hand	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Buttocks	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Thighs	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Knees	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Legs	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Ankles	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Feet	Beginning workday	D						
		P						
	Ending workday	D						
		P						

Figure 1.- Discomfort Map and Corlett & Bishop Method questionnaire.

Table 1.- Worker's answers example.

Part of the body	Time of registry		D	L	M	M	J	V
Head	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Neck	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Shoulders	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Upper back	Beginning workday	D						
		P						
	Ending workday	D	D	D				
		P			P	P		
Upper arms	Beginning workday	D						
		P						
	Ending workday	D						
		P				P		
Lower arms	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Middle back	Beginning workday	D		D		D		
		P						
	Ending workday	D						
		P					P	P
Lower back	Beginning workday	D	D					D
		P						
	Ending workday	D		D				
		P			P	P		
Wrist-hand	Beginning workday	D					D	
		P						
	Ending workday	D						
		P						
Buttocks	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Thighs	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Knees	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Legs	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Ankles	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Feet	Beginning workday	D						
		P						
	Ending workday	D						
		P						

RESULTS.

Table 2 shows the total results of the Corlett & Bishop questionnaire application to the bakery workers during 3 weeks. In this table can be seen that the highest results were obtained at donuts module, in both discomfort and pain, reason why this module is analyzed carefully to determine if CTDs are being developed by workers or, still worst, they already have CTDs.

Table 2. Total results for the Corlett & Bishop questionnaire application.

MODULE	PAIN	DISCOMFORT
Almohadita	87	122
Arreglado	72	86
Batidos	90	96
White bread	123	125
Conchitas / Minisemita	53	72
Corico	66	79
Donuts / fry	194	189
Package	63	87
Packing	78	89
Ovens	127	134
Pastry	114	127
Tortillas	68	78
Varieties	84	95

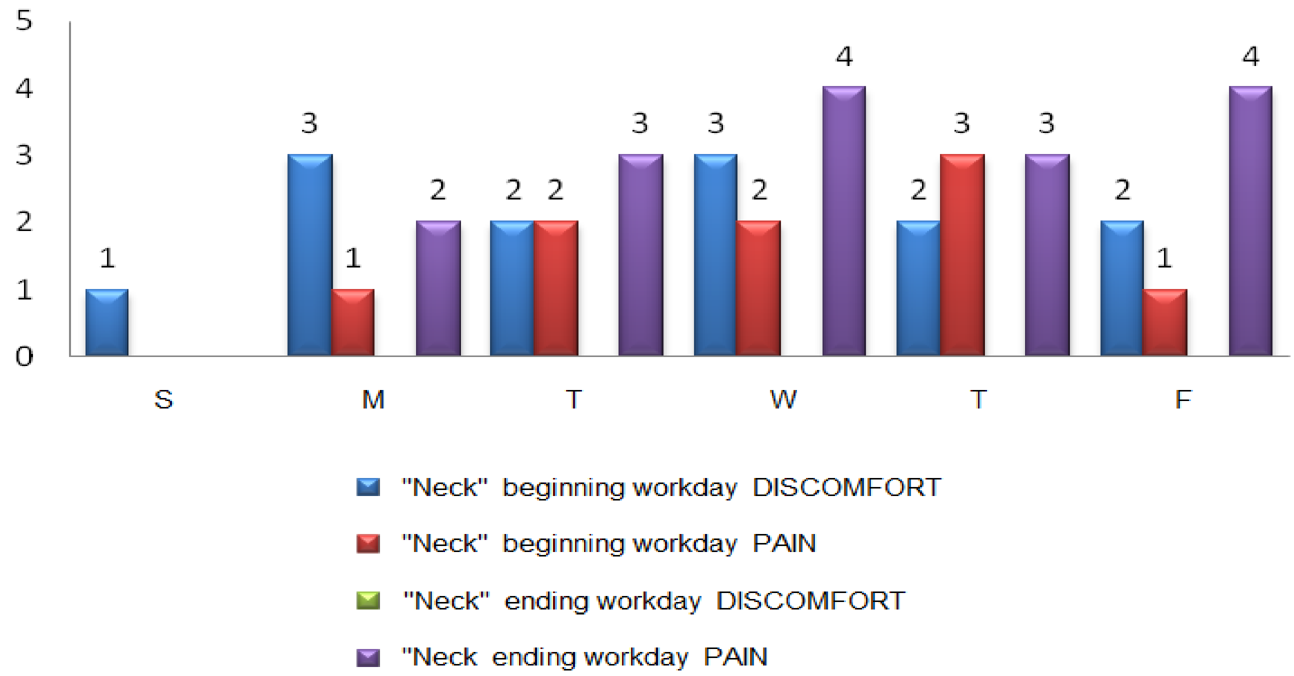
Detailed results at donuts module are shown in the Table 3.

Table 3. Corlett & Bishop questionnaire results (donuts module).

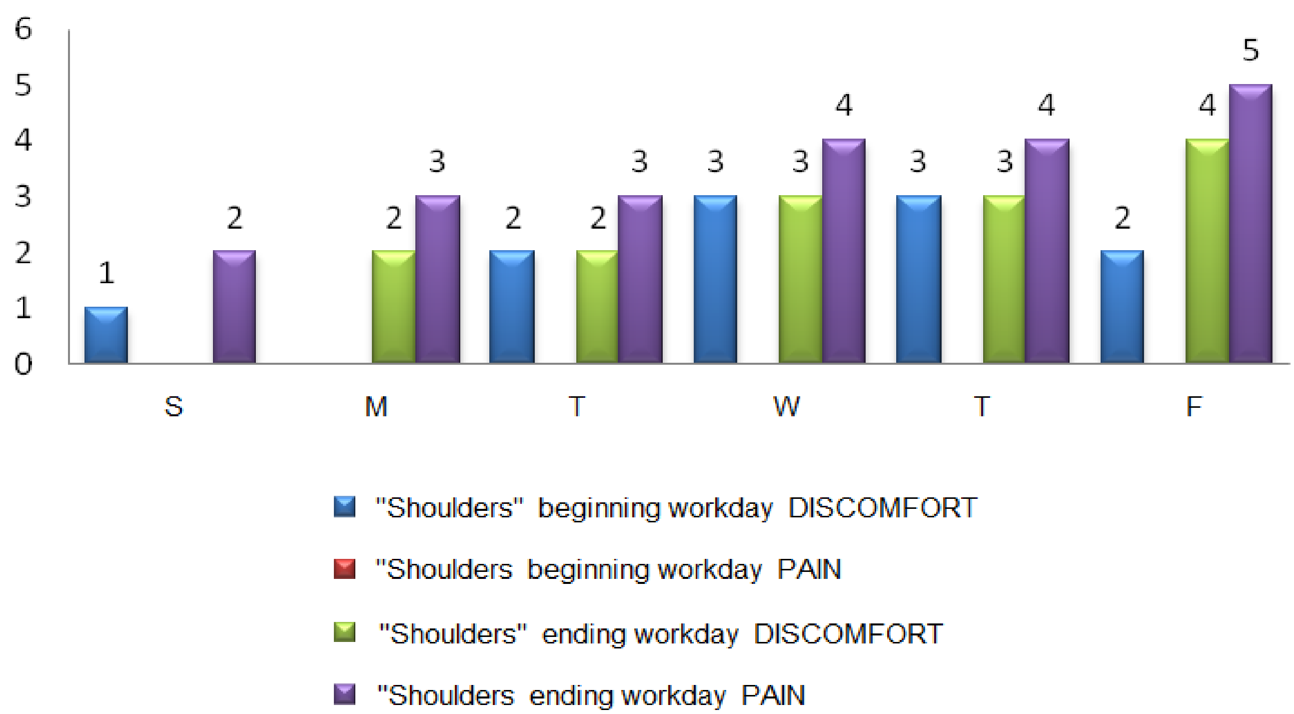
Part of the body	Time of registry		D	L	M	M	J	V
Head	Beginning workday	D						
		P						
	Ending workday	D						
		P		2	1	2	2	1
Neck	Beginning workday	D	1	3	2	3	2	2
		P		1	2	2	3	1
	Ending workday	D						
		P		2	3	4	3	4
Shoulders	Beginning workday	D	1		2	3	3	2
		P						
	Ending workday	D		2	2	3	3	4
		P	2	3	3	4	4	6
Upper back	Beginning workday	D		2	3			
		P		1	2			2
	Ending workday	D	1	1	2	3	2	1
		P		2	3	4	4	5
Upper arms	Beginning workday	D	2	1	3		3	2
		P				2	2	
	Ending workday	D		2	3	3	4	2
		P	2	3	4	4	4	5
Lower arms	Beginning workday	D		2	3	3		
		P						
	Ending workday	D		3	4	5	5	4
		P						
Middle back	Beginning workday	D		1	1	3	2	
		P						
	Ending workday	D		1	1		2	2
		P						
Lower back	Beginning workday	D	1	3	3	2	4	3
		P						
	Ending workday	D	2	2	4	3	3	2
		P	1	3	2	4	3	3
Wrist-hand	Beginning workday	D	1	4	5	3	4	4
		P		1	3	2	2	
	Ending workday	D			2	3	2	
		P	1	5	5	4	5	4
Buttocks	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Thighs	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Knees	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Legs	Beginning workday	D	1	2	1	1	3	
		P		3	4	3	5	4
	Ending workday	D	1	2	3	2	2	
		P	2	4	4	5	5	4
Ankles	Beginning workday	D						
		P						
	Ending workday	D						
		P						
Feet	Beginning workday	D						
		P						
	Ending workday	D						
		P						

Graphics 1 to 9 show the obtained results of the Corlett & Bishop questionnaire application according to the Table 3.

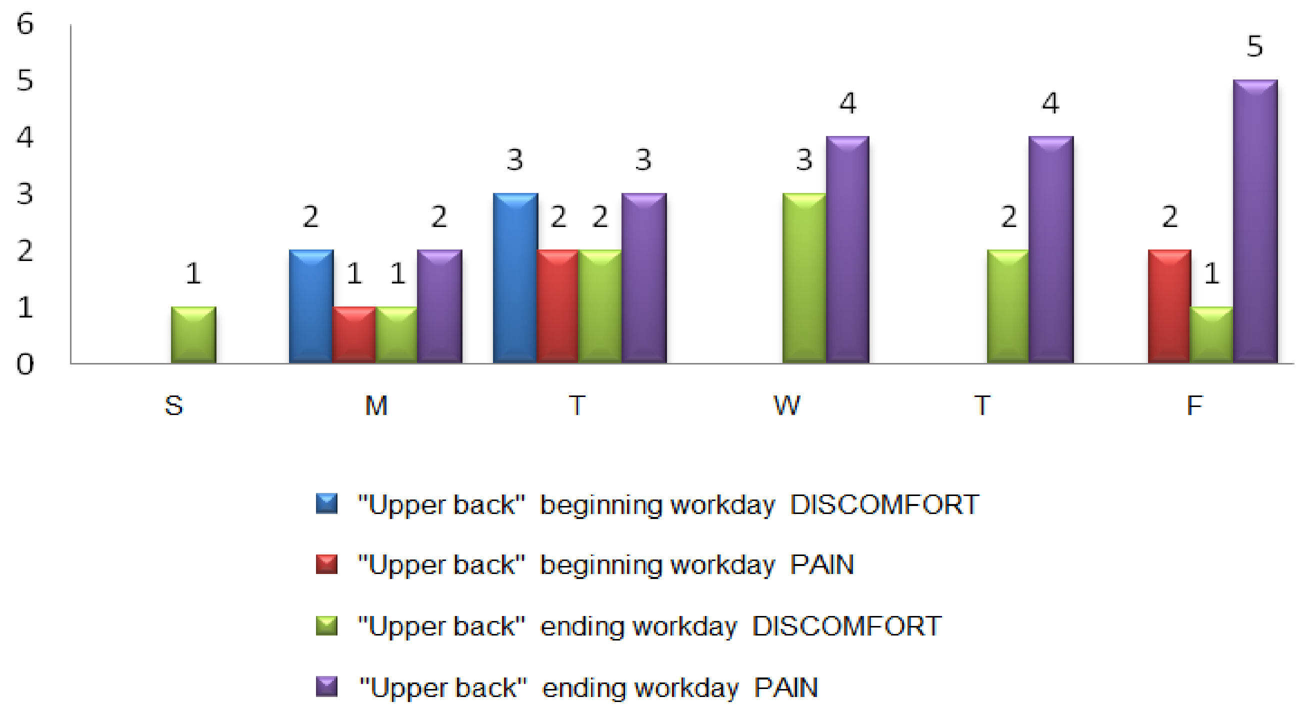
Graphic 1. Corlett & Bishop results, “Neck”



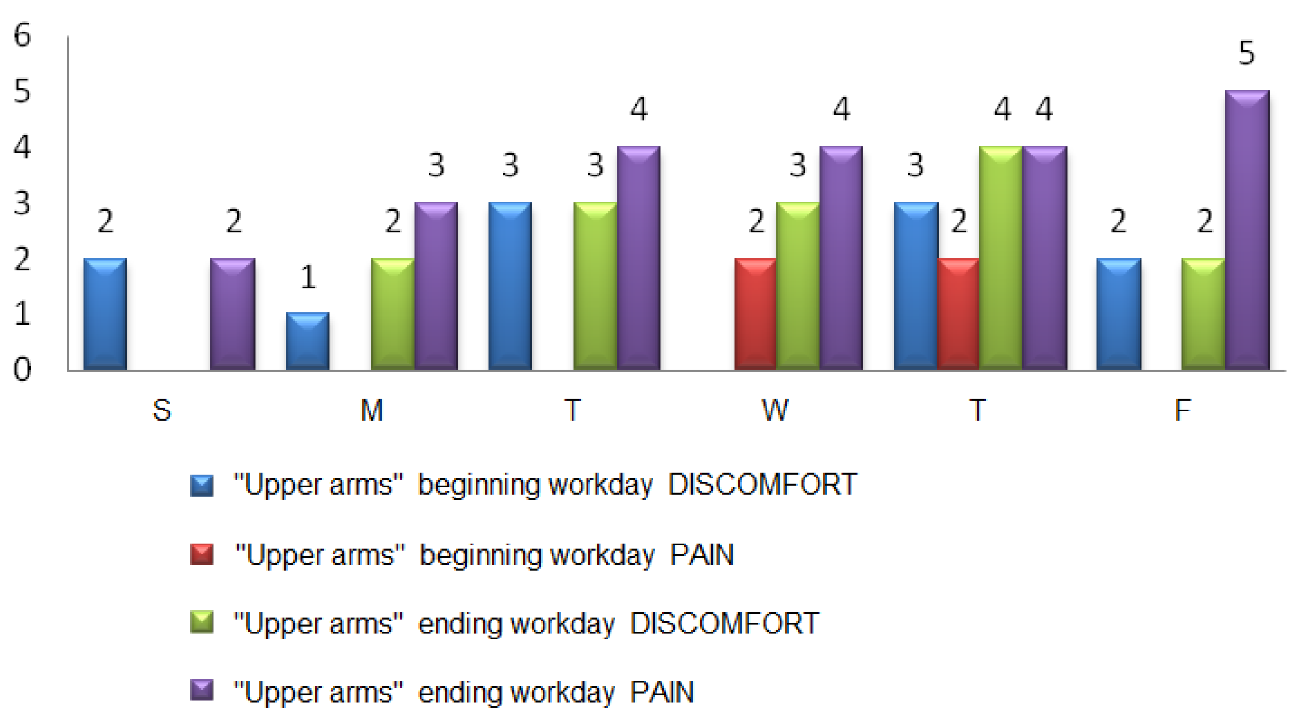
Graphic 2. Corlett & Bishop results, “Shoulders”



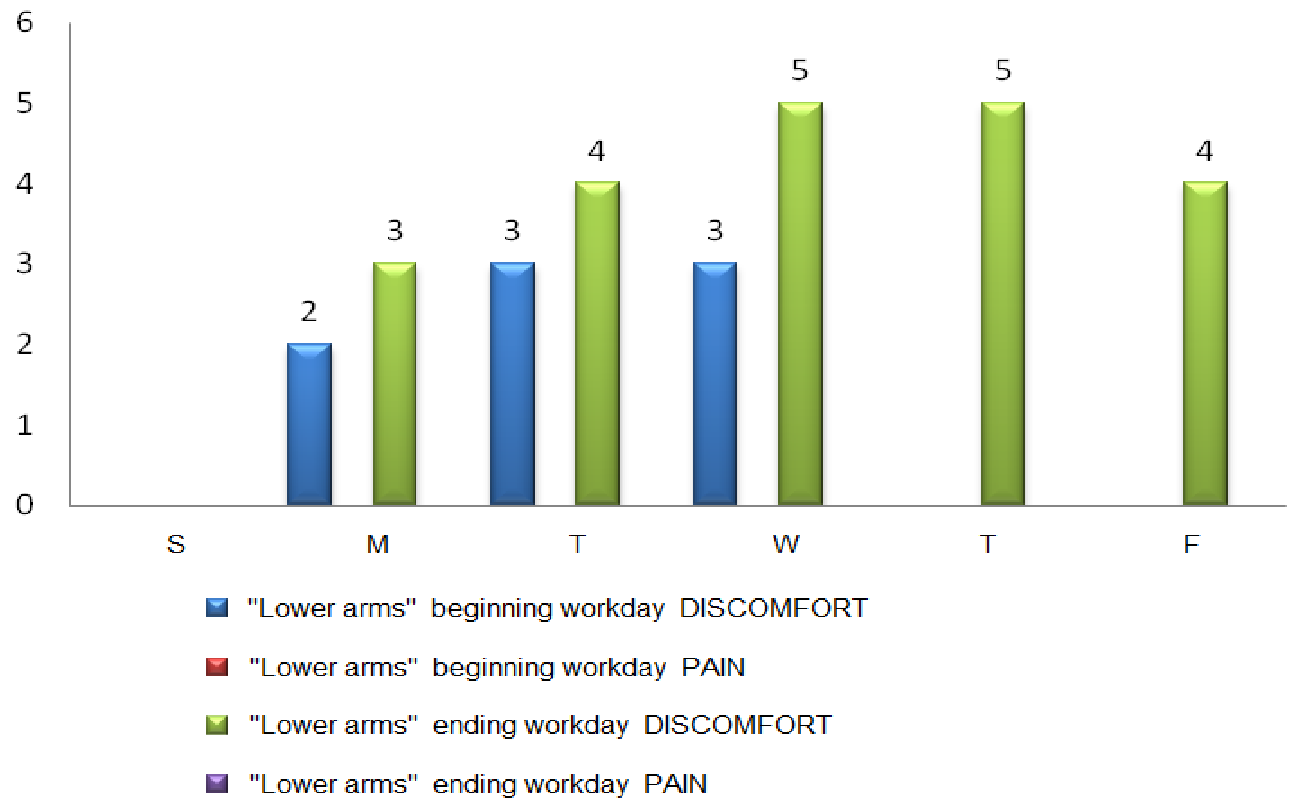
Graphic 3. Corlett & Bishop results, “Upper back”



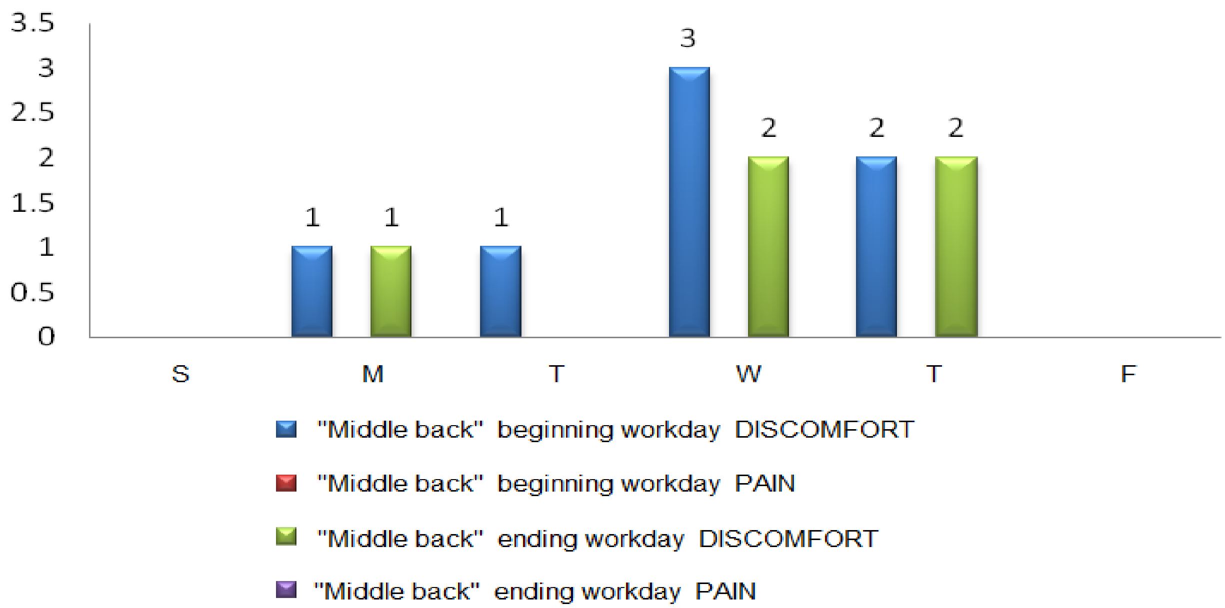
Graphic 4. Corlett & Bishop results, “Upper arms”



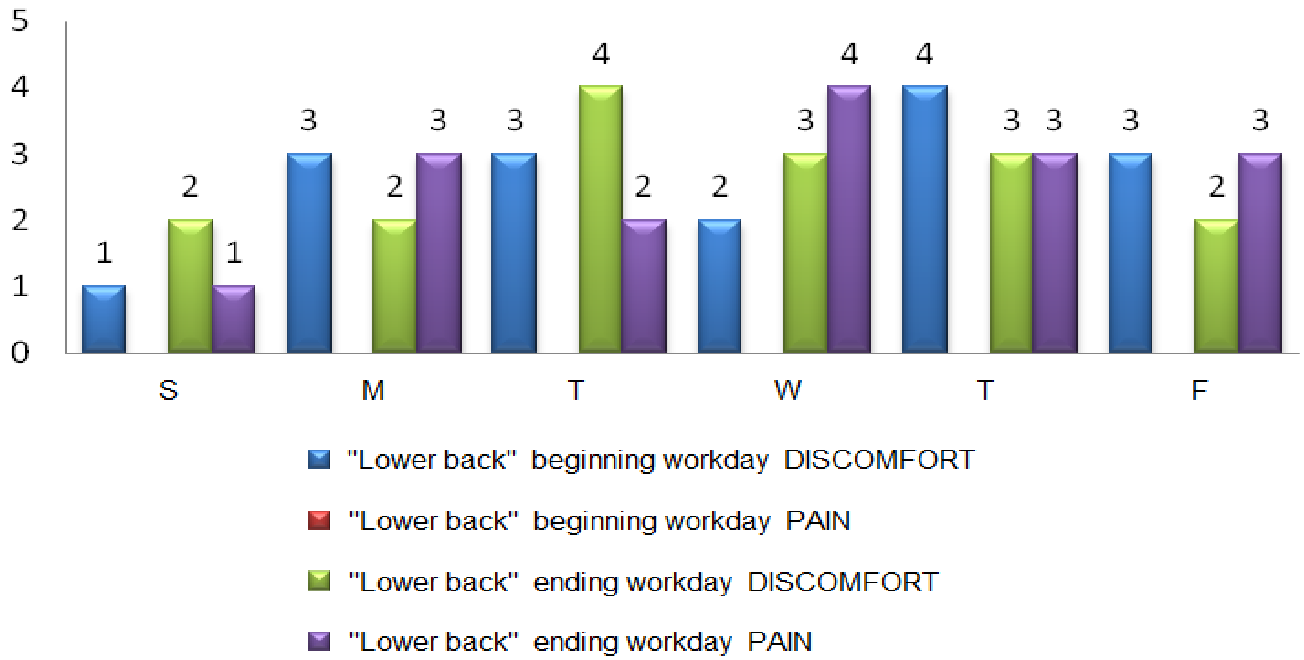
Graphic 5. Corlett & Bishop results, “Lower arms”



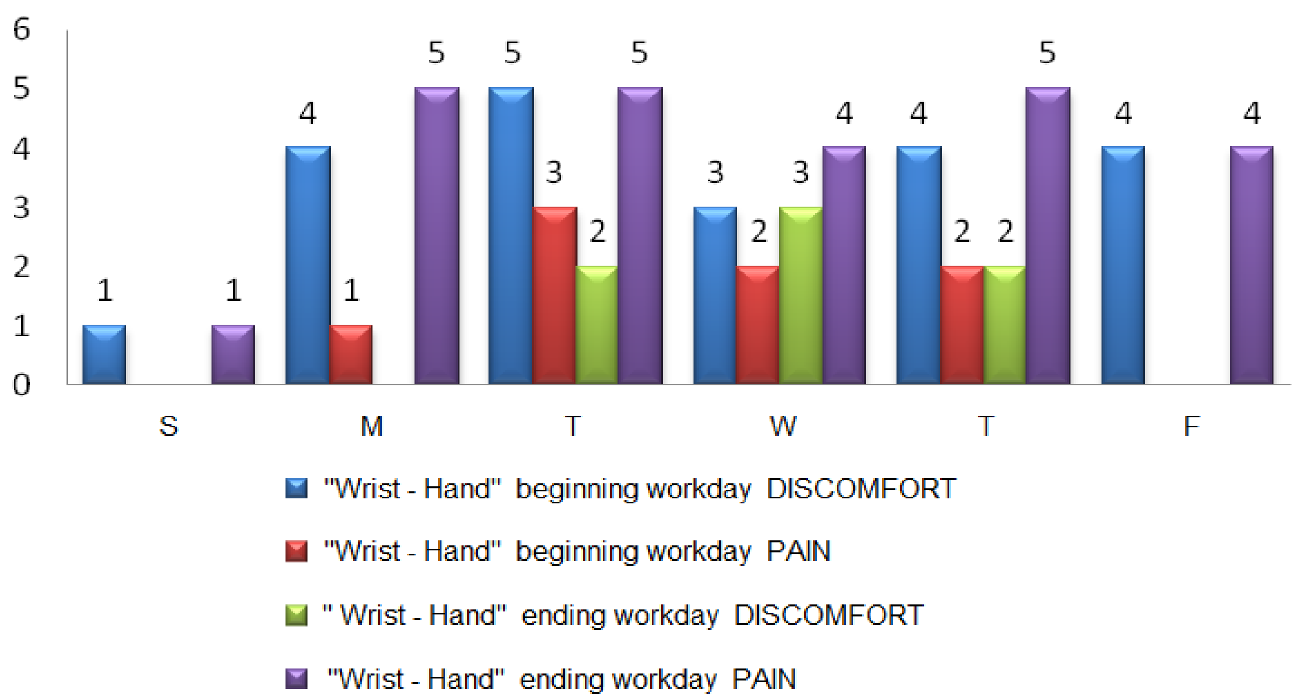
Graphic 6. Corlett & Bishop results, “Middle back”



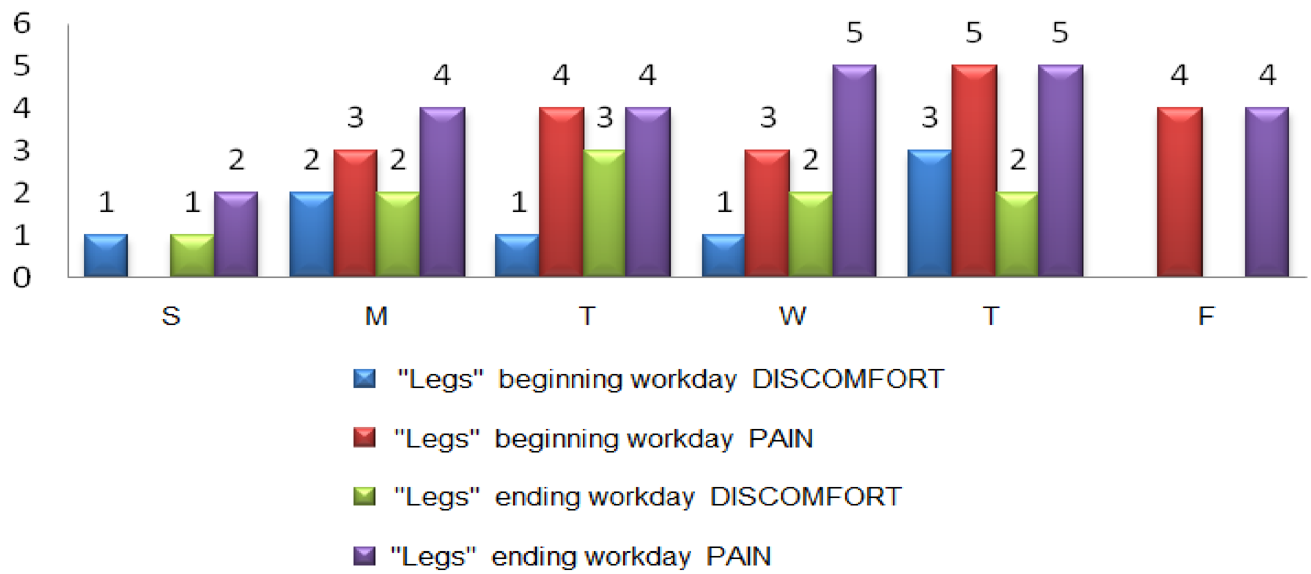
Graphic 7. Corlett & Bishop results, "Lower back"



Graphic 8. Corlett & Bishop results, "Hand"



Graphic 9. Corlett & Bishop results, "Legs"



CONCLUSIONS.

Base don the obtained results, it's posible to determine that exist CTDs in donuts module workers, due to the pain results are bigger than discomfort results (194 – 189 respectively), as can be seen in the Table 2 of total results for the Corlett & Bishop questionnaire application. It's recommended to use these results to evaluate the situation and the work conditions of this workers using the RULA Method, to establish an improvement proposal to modify the work methods or the work tools or both.

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ERGONOMIC EVALUATION OF PACKAGING PROCESS OF DAIRY PRODUCTS

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Resumen:

Esta investigación fue realizada en el proceso de envasado de productos lácteos. El principal objetivo fue identificar las tareas con mayor índice de riesgo ergonómico. Se aplicó a los trabajadores una encuesta sobre las condiciones de trabajo. Las actividades fueron evaluadas por los métodos LEST y REBA. Los trabajadores presentan molestias físicas como dolor de espalda, hombros, brazos, manos, muñecas y dedos, siendo la espalda la zona más afectada. El método ergonómico LEST identificó la carga estática y dinámica con índice de nocividad. El método REBA reportó tres actividades con índice de riesgo significativo para la salud del trabajador.

Palabra clave: Evaluación ergonómica, Método REBA, Método LEST

Abstract:

In this research, ergonomic evaluation in the process of packaging of dairy products was performed. The main objective was to identify the tasks with the highest ergonomic risk. A survey on working conditions was applied to workers. To perform ergonomic evaluation, REBA and LEST methods were applied. Workers present physical discomfort such as back pain, shoulders, arms, hands, wrists and fingers. Low back was the most affected area. LEST method identified the static and dynamic load as level of nuisance. REBA method reported three activities with significant risk index for workers' health.

Keywords: ergonomic evaluation, REBA and LEST method, dairy products.

INTRODUCTION

In the company where the research was conducted, most of the activities are performed manually. In the packaging of cheese and yogurt is common to identify the following problems: inadequate postures, standing work more than 8 hours, repetitive movements and manual material handling with heavy weights. Workers have reported musculoskeletal discomfort such as back pain, shoulders, arms, wrists and fingers. These annoyances cause the worker decrease their rhythm of work generating high over time costs and personnel rotation.

The objectives of this study were to evaluate ergonomic packaging activities of dairy products by using methods REBA and LEST and identify activities with significant risk index for workers' health.

METHODOLOGY

Subjects

For this research only considered the four workers from the production area, three women and one man.

Selection of Workstations

To identify high risk activities, the following details were observed: activities in each work area, identify the task that do not fit with ergonomic principles, select area with higher risk activities (considering that they are feasible to improve). The priority workstations were packaging processes of yogurt and cheese.

Task Analysis

In the production area were analyzed packaging activities. Time they are performed, the weight handled, the possible risks were observed applying video analysis.

Working Conditions Survey

The proposed survey was developed by the Occupational Health Program at the University of California, Berkeley (2003). This survey diagnoses the body parts affected workers. It includes a body map in which the workers indicate the parts most affected by their work. The questions investigate about the intensity in which they occur and how long they have affected them.

LEST Method

LEST method was developed by F. Guélaud, M.N. Beauchesne, J. Gautrat and G. Roustang, members of the Laboratoire d'Economie et Sociologie du Travail (L.E.S.T.), of the C.N.R.S., in Aix-in-Provence in 1978 and it carries out the evaluation of the conditions of work in the possible more objective and more global way, a final diagnosis that indicates if each one of the situations considered in the position is satisfactory, bothersome or noxious.

The method is of global character considering each aspect of the position of work in a general way. It is not deepened in each one of those aspects, a first valuation is only obtained that it allows determine if a deeper analysis is required with specific methods. The objective is, according to Guelaud (1977),to evaluate the group of relative factors to the content of the work that it can have repercussion so much about the health as envelope the personal life of the workers. Before the application of the method they should have been considered and resolved the relating labor risks to the Security and Hygiene in the Work because they are not contemplated by the method.

The information that is necessary to pick up to apply the method has a double objective-subjective character. On one hand quantitative variables they are used as the temperature or the sound level, and for other, it is necessary to pick up the worker's opinion regarding the work that he/she carries out in the position to value the mental load or the psychosocial demands.Resultswereobtainedfromwebpagewww.ergouanutas.upv.es.

The punctuation system and dimensions and factors considered by the LEST method are shown in table 1 and table 2.

Table 1. Dimension and factors in LEST method

	Dimensions				
Factors	Physical environment	Physical load	Mental demands	Psychosocial demands	Time demands
	Thermal conditions Noise	Static load Dynamic	Pressure of time Complexity	Initiative Social status Communications	Time demands

	Illumination Vibrations	load	Attention	Relationship with the manager	

Table 2. Punctuation system

Value	Meaning
0, 1, 2	Satisfactory situation
3, 4, 5	Weak nuisances
6,7	Significant nuisance. Risk of fatigue
8, 9	Strong nuisances. Exists fatigue
10	Harmful

REBA Method

REBA method (Rapid Entire Body Assessment) was proposed by Sue Hignett and Lynn McAtamney and published by the specialized magazine Applied Ergonomics in the year 2000. The method is the result of the combined work of an ergonomists team, physiotherapists, occupational therapists and nurses that identified around 600 postures for its elaboration.

The method allows the combined analysis of the positions adopted by the superior members of the body (arm, forearm and wrist), trunk, neck and the legs. Also, it defines other factors that it considers determinant for the final valuation of the posture, as the load or managed force, the type of coupling or the type of muscular activity developed by the worker. It allows to evaluate static as dynamic postures, and it incorporates as novelty the possibility to point out the existence of abrupt changes of posture or unstable postures.

REBA method is a tool of specially sensitive analysis of postures with the tasks that bear unexpected changes of position, as consequence usually of the manipulation of unstable loads.

Application of REBA method prevents the analyst about the risk of lesions associated to a posture, mainly of muscle-skeletal type, indicating in each case the urgency with which correction actions should be applied. It is, therefore, of an useful tool for the prevention of risks able to alert on inadequate work conditions. Results were obtained from webpage www.ergouanutas.upv.es.

Table 3. REBA method punctuation

Final Punctuation	**Action level**	**Risks level**	**Changes in work station**
1	0	No risk	No necessary
2 – 3	1	Low	It´s possible
4 – 7	2	Half	It´s necessary
8 – 10	3	High	It´s necessary quickly
11 – 15	4	Veru high	Urgent changes

RESULTS AND DISCUSSION

Task Analysis

Results of yogurt packaging process task analysis are shown in Table 4.

Table 4. Analysis of yogurt packaging process

Task/risk	Picture	Time	Weigh handled
Task: remove containers from the refrigerator. Risk: back pain, herniated disc, arm and hand injuries.		14 seg	60 kg
Task: homogenize mixture of yogurt Risk: tenosynovitis and epicondylitis		3 min	No apply
Task: fill containers. Risk: back discomfort, pain in articulations and muscles		3 liters containers/ 40 sec	3.0 kg
		1 liter containers/ 10 sec	1 kg
		250 ml containers/5 sec	0.25 kg
Task: sealed containers Risk: epicondylitis and carpal tunnel syndrome.		3 sec	No apply

Results of cheese packaging process task analysis are shown in Table 5.

Table 5. Analysis of cheese packaging process

Task/risk	Picture	Time	Weigh handled
Task: weigh and cutting cheese Risk: epicondylitis and carpal tunnel syndrome.		5 s	0.50 a 2 kg
Task: make cheese balls. Risk: epicondylitis and carpal tunnel syndrome.		7 a 12 s	0.50 a 2 kg
Task: wrap the cheese in a plastic bag. Risk: epicondylitis and carpaltunnelsyndrome.		4 a 7 s	0.50 a 2 kg
Task: put the product in plastic boxes. Risk: back discomfort, persistent pain in articulations and muscles.		2 s	0.50 a 2 kg
Task: ttransport boxes to the refrigerator. Risk: back pain, herniated discs and injury to hands and arms.		25 s	100 kg

Working Conditions Survey

Workers expressed physical discomfort such as back pain, shoulders, arms, hands, wrists and fingers, the back was the most affected area. The back problems occur during the course of the day increase at the end of the day. This discomfort prevent them from getting adequate rest at night. All the discomfort began after they entered to work in the company, which this work is causing these problems in the worker's health.

LEST Method

Figure 1 shows that the factors with the highest score (10) were dynamic and static load. 10 is considered harmful . This situation happens due to the workers take inappropriate positions for the back, arms and legs, as shown in Tables 1 and 2. Workers handle weight excessive and inappropriate. Therefore, the way they perform product packaging damages the health of the worker. Working time (score 4) generates weak discomfort. This is because overtime is perform to finish the activities, which is tired and tedious for the workers. Results were obtained from webpage www.ergouanutas.upv.es.

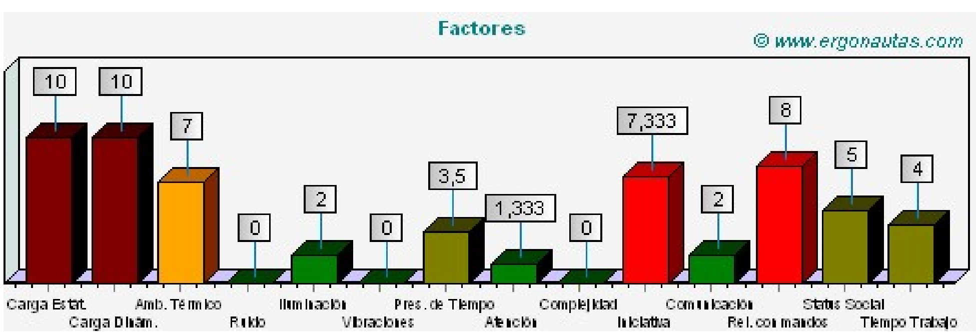

Figure 1. LEST method results. Packaging cheese and yogurt.

REBA Method

Table 6 shows the summary of the final REBA scores of yogurt packaging activities. Results are for left and right sides of the body).Task 1 and task 3 are the most dangerous activities in yogurt packaging process.

Table 6. Summary of REBA scores of yogurt packaging.

Final punctuation				
Side of the body	Task 1	Task 2	Task 3	Task 4
Right	9	4	9	5
Left	9	3	8	5

Summary of the final scores to determine the level of risk for cheese packaging activities shown in Table 7 (left and right side of the body).Task 1 and task 4 are the most dangerous activities in cheese packaging process.

Table 7. Summary of REBA score of cheese packaging.

Final punctuation					
Side of the body	Task 1	Task 2	Task 3	Task 4	Task 5
Right	7	5	6	7	10
Left	7	5	6	7	10

CONCLUSIONS

The static and dynamic load were the factors that obtained the highest level of risk to worker health. These factors include bad positions, the weight to be handled and the distance traveled to move the loading. As mentioned in the results of the evaluation of e-LEST method, there are inadequate conditions for the development of activities. Because physical load factor increased risk, corrective actions must be developed in positions and manual handling of materials to improve working conditions.

We conclude that the activities that require urgent modifications are:

- Activity 1 (Getting containers) and activity 3 (discharge container) of yogurt packaging process.
- Activity 5 (carrying boxes) of packaging process cheese.

These activities are causing physical discomfort to the workers, which is supported by the analysis of responses in the survey. Workers presented physical complaints such as back pain, shoulders, arms, hands, wrists and fingers, the back was the most affected area. These annoyances occur during the course of the day increasing at the end of the workday.

These annoyances cause workers rest properly at night. These problems began after they admitted to work in the company, which this work is causing these problems mentioned in the worker's health.

It is suggested to design a support device for the identified activities with the highest risk, which help to reduce the level of risk and physical discomfort among workers. Developing this device will be improve ergonomic risk, posture, as well as facilitate handling of materials.

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CHARACTERIZATION OF MUSCULOSKELETAL INJURIES IN THE UPPER EXTREMITIES TO HIGHLY REPETITIVE WORK IN THE MANUFACTURING INDUSTRY

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RESUMEN:

El planteamiento que desarrolla el estudio se enfoca estudiar el comportamiento de la fuerza en las extremidades superiores en el desarrollo de trabajo altamente repetitivo y de ciclos cortos, en ambientes de manufactura, con la intención de caracterizar el trabajo que se realiza con las manos, brazos y hombros. Se han considerado variables relacionadas con las características físicas de las personas y con el trabajo. Como variable de respuesta se analizará el comportamiento de la fuerza en mediciones hechas cada media hora a partir de la sexta hora de trabajo, durante una semana. La información bibliográfica no muestra una relación significativa entre el tipo de trabajo y el efecto acumulado en el comportamiento de la fuerza durante la jornada laboral, ni entre los días de la semana. Existe evidencia de fatiga percibida en las manifestaciones de dolor o entumecimiento en los dedos.

ABSTRACT:

The approach developed by this paper focuses on studying the behavior of force in the upper extremities in the development of highly repetitive and short cycles, manufacturing environments, with the intention of characterizing the work done with the hands, arms and shoulders. We have considered variables related to the physical characteristics of people and work. As response variable we will analyze the behavior of force measurements every half hour from the sixth hour of work for a week. Bibliographic data shows no significant relationship between the type of work and

the cumulative effect on the behavior of force during the workday, and between days of the week. There is evidence of fatigue perceived manifestations of pain or numbness in the fingers.

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