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Prefacio

La ergonomía se ha distinguido por ser una ciencia cada vez más comprometida con el bienestar humano, ampliando sus intereses y alcances en el estudio de las capacidades y limitaciones del hombre más allá de los puestos de trabajo en organizaciones formalmente establecidas, que compiten ferozmente en mercados globales exigentes, para estudiar también ambientes y puestos de trabajo en la informalidad. A nivel mundial y en México, el trabajo en esta modalidad se caracteriza por carecer de prestaciones laborales, seguridad social, acceso a instituciones de salud o son empleos en unidades económicas o empresas que se encuentran fuera de la formalidad. Sin embargo, éstos empleos no carecen de condiciones riesgosas y peligros laborales que vulneran la calidad de vida de quienes los realizan. Así, en México uno de cada dos trabajadores subsiste en la informalidad laboral y esta proporción parece estar aumentando en los últimos años, por lo que representa un desafío no solo en este país sino internacionalmente. Ante esta problemática, se reconoce que, por su complejidad, desde diversas perspectivas, económicas, sociales, ambientales, tecnológicas y de sostenibilidad, amerita un esfuerzo multidisciplinario para atender, reducir y mitigar sus efectos en la población laboral.

Este nuevo libro editado por la SEMAC, busca contribuir a dicha problemática y a otras, al generar conocimiento mediante el desarrollo de los interesantes estudios en el campo de la ergonomía como la evaluación del trabajo, diseño de puestos de trabajo, evaluación ergonómica y salud ocupacional, diseño del trabajo, antropometría, ergonomía industrial, ocupacional y organizacional, ergonomía cognitiva, desempeño humano en ambientes extremos, trabajos en situaciones especiales y estudios de fatiga.

Es una obra cuidadosamente editada, arbitrada e indizada que logra reunir autores que presentan casos de estudio, revisiones literarias e investigaciones originales, para ofrecer a los lectores un abanico de posibilidades, investigaciones y soluciones innovadoras y prácticas en el ejercicio y estudio de la ergonomía. Considero que, nuevamente se ha conseguido la meta de difundir y dar acceso libre a estos trabajos, los invito a leerlos, compartirlos y difundirlos para que sean de utilidad a aquellos estudiosos y practicantes de la ergonomía en México y el mundo y así se consiga el objetivo y lema de SEMAC “TRABAJO PARA OPTIMIZAR EL TRABAJO”.

Dra. Aide Aracely Maldonado Macías
PRESIDENTE DE SEMAC 2023-2024

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ANTHROPOMETRY OF THE STUDENT POPULATION FOR THE DESIGN OF UNIVERSITY SCHOOL FURNITURE

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Resumen: En México, el conocimiento y aplicación de la ergonomía es escasa lo que puede generar problemas al momento de interactuar con algún producto, maquinaria, herramienta o cualquier objeto que no cumple con las normas ergonómicas apropiadas. En esta investigación, se estudió el mobiliario de estudiantes universitarios; ellos tienen una jornada escolar mínima de 20 horas semanales, de las cuales aproximadamente el 80% del tiempo permanecen sentados varias horas consecutivas en un mobiliario que perciben disergonómico para ellos, mayormente porque no cumple con todas las necesidades antropométricas, y corren el riesgo de sufrir daño musculo esquelético o cualquier otro malestar (fatiga, cansancio, tensión muscular, etc.). Por lo tanto, se procedió a medir a los alumnos de una Universidad Pública del Estado de México para establecer una base de datos antropométrica y así obtener las medidas apropiadas de un mobiliario escolar. También se realizó una investigación documental sobre diseños factibles. Con la información obtenida de las medidas antropométricas se diseñó una propuesta de mobiliario con el propósito de reducir de manera considerable el riesgo ergonómico y ayudar a los estudiantes en su rendimiento académico con instalaciones más apropiadas.

Palabras clave: Antropometría, Ergonomía, Mobiliario, Población estudiantil

Relevancia para la ergonomía: La investigación aporta a la ergonomía de México una base de datos antropométricos que podrá utilizar la Universidad Pública estudiada para dar solución a otras problemáticas ergonómicas que existan o que puedan surgir, además de que también sirve para establecer una base de datos antropométricos para mayor población, ya sea a nivel estatal o nacional.

Abstract: In Mexico, the knowledge and application of ergonomics is scarce, which can cause problems when interacting with a product, machinery, tool or any object that does not comply with the appropriate ergonomic standards. In this research, the furniture of university students was studied; they have a minimum school day of 20 hours a week, of which approximately 80% of the time they remain seated for several consecutive hours in furniture that they perceive to be disergonomic for them, mainly because it does not meet all anthropometric needs, and they run the risk of suffering musculoskeletal damage or any other discomfort (fatigue, tiredness, muscle tension, etc.). Therefore, we proceeded to measure the students of a Public University of the State of Mexico to establish an anthropometric database and thus obtain the appropriate measurements of school furniture. Desk research on feasible designs was also carried out. With the information obtained from the anthropometric measurements, a furniture proposal was designed in order to considerably reduce the ergonomic risk and help students in their academic performance with more adequate facilities.

Keywords. Anthropometry, Ergonomics, Furniture, Student population

Relevance to Ergonomics: The research provides ergonomics in Mexico with an anthropometric database that the Public University studied can use to solve other ergonomic problems that exist or may arise, in addition to establishing an anthropometric database for a broader population. either at the state or national level.

1. INTRODUCTION

Anthropometry is a bloodless, inexpensive, portable and globally applicable technique for assessing the size, proportions and composition of the human body (World Health Organization, WHO, 1995). It is a discipline that serves as a tool to support the application of ergonomics, which according to the Council of the International Ergonomics Association (2000) is defined as "the science that studies how to adapt the relationship of human beings with their environment".

Anthropometric data are fundamental for the design in terms of user interaction, whether it is the design of a work area, a vehicle, machinery, furniture, clothing, etc., as this avoids ergonomic problems (musculoskeletal damage, circulatory problems, muscle pain, fatigue, among others). In the case of school furniture, anthropometry allows the student to sit in such a way that is comfortable, reduces ergonomic risk and gives some comfort to students to help them in their academic performance.

The problem is that, in Mexico, the knowledge and application of ergonomics is scarce which generates great ergonomic problems, an example would be in the case of students, the Ministry of Public Education (SEP) makes plans and curricula that makes them have a minimum school day of 4 hours and a maximum of 8 hours a day (generally university students are those who are a third of the day at the university), of which approximately 80% of the time they remain seated during their classes. This means that, taking into account that ergonomics is not very present in Mexico, students remain several consecutive hours in a seat that is not ergonomic for them or that does not meet their anthropometric needs, so that they run the risk of suffering musculoskeletal damage or any other ergonomic risk.

In Mexico, various researchers have conducted anthropometric studies of the Mexican population over the years to establish a database or to solve ergonomic problems, such as Dr. Enrique de la Vega, Prof. Mauricio López Acosta, Dr. Rosalío Ávila Chaurand, among others, each with their respective investigations and anthropometric studies. With the information that Mexico has, some safety or construction regulations have already been made, but it is still not enough to help Mexico with all the ergonomic problems it has.

This research aimed to contribute to ergonomics with an anthropometric database of a student population with the aim of developing school furniture suitable for their anthropometric needs.

1.1 Objectives

1.1.1 General Objectives

To develop furniture based on general and ergonomic standards to reduce ergonomic problems for students.

1.1.2. Particular Objectives

- Establish an anthropometric database of the student population.
- Improving academic performance through adequate school furniture

1.2. Delimitations

The research of the project was carried out within the geographical limits of Tultitlán, State of Mexico, only the student population of a Public University was observed.

2. Methodology

2.1. User-Product Interactions

The user, in this case a university student, when sitting at the desk interacts with the seat, the backrest and the table/work surface (as can be seen in figure 1). Therefore, the dimensions were grouped into seat dimensions, back dimensions, and worktable dimensions.

Figure 1 User-Product Interactions

2.2. Determination of dimensions and percentiles

Table 1 Dimensions and Percentiles

User-Product Interactions	Product Dimension Name	User Dimension Name	Ptil
Seat	**D1.** Seat height **D2.** Seat width **D3.** Seat depth	**1.** Popliteal height **2.** Hip width **3.** Sacro-popliteal distance	**1.** Ptil 50 **2.** Ptil 95 **3.** Ptil 5
Backrest	**D4.** Backrest width **D5.** Backrest height	**4.** Shoulder width **5.** Sitting shoulder height	**4.** Ptil 95 **5.** Ptil 95
Worktable	**D7.** Worktable height **D8.** Worktable width **D9.** Worktable depth	**6.** Sitting elbow height **7.** Bideltoid shoulder width **8.** Arm reach forward without grip (minimum and maximum**)**	**6.** Ptil 95 **7.** Ptil 95 **8.** Ptil 50

2.3. Collection of Anthropometric Data

A calculated sample of the school population of the University was taken and the necessary dimensions for the development of the project were obtained.

Subsequently, the mean, standard deviation and percentiles were obtained for each of the measurements obtained. Once these data are obtained, the dimensions of the school furniture will be obtained and thus be able to carry out the technical plans and reach the desired result.

To obtain the finite population sample, the Murray and Larry (2005) equation was used. Therefore, based on the research objectives, the universe size was 831 students, a standard deviation of .5, a confidence level of 95%, and a permissible sampling error limit of 5%. With these data, the formula would end like this:

$$n = \frac{(831)(1.96^2)(.5^2)}{.05^2(831-1) + (1.96^2)(.5^2)} \tag{1}$$

The result of this formula is 262.9369 but considering that it is not possible to have a population sample with a decimal point, it is rounded to the amount of 263. In this way, the necessary dimensions of the 263 students were obtained.

3. Results

3.1. Anthropometric Data

• Anthropometric measurements were performed on 263 students.
• Each of the dimensions obtained from each of the students was recorded (Table 2 shows an example of how the data obtained was recorded).

Table 2 Individual anthropometric data

Anthropometrics Data			
Age	22 years old	Gender	Masculine
Dimensions		Measures (cm)	
1. Stature		172	
2. Popliteal height		44.8	
3. Sacro-popliteal distance (SP)		42.7	
4. Sacro-patellar distance (SR)		53.6	
5. Thigh-Seat Height (MA)		9.9	
6. Elbow-Seat Height (CA)		17.2	
7. Minimum Arm Reach Forward Without Grip (AminB)		35.3	
8. Maximum Arm Reach Forward Without Grip (AmaxB)		69.2	
9. Shoulder-Seat Height (HA)		55.2	
10. Seated hip width (CdCd)		32	
11. Shoulder Width (HH)		38.2	

• The data obtained were analyzed and evaluated to later carry out the calculations to obtain the mean, the standard deviation and the percentiles, obtaining the following results (table 3).

3.2. Obtaining appropriate measurements for school furniture

The dimensions of the furniture were established based on the percentiles obtained. These dimensions were divided into the different parts of the furniture (Seat, Backrest and Worktable).

Table 3 Anthropometric data of the student population

Dimensions	Student population						
	X	**S**	Ptil 1	Ptil 5	Ptil 50	Ptil 95	Ptil 99
Popliteal height	44.43	4.30613769	34.4	37.3	44.4	51.5	54.4
Sacro-popliteal distance	42.48	7.4944496	25.0	30.2	42.5	54.8	59.9
Sacro-patella distance	51.30	8.65117353	31.2	37.1	51.3	65.5	71.4
Thigh-Seat Height	15.96	7.25861761	0	4.0	16.0	27.9	32.9
Elbow-Seat Height	24.09	6.18943025	9.7	13.9	24.1	34.3	38.5
Minimum Forward Arm Reach	40.80	9.87308006	17.8	24.6	40.8	57.0	63.8
Maximum Arm Reach Forward	64.55	6.30132462	49.9	54.2	64.5	74.9	79.2
Shoulder-Seat Height	56.77	6.83566168	40.9	45.5	56.8	68.0	72.7
Sitting hip width	42.29	7.94999065	23.8	29.2	42.3	55.4	60.8
Shoulder Width	40.06	5.8040314	26.6	30.5	40.1	49.6	53.6
Height	165.20	13.403036	134.0	143.2	165.2	187.3	196.4

3.3. Technical drawings and Renders

When finishing selecting the best and most appropriate proposal to solve the problem, the plans and renders were made for the graphic representation of the project in its technical, constructive, regulatory, and aspects of property.

3.3.1. Technical drawings

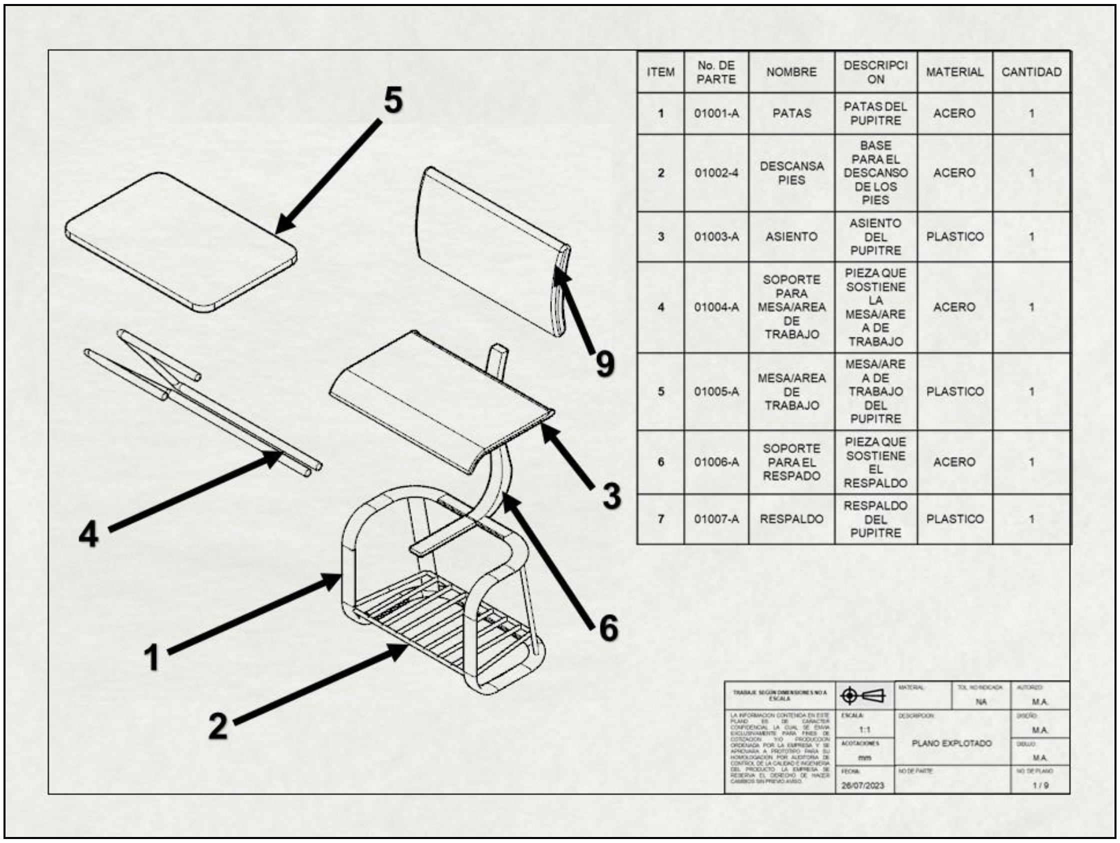

Figure 2 Exploded technical plane.

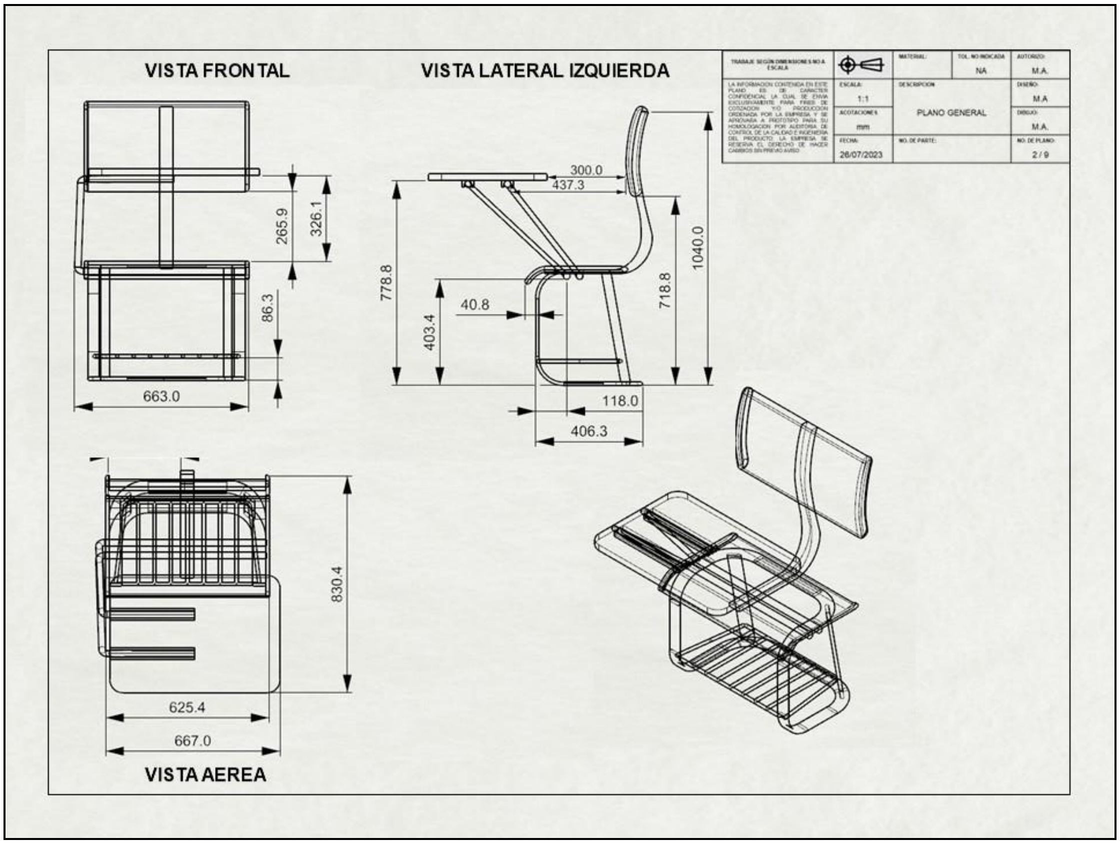

Figure 3 General technic plane

3.3.2. Render

Figure 4 Render

4. Conclusions

In this research we have observed the difference that exists when the anthropometric dimensions of the user are taken into account and when they are not, and not only in school furniture, but also in the work area or any product or object with which they interact. Students are more comfortable and are given comfort when their anthropometric needs are covered and that helps their academic performance.

Generally problems like this are generated because ergonomics is not taken into account or have the erroneous idea that the user has to adapt to the object to use it, when in fact it is the object that has to adapt to the needs of the user, so if there is an ergonomic problem based on anthropometry, the correct thing to do is to adapt the furniture, machinery or work area so that there is an interaction with the user in an appropriate, optimal and efficient manner.

Therefore, it is important to make Mexico aware of the importance of the application of ergonomics in design, the creation of more appropriate safety and health standards and to have an official anthropometric database at the national and state level, in this way, as in this research, a solution to certain ergonomic problems can be reached.

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EFFECTS OF MEDITATION TRAINNING ON TRAIL ANXIETY AND CONCENTRATED ATTENTION IN QUALITY INSPECTION TASK OF INDUSTRIAL WORKERS

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Resumen: La responsabilidad de la calidad de un producto está migrando a los departamentos de fabricación donde tienen lugar los procesos de montaje. En algunas industrias existen prácticas relacionadas con el control de calidad autónomo a las que les denomina autoinspección y que suele consistir en lo siguiente: el trabajador, después de realizar su tarea de montaje, comprueba la calidad de la pieza antes de que pase a su procesamiento posterior. La detección oportuna y la prevención de defectos por parte del trabajador aumentan la calidad al tiempo que reducen los costes por reprocesamientos y reclamaciones. Sin embargo, un efecto probable de esta condición puede que estos trabajadores se sientan abrumados, debido a la creciente complejidad de sus tareas, lo que puede llevar a una reducción de la concentración de la atención y, en algunos casos, ansiedad. El entrenamiento en meditación parece ser un medio para la autorregulación y un medio para alcanzar la conciencia que podría ayudar a reducir la ansiedad y mejorar la atención concentrada. A pesar del creciente interés en el impacto del entrenamiento en meditación, existe una escasez investigación fuera del contexto terapéutico. Este estudio explora el impacto de este entrenamiento sobre la atención concentrada y la ansiedad en trabajadores industriales implicados en tareas de autoinspección. El estudio fue de diseño experimental. Los participantes se dividieron aleatoriamente en dos grupos: el grupo de tratamiento (n=50) que recibió el entrenamiento en meditación y el grupo de control (n=50) que no recibió el entrenamiento. El grupo experimental recibió el entrenamiento en meditación de un especialista durante cuatro semanas. El estudio completo incluyó la administración de un cuestionario destinado a investigar las características sociodemográficas y tres instrumentos (cuestionarios) validados para la población Mexicana. La primera encuesta fue el Inventario de ansiedad (IA). El segundo instrumento fue la prueba de Toulouse (PT), La tercera prueba fue el cuestionario de Mindfulness (CM). Los datos se analizaron mediante un análisis descriptivo (análisis de porcentajes y frecuencias). Se utilizó un ANOVA de una vía en la prueba inicial para comparar cada uno de los resultados entre los grupos individualmente. El Modelo Lineal General (MLG) para medidas repetidas se empleó para comparar cada uno de los resultados por separado. Los resultados que el grupo de meditación presentó una reducción significativamente mayor de ansiedad entre la prueba inicial y la prueba final, en comparación con el grupo control. Con relación a la prueba de atención concentrada, hubo un efecto principal para el tiempo para la tasa de respuestas correctas, así como una interacción entre grupo vs tiempo para esta tasa. El grupo de tratamiento presentó un aumento significativamente mayor de respuestas correctas entre la prueba inicial y la final, en comparación con el grupo de control. En conclusión, este estudio proporciona evidencia preliminar de que un programa de entrenamiento de meditación focalizada (Mindfulness) en un periodo de veinte días continuos mejoró la ansiedad, y la atención focalizada en una muestra no clínica de trabajadores industriales dedicados a actividades de autoinspección.

Palabras clave: concentración, meditación, ansiedad, trabajadores industriales, inspectores.

Relevancia para la ergonomía: La presente investigación es un primer paso en la exploración de los efectos de la meditación sobre la ansiedad y la atención concentrada en trabajadores industriales. Los resultados mostraron que sus efectos específicos no están del todo claros, y menos aún los mecanismos que producen los efectos; sin embargo, el procesamiento estadístico de los datos ofrece una alternativa para determinar sus posibles interacciones. El avance en este intento puede resultar bastante difícil, pero los frutos potenciales de esta investigación hacen que el esfuerzo merezca la pena.

Abstract: The responsibility for quality is increasingly being transferred to manufacturing departments where assembly processes take place. In some industries there is a practice related to self-contained quality control which is called worker self-inspection which usually consists of the following: the worker after carrying out their assembly step, checks the quality of the workpiece before it goes on to further processing. Early defect detection and defect prevention by the worker increase quality while reducing costs for rework and complaints. However, they likely to feel overwhelmed by the increasing complexity in their tasks, which can lead to more concentrated attention and possibly leading to trait anxiety in some cases. Meditation training seems to be a means for self-regulation and a mean for achieve consciousness that could help in reducing trait anxiety and improving concentrate attention. Despite the growing interest on the impact of meditation training, there is a scarcity of evidence of research outside the therapeutic context. This study explores how this training impact concentrated attention and trait anxiety in industrial workers involved in self-inspection tasks. The study followed an experimental design. The study participants were divided randomly in two groups: the treatment group (n=50) that received the meditation training and the control group (n=50) that do not received the training. The experimental group received the meditation training from a specialist for four weeks. The complete study included the administration of a questionnaire aimed at investigating socio-demographic characteristics and three self-report instruments (questionnaires) validated for the Mexican population. The first self-report survey was the State-trait anxiety inventory (STAI). The second instrument was The Toulouse test (TT) used to measure attention span, perceptive acuity, a person's concentration, and resistance to monotony. The third test was the Trait mindfulness questionnaire (TMQ) is an established questionnaire that is used to assess trait mindfulness. Data was analyzed by using descriptive analysis (percentage and frequency analysis). A one-way ANOVA was used in the pre-test to compare each of the results between the groups individually. The General Linear Model (GLM) for repeated measures was employed in the post-test to compare each of the results separately. The meditation group presented a significantly greater reduction of the trait anxiety trait between the pre- and the post-test, in comparison with the control group. Referent to the test of concentrated attention, there was a main effect for time for the rate of correct answers, as well as an interaction between group vs time for this rate. The treatment group presented a significantly greater increase of correct responses between the pre- and the posttest, in comparison with the control group. In conclusion, this study provides preliminary evidence that a training program of twenty days straight of roughly 30 minutes of focused meditation (Mindfulness) was able to improve some psychological variables, especially trait anxiety, and focused attention in a non-clinical sample of industrial workers dedicated to self-inspection activities.

Keywords: Concentration, meditation training, anxiety, industrial workers, inspectors

Relevance to Ergonomics: The present investigation is a first step in exploring the effects of meditation on trait anxiety and concentrated attention in industrial workers. Results showed that its specific effects are not fully clear, and even less so are the mechanisms that yield the effects, however statistical data processing gives an insight in this matter. The advancement in this attempt might turn out to be quite difficult, but the potential fruits of this research make the endeavor worthwhile.

1. INTRODUCTION

The responsibility for quality is increasingly being transferred to manufacturing departments where assembly processes take place. An assembly process consists of several steps that are carried out by different employees one after the other. In some industries there is a practice related to self-contained quality control which is called worker self-inspection which usually consists of the following: the worker after carrying out their assembly step, checks the quality of the workpiece before it goes on to further processing. Worker self-inspection is an increasingly manufacturing practice and offers early identification of findings and error prevention (Safety and Health, 2021). Manufacturing companies can benefit from the introduction of worker self-inspection. Early defect detection and defect prevention by the worker increase quality while reducing costs for rework and complaints (ISO/TS 22367, 2008). However, they likely to feel overwhelmed by the increasing complexity in their tasks, which can lead to more concentrated attention and possibly leading to trait anxiety in some cases (Naragon et al., 2018). The ability to remain focused on goal-relevant stimuli in the presence of potentially interfering distractors is crucial for any coherent cognitive function such required for self- inspection tasks in industrial workers (Safety and Health, 2021). Concentrated attention on a task is vital for any coherent cognitive function, especially when there might be potential interference from distractors that are irrelevant for the task, which is the case when industrial workers are required to perform self-inspection activities. Research on the role of load in processing of task-relevant information in determining of task-irrelevant distractors have provided better understanding of the circumstances under which people can achieve coherent focused behavior with minimal intrusions of irrelevant information (Menezes and Bizarro, 2015). Anxiety is a feeling of uneasiness and worry, usually generalized and unfocused as an overreaction to a situation that is only subjectively seen as menacing. Anxiety is often accompanied by muscular tension, restlessness, fatigue, and difficulties in concentration (Hamaideh, S. H., 2018). Regarding emotional reactions in the industry workers, they experience a range of positive emotional reactions, such as pride, enthusiasm for work, and motivation to achieve success as well as negative affective responses that include anxiety, depression, anger, and guilt. Anxiety is associated with impaired work performance and safety. At the organizational context there are likely to be effects on productivity, absenteeism, and turnover (Safety and Health, 2021). On the other hand, it's reported that anxiety traits and role overload partially mediate the relationship between the interaction of high-performance work systems perceptions and job control (Lonigan and Phillips, 2001). In addition, employes exposed to anxiety are likely to experience fatigue and poor cooperation that weaken their performance (Linch et al., 2001). Meditation training seems to be a means for self-regulation and a mean for achieve consciousness that could help in reducing trait anxiety and improving concentrate attention (Tang et al., 2007). There are many varieties of meditation, the approaches differ in mental faculties such attention, reasoning, memory, or how these faculties are used (Sukhsohale, and Phatak, (2012). In practice, however it is difficult to find an approach to meditation that can be reduced to a single mechanism (Sedlmeier et al., 2012). The most pertinent personality trait to date for meditation-based interventions is likely trait mindfulness (also known as dispositional mindfulness). It refers to the innate ability to pay attention to present-moment experiences and to maintain that attention while maintaining an open and nonjudgmental attitude (Brown & Ryan, 2003). Given that one of the main objectives of meditation is to encourage present-moment awareness and attention (Menezes and Dell'Aglio (2010).

Despite the growing interest on the impact of meditation training, there is a scarcity of evidence of research outside the therapeutic context. This study explores how this training impact concentrated attention and trait anxiety in industrial workers involved in self-inspection tasks.

2. OBJETIVES

Concentrated attention is a crucial cognitive process. The capacity to concentrate one's psychological processes on something is referred to as attention. A system known as working memory has a limited capacity and is used to temporarily store and process current information. The working memory system uses attention as a cognitive resource to handle a variety of tasks (Soto et al., 2005; Kumar et al., 2009; Dunning and Holmes, 2014). Discussions have also centered on the issue of what psychological and environmental factors can affect attention and working memory.
In recent years, psychological research on mindfulness has become increasingly popular (Davidson, 2010; Brown et al., 2015; Lindsay and Creswell, 2017).
According to Medvedev et al. (2017), state mindfulness refers to the non-judgmental, moment-by-moment awareness that is felt at any given time. In terms of average frequency and intensity of mindful states over time, trait mindfulness or dispositional mindfulness refers to stable individual differences (Brown and Ryan, 2013; Jamieson and Tuckey, 2017; Mesmer-Magnus et al., 2017). It has been demonstrated that mindfulness practice, such as mindfulness meditation and some mindfulness-based interventions, can enhance the trait of mindfulness (Davidson, 2010). Therefore, the following objective is proposed:

a) To test if mindfulness meditation is positively related to concentrated attention in industrial quality inspectors in two different periods (before meditation and after meditation training).

According to Bouras and Holt (2007), anxiety is a feeling of unease and worry that is typically overstated and unfocused as a reaction to a situation that is only perceived as threatening by the individual. Muscle tension, restlessness, exhaustion, and concentration problems are frequently present during times of anxiety (American Psychiatric Association, 2013). It has been researched the impact of meditation techniques to reduce levels of anxiety (Brown and Ryan, 2013). Thus, the second objective of this study is the following:

b) To test if mindfulness meditation is positively related to trait of anxiety in industrial quality inspector in two different periods (before meditation and after meditation training).

3. METHODOLOGY

The study followed an experimental design The experimental group received the meditation training from a specialist for four weeks. The complete study included the administration of a questionnaire aimed at investigating socio-demographic characteristics and three self-report instruments (questionnaires) validated for the Mexican population.

3.1 Participants

Sample size consisted of one hundred industrial workers performing quality self-inspection tasks.

3.2 Study design

The study followed an experimental design, cross-sectional study. To know the impact of meditation training in self-inspection workers. the study participants were divided randomly in two groups: the treatment group (n=50) that received the meditation training and the control group (n=50) that do not received the training. Five daily meetings that were back-to-back in the meditation training each lasted about 90 minutes during the four weeks of study. The importance of attending all five days of the study was stressed to the participants, who were informed that skipping one or more meetings would result in their exclusion. The participants in the control group did not engage in any activity during this time, but they did receive the same instruction at the study's conclusion.

A psychologist with fifteen years of experience in group work, provided training to the workers.

3.2 Materials

The complete study included the administration of a questionnaire aimed at investigating socio-demographic characteristics and threeo self-report instruments (questionnaires) validated for the Mexican population. The first self-report survey was the State-trait anxiety inventory STAI (Pasquali, Pinelli Jnior, & Solha, 1994) that is a measure of trait anxiety with 20 questions, to measure trait anxiety. The questions for trait anxiety represent how the person typically feels. The responses use a four-point Likert scale, ranging from not at all to a lot, to indicate the levels of anxiety in these two situations. The level of anxiety increases as the score rises. For the scale of trait anxiety, the Spanish version had Cronbach’s alpha of 0.081, made in a pilot study by the authors.

The second instrument was The Toulouse test (TT) used to measure attention span, perceptive acuity, a person’s concentration, and resistance to monotony (Monzón et al. 2022). The test consists of detecting the symbols and crossing out the drawings that are identical to the sample, some small squares with little lines in different directions. The Toulouse test has a quantitative and a qualitative evaluation. The quantitative part analyses the amount of Hits: Number of figures marked by the evaluated person that are identical to the models provided. The number of correctly marked images should be greater than 100. This denotes a high sustained attention and concentration. Omissions: Correct answers that the reviewer missed and did not check. Errors: The number of figures different to the models provided that marked the person. Errors must not exceed two fifths of omissions. The test consists of detecting the symbols and crossing out the drawings that are identical to the sample, some small squares with little lines in different directions. The Toulouse test has a quantitative and a qualitative evaluation. The quantitative part analyses the amount of: Hits which are the number of figures marked by the evaluated person that are identical to the models provided. The number of correctly marked images should be greater than 100. This denotes a high sustained attention and concentration. Omissions are the correct answers that the reviewer missed and did not check. Errors are the number of figures different to the models provided that marked the person. Errors must not exceed two fifths of omissions. The total number of failures (omissions + errors) should not exceed 10% of the hits. The qualitative evaluation may yield some possible scenarios, such as: If the number of hits is less than 100 or 80, the person may have a mood inhibition. Likewise, a high score of hits, but with many errors and omissions, can denote a state of generalized anxiety. On the other hand, if the number of failures exceeds 10% of the hits, it is interpreted as a failure in concentration. The same can be sharpened in the case of exceeding 20% of failures between errors and omissions.

The third test was the Trait mindfulness questionnaire (TMQ) is an established questionnaire that is used to assess trait mindfulness (Baer et al., 2006). In the current study, the Spahis version of the TMQ was used. The validation of this instrument was done in a previous pilot study by authors. It consists of 39 items rated on a five-point Likert scale from 1 = never or very rarely true to 5 = very often or always true. The TMQ is composed of five subscales, including “observe,” “describe,” “act aware,” “non-judge,” and “non-react.” Item scores are summed to form a mindfulness score, with higher scores indicating higher levels of trait mindfulness. In this study, the Cronbach’s alpha value for this scale was 0.89.

3.3 Procedure

At the end of each week of study, they were administered the three instruments (in Spanish versions). The administration of surveys last for four weeks between April and May of 2023. Surveys were answered after 9.6 hours of uninterrupted work activity. This study was approved by the Research Ethics Committee of manufacture site. All the participants provided informed consent prior to the assessments.

3.4 Statistical data analysis

Data was analyzed by using descriptive analysis (percentage and frequency analysis). A one-way ANOVA was used in the pre-test to compare each of the results between the groups individually. The General Linear Model (GLM) for repeated measures was employed in the post-test to compare each of the results separately. Later, as needed, the ANOVA and polynomial contrasts were applied. The Pearson Partial Correlation test was also used in the post-test to assess the correlation between the outcomes within each group while adjusting the pre-test scores for each outcome. A significance level of 0.05 was used for all analyses, and SPSS version 24 was employed. The correlation between the trait anxiety, concentrated attention and meditation was found through simple correlation analysis, and then the Pearson correlation coefficient was estimated.

4 RESULTS

Trait anxiety and concentrated attention significantly differ in term of meditation training. According to the findings, as the meditation training is given, their trait anxiety (F=11,791; p<0,05) decreased and concentrated attention (F=22,172; p<0,05), increases. Contrary to this, for the control group the level of trait anxiety of the participants reduces, and concentrated attention reduces (F=8,466; p<0,05). The results are not as expected; however, it is necessary to perform the experiment considering the training time as a variable that can affect the expected results.

3.1 Sample demographics

One hundred percent of participants were women, who works for fiber optic harness manufacturing, from one shift. Age average is 21.28 years (SD 1.23) and almost a third of sample is married.

3.2 Descriptive data for outcomes evaluated.

Table 1 shows descriptive data for all the outcomes evaluated using a general linear model (GLM).

Table 1 General Linear Model (GLM) for Repeated Measures: Interaction of the Outcomes Between Time (Pre- vs. Post-Test) and Treatment Group and control group; Single-Factor ANOVA: Post-Hoc Comparison of the Outcomes (Mean and Standard Deviation) Between Pre- and Post-Test for Each Group

	GLM		ANOVA					
			Treatment Group			Control Group		
			Pre-test	Post-test		Pre-test	*n* = 50	
			n = 50	*n* = 50		*n* = 50	Post -test	
Questionnaires	F	η^2	Mean (SD)	Mean (SD)	η^2	Mean (SD)	Mean (SD)	η^2
Trait-Anxiety	0.52	0.25	3.8 (2.35)	3.5(1.229	0.53*	2.89 (0.65)	3.1(2.36)	0.69*
Concentrated attention	15.5	0.35	1.2(0.53)	1.4(1.11)		2.40(0.45)	2.21(1.36)	
Correct responses	5.8	0.04	125 (5.99)	157 (6.78)	0.75*	165 (5.6)	189.6(5.2)	0.57*
Errors	0.15	0.03	0.85(1.08)	4 (1.19)		0.63(0.65)	0.538.359	
Omissions	0.18	0.02	12.5(1.1)	5(2.55)		1.36(0.85)	3.6980.589	
Total score	0.75	1.2	89.5 (15.8)	136.8(1.25)		75.8 (25.6)	105.23(12.5)	

Note:*p<0.05

In relation to the trait anxiety, there was main effect for time as well as interaction between group vs time. The meditation group presented a significantly greater reduction of the trait anxiety trait between the pre- and the post-test, in comparison with the control group. Referent to the test of concentrated attention, there was a main effect for time for the rate of correct answers, as well as an interaction between group vs time for this rate. The treatment group presented a significantly greater increase of correct responses between the pre- and the posttest, in comparison with the control group. Significant responses were not found for the other rates of concentrated attention (error, omission, or total score: $p > .05$).

The findings demonstrated that, when compared to a control group, meditation training resulted in significant and advantageous changes, including a decrease in the self-reported scores for trait anxiety as well as improved performance on the concentrated attention tests, as shown by a higher rate of correct answers. These findings corroborate those of other studies (Tang et al., 2007; Zeidan, Johnson, Diamond, et al., 2010) that also assessed emotional and attentional variables after brief interventions lasting three to seven days. Additionally, the findings support the literature on brief training programs by showing that beneficial outcomes can also result from a focused meditation intervention.

Focused attention and mindfulness meditation, also known as open monitoring meditation, have been discussed and shown to involve some unique and specific processes and mechanisms (Lutz et al., 2008; Tang and Posner, 2013). For instance, it has been suggested that mindfulness practices are more conducive to producing insights into the nature of mental processes, whereas concentrative meditation is more related to improving mental stability (Lutz et al., 2008). But from a psychological standpoint—whether cognitive, emotional, social, or behavioral—different practice methods appear to produce equivalent changes, like the suppression of unpleasant emotions and an improvement in attentional capacity (Sedlmeier et al., 2012). It has been proposed that an increase in mindfulness may aid in reducing a process that gives preference to negative emotions by reducing the bias for negative stimuli. People who practiced meditation for one fifteen minute session before taking a verbal learning test that included words with negative, positive, and neutral valence remembered significantly fewer negative words in the delayed recall task than a control group who did not meditate (Alberts and Thewissen, 2011). This finding is consistent with the reduction of negative affect in the current study.

5. CONCLUSIONS

In conclusion, this study provides preliminary evidence that a training program of twenty days straight of roughly 30 minutes of focused meditation (Mindfulness) was able to improve some psychological variables, especially trait anxiety, and focused attention in a non-clinical sample of industrial workers dedicated to self-inspection activities.

This work, which is a pilot study, has some significant methodological flaws, including a small sample size, and the failure to assess the individual effects of the intervention. The study did not assess neurophysiological responses or use a psychometric measure of mindfulness, so some of the hypotheses considered should be taken with caution. A further drawback of this study is the lack of follow-up, which prevents conclusions about the durability or permanence of the changes seen from being drawn.

The observed changes support the inclusion of meditation trainings in a variety of settings, including other educational, services for mental and physical healthcare, and even in the context of individual interventions, whether in the public or private sectors.

Declaration of competing interest

The authors affirm that no commercial or financial connections existed that might be interpreted as creating a conflict of interest during the conduct of the study.

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STUDY OF MENTAL WORKLOAD AND HUMAN ERROR IN THE TOOLING DESIGN PROCESS FOR THE SOLDERING OF ELECTRONIC BOARDS.

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Resumen: Ciudad Juárez México, una empresa de diseño y manufactura de herramentales para procesos de soldado de tablillas electrónicas cotidianamente atiende situaciones apremiantes de requerimientos de clientes en limitados periodos de tiempo. Estas situaciones de premura alteran las capacidades de respuesta y afectan directamente a los ingenieros del departamento de diseño, ya que propician condiciones estresantes de presión, fatiga, frustración entre otras y derivan en exigencias de recursos y capacidades cognitivas provocando fallas del proceso, errores de diseño y rechazos de calidad. Esta investigación pretende determinar fuentes principales de carga mental del personal, así como analizar los errores cometidos en el proceso. La metodología consta de 3 fases. En la primera, se realizó un Análisis Jerárquico de Tareas para estructurar las tareas del proceso. En la segunda fase, se efectuó una valoración de carga mental a 8 diseñadores con NASA TLX. En la tercera fase, se utilizó el análisis sistemático para la reducción y predicción del error humano para la identificación de los errores. Como resultados, se presenta el análisis jerárquico de tareas de la primera tarea del proceso con 5 subtareas. En cuanto a la carga mental, el 75% de la muestra presenta un nivel de carga mental alta y el resto presentó carga mental media. El rendimiento y las exigencias mentales resultaron las fuentes relevantes de carga mental. En cuanto al error humano, el 55% fueron de verificación, 26% de comunicación y 19% de verificación. Se concluye que los análisis realizados contribuyen a incrementar el conocimiento sobre las exigencias de la tarea de diseño y proponer cambios en los procedimientos como en los métodos existentes en la empresa para el diseño y desarrollo del producto.

Palabras clave: Carga Mental de Trabajo, Error Humano, Nasa TLX

Relevancia para la ergonomía: Esta investigación contribuye a la representación y estudio de las tareas realizadas en el diseño de herramentales para el soldado de tablillas electrónicas. Este estudio evalúa el nivel de carga mental percibida, así como el de los errores humanos que se presentan en un equipo de diseñadores. Las características del entorno y las condiciones emergentes que se presentan se manifiestan de forma contundente y fomentan situaciones en las que debido a la saturación de tareas en el individuo se presenta carga mental y sus efectos.

La publicación de este artículo es importante ya que representa resultados de interés y relevancia para aquellos individuos cuyos campos de trabajo estén relacionados con procesos de diseño y desarrollo del producto, producción o manufactura, ya que aquí encontrarán resultados que ayuden a comprender de una manera más clara algunas de las razones causantes del error humano y la carga mental que pueden influir en el desempeño de las tareas.

Abstract: Ciudad Juarez Mexico, a company that designs and manufactures tooling for soldering processes of electronic boards daily attends to urgent situations of customer requirements in limited periods. These situations of urgency alter the response capabilities and directly affect the engineers of the design department, since they cause stressful conditions of pressure, fatigue, and frustration, among others, and derive in demands of resources and cognitive capabilities, causing process failures, design errors, and quality rejections. This research aims to determine the main sources of the mental workload of the personnel, as well as to analyze the errors committed in the process. The methodology consists of 3 phases. In the first phase, a Hierarchical Task Analysis was performed to structure the process tasks. In the second phase, a mental workload assessment was performed on 8 designers with NASA TLX. In the third phase, systematic analysis for human error reduction and prediction was used to identify errors. As a result, the hierarchical task analysis of the first task of the process with 5 subtasks is presented. Regarding mental workload, 75% of the sample presented a high mental workload level and the rest presented a medium mental workload. Performance and mental demands were the relevant sources of mental workload. As for human error, 55% were verification, 26% were communication and 19% were verification. It is concluded that the analyses carried out contribute to increasing the knowledge about the demands of the design task and propose changes in the procedures and methods existing in the company for the design and development of the product.

Key words: Mental Workload, Human Error, Nasa TLX.

Relevance to ergonomics: This research contributes to the representation and study of the tasks performed in the design of tooling for the soldering of electronic boards. This study evaluates the level of perceived mental workload, as well as the level of human errors that occur in a team of designers. The characteristics of the environment and the emergent conditions that are presented are strongly manifested and promote situations in which, due to the saturation of tasks in the individual, mental load and its effects are presented.

The publication of this article is important because it represents results of interest and relevance for those individuals whose fields of work are related to design processes and product development, production, or manufacturing since here they will find results that help to understand in a clearer way some of the reasons causing human error and mental load that can influence the performance of tasks.

1. INTRODUCTION

In the design department of a manufacturing company in Cd Juarez Chihuahua Mexico, a team of engineers designing tooling for electronic boards, generates failures or errors frequently in the design process. These errors or faults can vary from minor to serious, of which the minor is easily recovered by updating digital information or reprinting a document. However, there are serious failures that generate additional costs and time in the development of the product, which represents an economic loss for the company. The tooling is a device that provides fastening and support to the splint in the wave soldering process and its design implies the realization in the first instance of a 2D and/or 3D drawing representative of the general geometries of both the splint and the tooling. Its design is relevant since the efficiency of the wave soldering process will largely depend on it, as well as the protection of the board to avoid any damage it may suffer and lead to a loss of the part. In this study, a task analysis will be developed, and the mental workload and the human error in the tooling design process for electronic boards will be analyzed, so it is important to define the topics and other relevant aspects.

Hierarchical Task Analysis (HTA) (Navas de Maya et al., 2022), uses the concept of "operation", a unit of behavior defined in terms of its objectives, of any degree of complexity and any duration (Annett and Duncan, 1967). These operations can be broken down into sub-operations, but sub-operations are themselves operations and can be further broken down. According to Kirwan and Ainsworth (1992), hierarchical task analysis (HTA) is the "best-known task analysis technique" among ergonomic methods, and it continues to be employed as it remains a central focus for cognitive analyses (Stanton 2005).

On the other hand, the National Institute of Occupational Safety and Health (INSST), O.A., M.P. (Divulgations, 2019), explains that despite the disparity of existing definitions, there is a certain degree of agreement on the content of the "subjective" mental workload and it is assumed that it is a consequence of three major dimensions (Ferrer, Dalmau, 2004); (Díaz Canepa, 2010) among which are: time pressure of the task (time available, time needed); amount of processing resources demanded by the task (whether mental, sensory, etc.); emotional aspects (fatigue, frustration, etc.). One of the most recognized methods is the NASA TLX, which proposes a multidimensional assessment procedure that gives an overall workload score, based on a weighted average of the scores in six subscales, whose content is the result of research aimed at empirically isolating and defining the factors that are of relevance in the subjective experience of workload. These subscales are mental demands, physical demands, time demands, performance levels, effort levels, and frustration levels. The concept of workload cannot be defined only in terms of task demands but is the product of a combination of factors among which subjective appraisal of workload is of particular importance. The NASA method, starting from these criteria, establishes firstly the need to define the sources of load and secondly establishes the assessment of these. The objective pursued in its design was to achieve a scale sensitive to variations within and between tasks, with diagnostic capacity on the sources of load and relatively insensitive to interpersonal variations (Ministry of Labor and Social Affairs Spain & INSHT, 2000).

As for human error, it is defined as the incorrect or inappropriate execution of an action, specifically the failure to act. In other words, an error is a failure to perform an activity that produces an undesirable or unacceptable result (Chamby, 2018; Correa Torres, 2021; Reason, 1990). The process of human error analysis is known as "human reliability", and for this, there are several methods for error analysis that allow to identification and classify the error, while others the probability of occurrence of the same. The identification methods are based on classification or taxonomies established from studies on human cognitive processes. A very flexible method of relative simplicity is the Systematic Human Error Reduction and Prediction Approach (SHERPA) method (American Nuclear Society. Human Factors Division. et al., 1986); (Ghasemi et al., 2013). This method allows the structured identification and classification of error modes associated with specific operations within a task. The method was developed in the UK by Professor David Embrey, (1986) and is inspired by the well-known system reliability methods FMAS (Failure Modes and Effect Analysis) and HAZOP (Hazard and Operability Study).

To pose the research problem, evidence is presented that mental workload and human errors of various categories can have effects on organizational performance, product design, and development (Salas-Arias et al., 2018), (Angel et al., 2013). Such effects impact product development and quality. In this work, the mental workload and human error in tooling design processes for electronic tablet soldering will be studied. Initially, the data provided by the internal quality department of the company shows the most recurrent errors in the years 2019, 2020, and 2021, the information is presented in Figure 1. According to this histogram, outdated information stands out as the most frequent error in three consecutive years and presents an increasing trend. This problem occurs when changes or updates are made to either the design of the tooling or the tooling and such information is not communicated on time to the design team, thus generating an erroneous or obsolete tooling design or verification, affecting the manufacturing of the tooling. The next most recurrent error is the lack of information. It occurs when the details of the requirement are not fully exposed, as well as all the elements or specifications that the tooling design must include for its correct functionality. Lastly, and less frequently, errors with different engravings are recorded; this error is reported when the physical tooling has a different legend than the one indicated on the part drawing, and it is not known with certainty which information is correct. This is due to the previous errors in not verifying or ensuring that the design information is up to date.

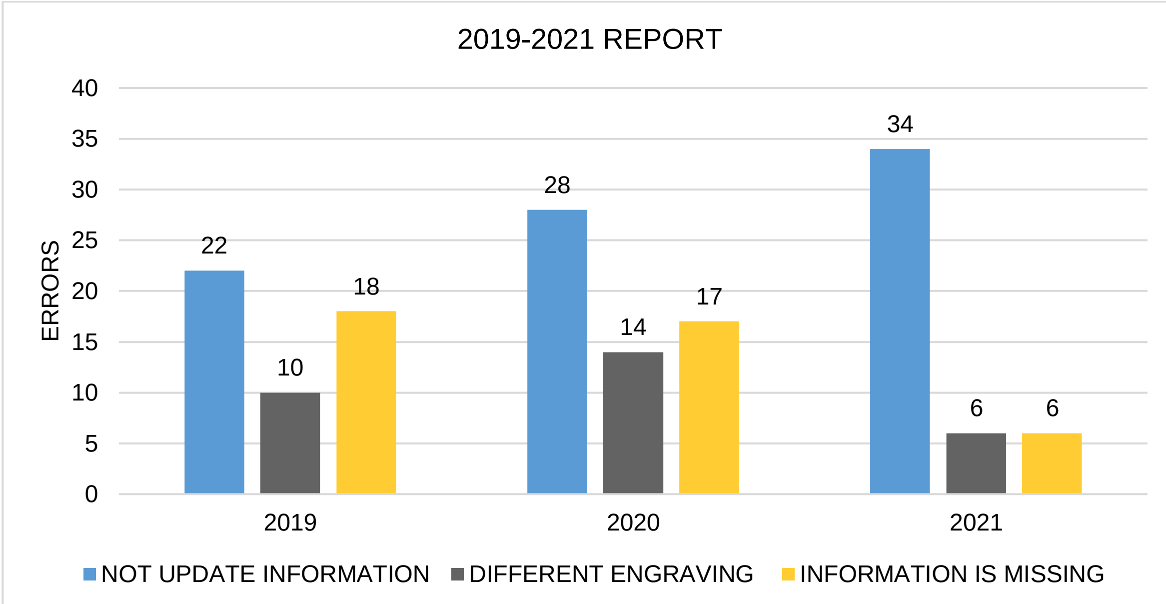

Figure 1. Quality department errors report.

2. OBJECTIVES

The general objective is to analyze the mental workload and identify and classify human errors in the design of tooling for soldering electronic boards associated with the company's quality problems to propose changes in the design process.

As particular objectives:

1. Develop a Hierarchical Task Analysis (HAT) of the tooling design process for the soldering process of electronic boards.
2. To evaluate the mental workload of the designers.
3. Identify human errors in the process.

3. DELIMITATION

This project seeks particularly to analyze and determine the most important sources of mental workload in the engineers of the design department of a company in Cd. Juarez Chihuahua is dedicated to the design and manufacture of mechanical tooling for the soldering process of electronic boards. Only the task of reviewing information for impact on the product design process will be studied and only the tooling for wave soldering for individual type boards will be studied. Also, human error will be analyzed by a taxonomy method.

4. METHODOLOGY

This descriptive study seeks to determine the main sources of mental workload and to classify human error in the design process. The study will be conducted in three stages according to Figure 2. In the first stage, an HTA will be performed to break down the operations of the information review task process. In the second stage, the NASA TLX method will be applied to a convenience sample of 8 volunteers in the group. The sample comprises individuals between 25 and 45 years old, seven of them male and one female, and the weighted and unweighted mental workload of the information review task will be obtained. Finally, in the third stage, human error will be classified and analyzed with the SHERPA method, and the type of error associated with the specific operations within the task will be identified with the established taxonomies.

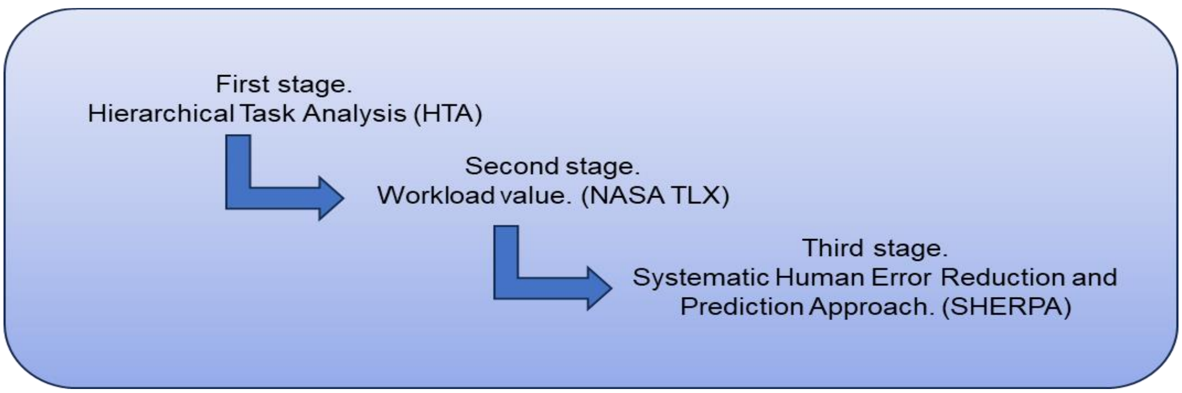

Figure 2. Methodology Stages.

First stage. Hierarchical Task Analysis (HTA). The HTA was carried out according to the methodology proposed by Stanton (2005). Flowchart shown in Figure 3.

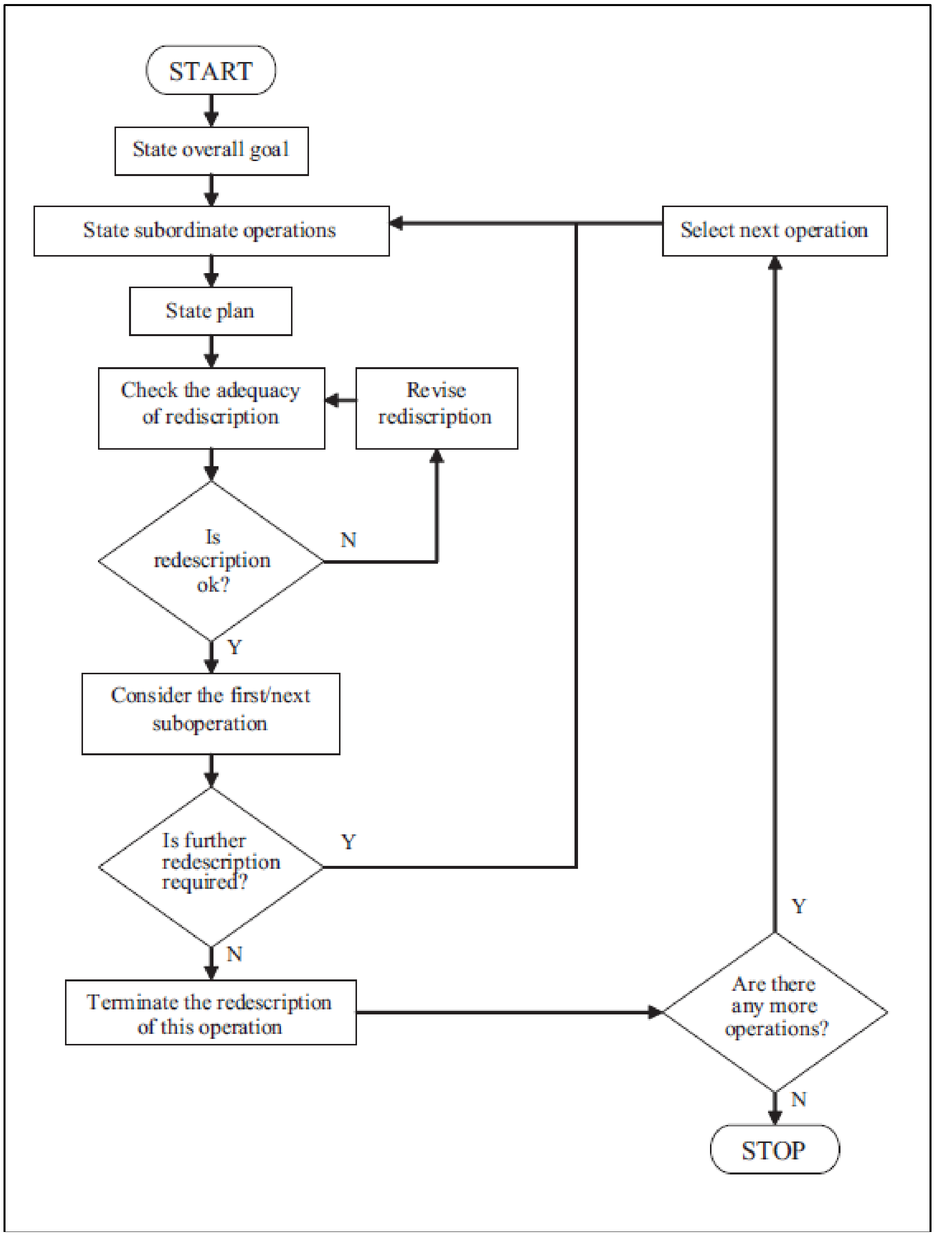

Figure 3. Methodology proposed (HTA) by Stanton (2005).

Second stage. Mental workload assessment with NASA TLX. In this stage the method will be applied by applying it to 8 members of the design team in two phases: a weighting phase that is performed at the time prior to task performance using the format in Figure 4 and another scoring phase immediately after task performance using the format in Figure 5.

From the following questions, please choose one option that you consider to be causing you the greatest workload. Please circle or mark with an "X" the box for each of the combinations shown.				
MENTAL DEMAND? (M)	MENTAL DEMAND? (M)	MENTAL DEMAND? (M)	MENTAL DEMAND? (M)	MENTAL DEMAND? (M)
OR	OR	OR	OR	OR
PHYSICAL DEMAND? (F)	TEMPORAL DEMAND? (T)	PERFORMANCE? (E)	EFFORT? (R)	FRUSTRATION LEVEL? (Fr)
PHYSICAL DEMAND? (F)	PHYSICAL DEMAND? (F)	PHYSICAL DEMAND? (F)	PHYSICAL DEMAND? (F)	TEMPORAL DEMAND? (T)
OR	OR	OR	OR	OR
TEMPORAL DEMAND? (T)	PERFORMANCE? (E)	EFFORT? (R)	FRUSTRATION LEVEL? (Fr)	PERFORMANCE? (E)
TEMPORAL DEMAND? (T)	TEMPORAL DEMAND? (T)	PERFORMANCE? (E)	PERFORMANCE? (E)	EFFORT? (R)
OR	OR	OR	OR	OR
EFFORT? (R)	FRUSTRATION LEVEL? (Fr)	EFFORT? (R)	FRUSTRATION LEVEL? (Fr)	FRUSTRATION LEVEL? (Fr)
WEIGHTING RESULTS				
M			DATE:	
F				
T				
R			NAME:	
FR				
E				
TOTAL				

Figure 4. Weighting phase.

DATE:											NAME:										
The purpose of this survey is to assess the mental workload of the persons evaluated. Please answer all questions. Please tick the box appropriate to your level of perception of the activities you perform, on a scale from 5 to 100, where 5 represents the lowest level and 100 the highest level of mental workload.																					
TASK DESCRIPTION									*REVIEW DESIGN PROCESS INFORMATION: 1.1 DESIGN ORDER, 1.2 SALES ORDER, 1.3 COMPLETE GERBER FILE, 1.4 EDIT FILE, 1.5 CONVERT FILE TO DXF.*												
MENTAL WORKLOAD ASSESSMENT																					
DIMENSION	PLEASE A MARK AT THE DESIRED POINT ON EACH SCALE																				DESCRIPTIONS
	LOW																			HIGH	
MENTAL DEMAND (M)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	How much mental or perceptual activity does it require (e.g. thinking, deciding, calculating, remembering, observing, reading, searching)? Is the task easy or difficult, simple or complex, heavy or light?
	LOW																			HIGH	
PHYSICAL DEMAND (F)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	How much physical activity is required for (e.g. pushing, pulling, turning, controlling, activating, carrying)? Is the task slow or fast, relaxed or tiring?
	LOW																			HIGH	
TEMPORAL DEMAND (T)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	How much time pressure (e.g. time, pressure from someone, etc.) do you feel because of the pace at which activities or elements of activities happen?
	GOOD																			BAD	
PERFORMANCE (E)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	How hard do you have to work (physically or mentally) to reach your level of success in the activities?
	LOW																			HIGH	
EFFORT (R)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	How satisfied are you with your performance in the activities you do?
	LOW																			HIGH	
FRUSTRATION LEVEL (Fr)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	During the activities, to what extent did you feel insecure, discouraged, irritable, tense or worried?

Figure 5. Scoring phase

Third Stage. SHERPA methodology. In this stage, the methodology proposed by Stanton 2005 was developed. Thus, once the HTA was performed, the task is classified from the lower level of the HTA to the higher level and the error modes were classified according to the SHERPA taxonomy shown in Figure 6. He must then determine and describe the consequences associated with each error mode; in addition, he must determine the recovery from the identified error. Also, once these steps are completed, the probability of occurrence of the error, its criticality, and how to remedy it through redesign, equipment modification, personnel training, changes to procedures, or changes in organizational culture and policies.

Action error		Checking error	
A1	Operation too long/short	C1	Check omitted
A2	Operation mistimed	C2	Check incomplete
A3	Operation in wrong direction	C3	Right check on wrong object
A4	Operation too little/much	C4	Wrong check on right object
A5	Misaligned	C5	Check mistimed
A6	Right direction on wrong object	C6	Wrong check on wrong object
A7	Wrong operation on right object	Selection error	
A8	Operation omitted	S1	Selection omitted
A9	Operation incomplete	S2	Wrong selection made
A10	Wrong operation on wrong object		
Retrieval error		Information communication error	
R1	Information not obtained	I1	Information not communicated
R2	Wrong information obtained	I2	Wrong information communicated
R3	Information retrieval incomplete	I3	Information communication incomplete

Figure 6. Taxonomic error mode.

5. RESULTS

The results of this research have been organized by stages and are shown below.

First stage. Hierarchical task analysis. Figure 7 shows the HTA for the task selected and shown highlighted in green broken down into 5 subtasks. These tasks are mainly information verification and editing, they follow a linear plan from 1.1 to 1.3 and then move to a branched plan in 1.4 and 1.3 ending with task 1.5 to transform the file to DXF.

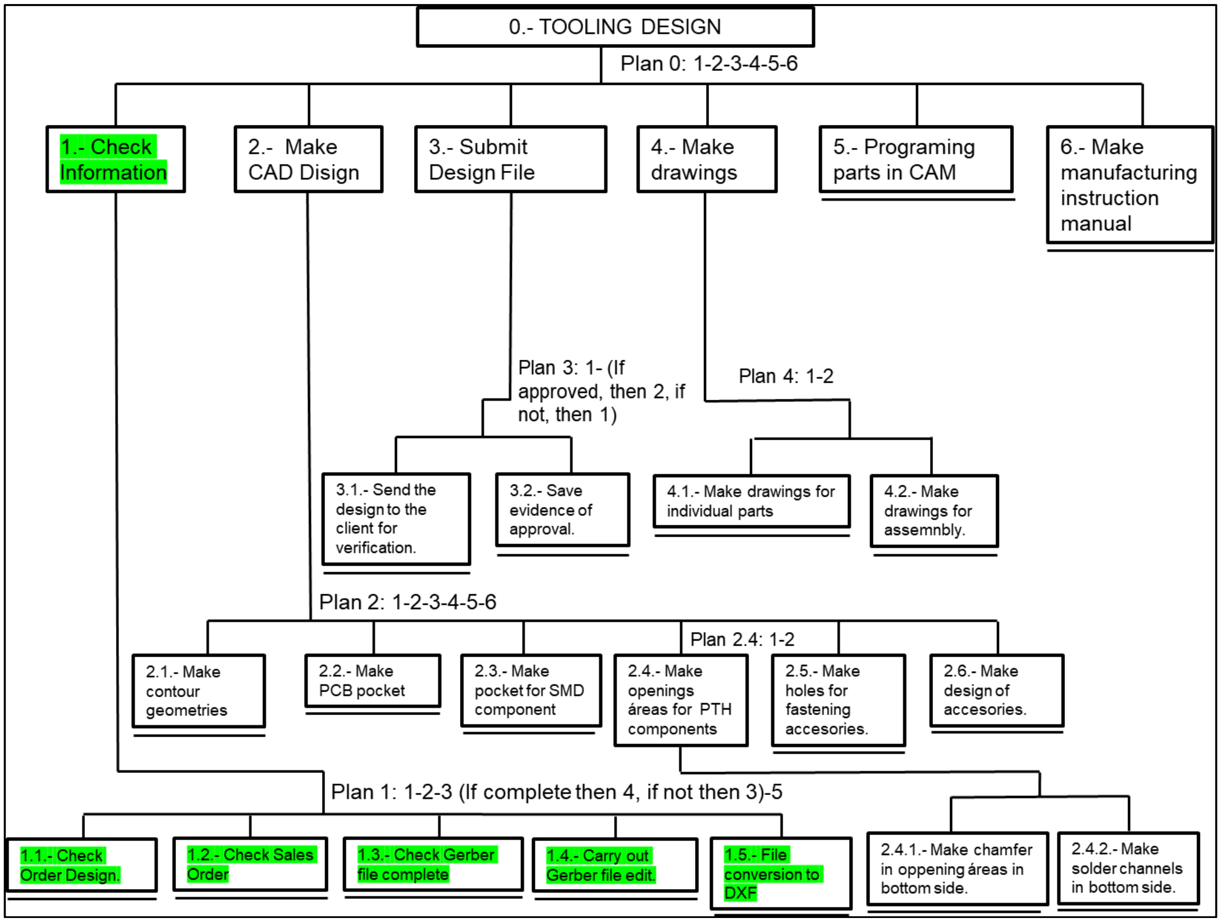

Figure 7. Hierarchical Task Analysis (HTA).

Second stage. Mental workload assessment. The results of the weighting stage are shown in Table 1 for the participant with the highest perceived mental workload.

Table 1. Weighted average rating of the highest recorder.

NAME:	N.A.			
VARIABLES	WEIGHT	SCORE	CONVERTED SCORE	WEIGHTED SCORE
MENTAL DEMANDS	3	16	80	240
PHYSICAL DEMANDS	0	4	20	0
TEMPORARY DEMANDS	3	10	90	270
EFFORT	1	15	70	70
PERFORMANCE	5	15	95	475
FRUSTATION	3	10	70	210
TOTAL	15			1265
			OVERALL WEIGHTED AVERAGE	84.33333333

Figure 8. Shows the results of the 8 evaluated participants.

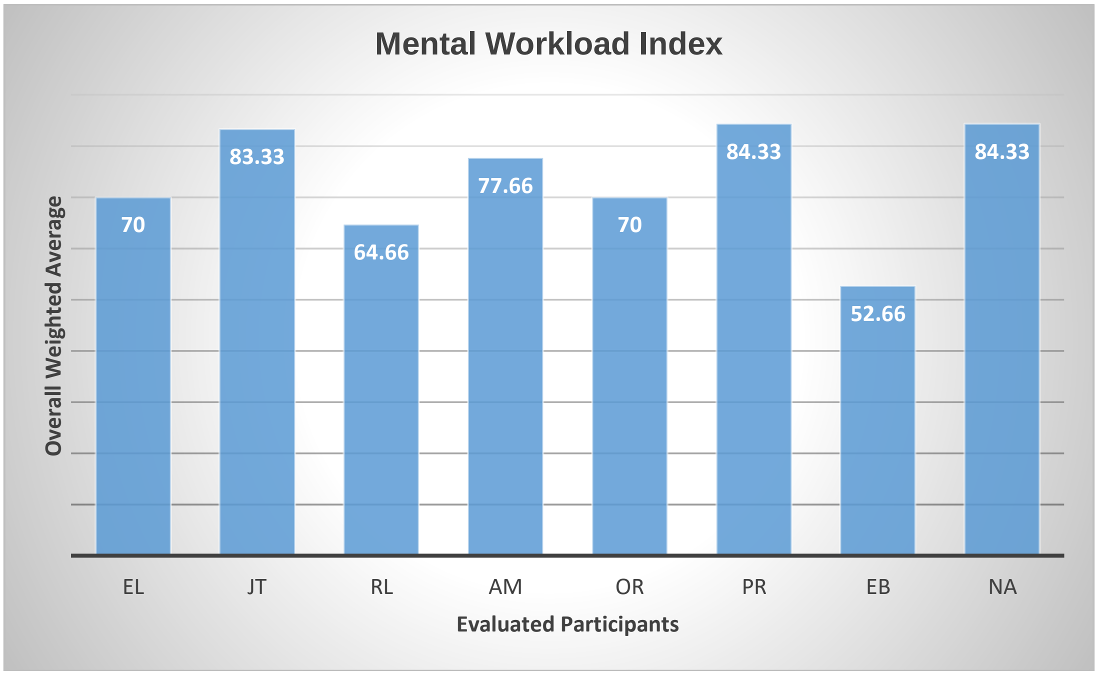

Figure 8. Mental workload index.

The information obtained after the weighting phase and obtaining the average weighted mental workload and using the cut-off values proposed by Hart and Staveland (1988) is shown in Table 2.

Table 2. Cut-off values

Workload	**Value**
0-50	Low
51-69	Medium
70-100	High

It was determined that 75% of the sample presented a high mental workload, while the rest presented a medium mental workload. It is important to define the main sources of mental workload perceived by the participants; to this end, Figure 9 presents the dimensional values obtained from the entire sample and shows that according to the NASA TLX analysis, performance, mental demands, and frustration are the dimensions with the highest scores and are identified as the main sources of mental workload perceived by the participants.

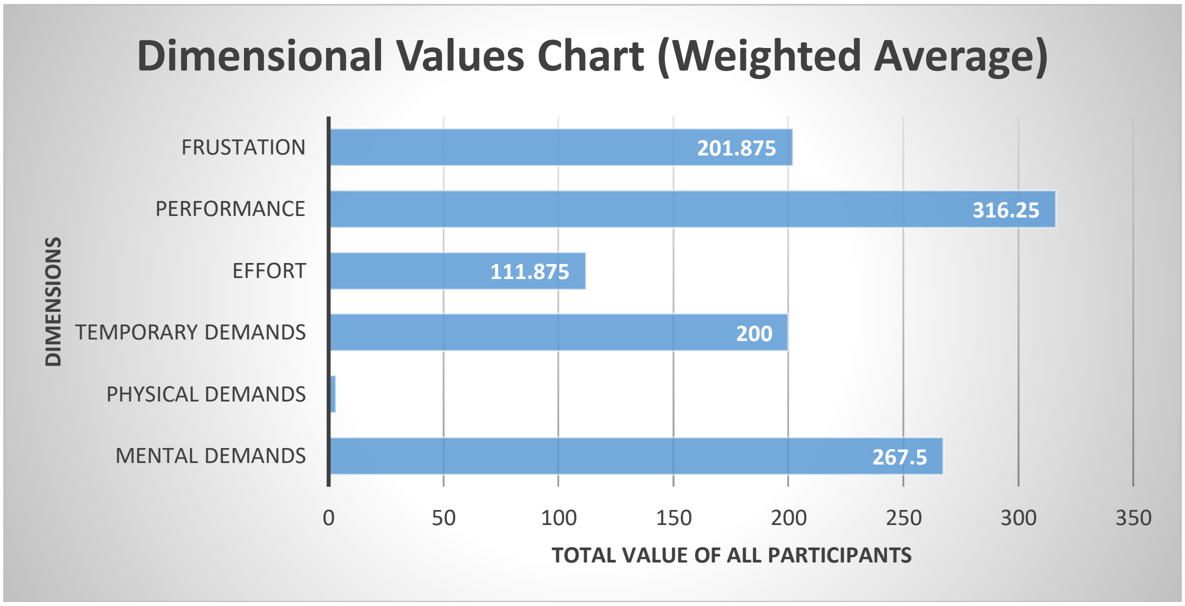

Figure 9. Graph of dimensional values.

Third stage. SHERPA. According to the information provided by the company's internal quality department and based on the methodology used, the errors were classified according to the taxonomies corresponding to the method. Based on the HTA and the SHERPA method, a total of 165 errors were identified during the tooling design process. Fifty-five percent of the errors are action errors, 26% are communication errors and the rest are verification errors. The complete information on the SHERPA analysis is shown in Table 3.

Table 3. SHERPA method results.

TASK	Error Mode	Error Description	Consecuences	Recovery	P	C	Recovery Strategy
1.1.- Check Order Design.	C1	No reading information	Carry out wrong design	Immediately	L	L	Leer requerimientos de orden de diseño
	I1	Information not communicated	Carry out incorrect design	No recovery	M	M	Confirm Infortation with sales department
	I2	Erroneous information communicated	Carry out incorrect design	No recovery	L	M	Confirm Information with sales department
1.2.- Check Sales Order.							
1.3.- Check Gerber file complete.	A6	The verified file is not the correct one	Verification to wrong file	No recovery	L	L	Confirm Information with customer
	R1	The file is not present, or is corrupt and cannot be opened.	Verification is not possible.	Immediately	M	L	Request information.
	R2	The verified file is not the correct version or model.	Verification to wrong file	No recovery	L	L	Confirm Information with customer
	R3	The file is incomplete	cannot be processed	Immediately	L	L	Request missing information.
1.4.- Carry out Gerber file edit.	A6	That the edit is to the wrong file.	Edit to the wrong file. Time lost.	No recovery	L	M	Confirm Information with customer
	C3	That the edit is to the wrong file.	Edit to the wrong file. Time lost.	No recovery	L	M	Confirm Information with customer
1.5.- File conversion to DXF.	A6	Conversion to the wrong file	Conversion to the incorrect file.	No recovery	L	M	Confirm Information with customer
	C3	Revision to the wrong file	Conversion to the incorrect file.	No recovery	L	M	Confirm Information with customer

The highest frequency of errors is highlighted in those of action, which are attributable to tasks not being performed or being performed inadequately. The most critical error is "not reading the indications of the requirement" which can be remedied by establishing a verification control to ensure that the information was read and understood. Communication errors are linked to the omission of information which may be basic or relevant to the performance of the task, the most critical error is when "information is modified and not reported" and can be remedied by establishing a control to ensure that the information received and delivered has been updated. Verification errors arise from not ensuring the correct performance of the task, the most critical error is "not making the checks corresponding to the tasks performed" and can be remedied by establishing a checklist.

6. CONCLUSIONS

As conclusions of this research, the hierarchical task analysis carried out in a structured way to the first task or phase of the process helped to understand in an orderly manner the activities performed by the individual, the use of this tool provided essential information to perform the evaluation of mental workload and human error.

The results obtained from the mental workload analysis of the individuals evaluated showed that 100% of these individuals have medium to high levels of mental workload in their daily work tasks according to the NASA TLX mental workload assessment index, which leads to taking strategic organizational improvement measures to reduce the levels of mental workload and avoid subsequent health problems for these individuals.

On the other hand, the SHERPA error analysis method contributed to classifying the errors and thus provide a starting reference for the company and establish different strategies to ensure the correct performance of each of the tasks in order to reduce or eliminate human error in the process. It is also observed that the errors mentioned and identified by SHERPA coincide with the errors reported by the company's quality department, which are the source of product defects.

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NEUROERGONOMICS: A LITERARY REVIEW ON THE CONNECTION BETWEEN NEUROSCIENCES AND COGNITIVE ERGONOMICS

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Resumen: En los últimos años, el impacto de las neurociencias en diversas áreas de conocimiento y disciplinas ha trascendido significativamente los confines médicos. La investigación neurocientífica, centrada en el análisis del comportamiento del sistema nervioso central, ha arrojado luz sobre la manifestación de emociones, tanto positivas como negativas, así como sobre las conductas y funciones corporales fundamentales desencadenadas por una variedad de estímulos.

Este artículo tiene como objetivo explorar la estrecha relación entre la neurociencia y un ámbito clásico de la Ingeniería Industrial: la ergonomía. El propósito fundamental radica en discernir las conexiones y coincidencias entre ambas disciplinas, lo que ha dado lugar a la formación de un campo emergente crucial en el ámbito de la seguridad y la salud laboral, conocido como Neuroergonomía.

Palabras clave: Neuroergonomía, Neurociencias, Ergonomía cognitiva

Relevancia para la ergonomía: La creación de un marco de referencia resulta esencial para una comprensión más profunda de los fundamentos de la neuroergonomía, al ser la convergencia de dos disciplinas. Esto habilita a los profesionales en ergonomía para conceptualizar y asimilar esta fusión como una herramienta adicional en el enfoque de casos de estudio e investigaciones en desarrollo.

Abstract: In recent years, the impact of neuroscience on various fields of knowledge

and disciplines has significantly transcended medical boundaries. Neuroscientific research, focused on the analysis of central nervous system behavior, has shed light on the manifestation of both positive and negative emotions, as well as on fundamental bodily behaviors and functions triggered by a variety of stimuli.

This article aims to explore the close relationship between neuroscience and a classic realm of Industrial Engineering: ergonomics. The fundamental purpose is to discern the connections and overlaps between these two disciplines, resulting in the emergence of a critical field in the realm of occupational safety and health, known as Neuroergonomics.

Keywords. Neuroergonomics, Neuroscience, Cognitive Ergonomics.

Relevance to Ergonomics: Establishing a framework is essential to gain a deeper understanding of the underpinnings of neuroergonomics, as it represents the convergence of two disciplines. This empowers ergonomic professionals to conceptualize and assimilate this fusion as an additional tool in approaching case studies and ongoing research investigations.

1. INTRODUCTION

Neuroscience is defined as the study of the nervous system, which includes the brain, spinal cord, and networks of sensory or motor nerve cells, commonly known as neurons, under a multidisciplinary perspective. Its goal is to comprehend how humans produce and regulate their emotions, thoughts, behaviors, and basic bodily functions. Even the dynamics of the nervous system encompass aspects such as breathing and heartbeat regulation (Eunice Kennedy Shriver National Institute of Child Health and Human Development NICHD, 2019).

Neuroscience is recognized as a relatively "young" cognitive science, with the term itself coined in the late 1960s as a consequence of 19th-century efforts to localize brain functions. Presently, neuroscience's applications extend beyond medicine, biomechanics, psychology, and the learning process. It integrates into fields like physiology, biochemistry, pharmacology, and neurology, and notably, computer science and artificial intelligence (Duque Parra et al., 2011), (Ángeles Castro, 2022).

Applied neuroscience, combining technology and knowledge to target specific problems, employs principles from classical disciplines like ergonomics. This orientation includes monitoring psychophysiological variables to enhance occupational safety and productivity. It improves human-machine interaction and predicts cognitive states that could lead to work-related risks (Correa, Á., 2008).

Within a work context, monitoring psychophysiological variables yields valuable insights into stimulus design and the information provided to workers daily. It aids decision-making and proper task execution, enabling modifications that impact efficiency, productivity, fatigue reduction, stress alleviation, and error prevention.

Additionally, individual-level treatment is possible through neurofeedback or biofeedback. Individuals receive feedback on their recorded variables and collaborate on a therapeutic plan with continuous feedback, allowing them to regulate their bodily reactions. In clinical settings, this technique addresses sleep disorders, brain injury rehabilitation, obsessive-compulsive disorder, attention-deficit/hyperactivity disorder, and conditions affecting human anatomy like tinnitus and pain.

Commercially, therapies to enhance athletic and academic performance are common, as well as linguistic, musical, dance, and meditation skills. These enhancements stem from cognitive training focused on concentration, attention, and memory.

Given the potential of neuroscience's applications in performance-enhancing disciplines, understanding its relationship with ergonomics is of particular interest. This comprehension guides studies that harness the synergy between the two fields, enabling improvements in occupational environments.

2. OBJECTIVES

The aim of this chapter is to elucidate the evolution and analyze the information resulting from a literature review regarding the concepts of neuroscience and ergonomics. The primary objective is to pinpoint the interconnection where the techniques and tools of one discipline synergistically contribute to the objectives of the other. This symbiotic relationship gives rise to the emergence of a field intertwined with occupational safety and health—Neuroergonomics.

3. METHODOLOGY

The literary review aimed at establishing the relationship between ergonomics and neuroscience was organized in a hierarchical manner, progressing from the general to the specific. The deductive method was employed, starting from the concept of ergonomics and characterizing its domains. The focus was then narrowed down to cognitive ergonomics, mental workload, its assessment, and its impacts on worker health. Simultaneously, the same methodology was applied to the concept of neuroscience, encompassing descriptions of brain monitoring types and the utilized instruments.

The literature search prioritized formal contributions and research findings related to the subject matter. Inclusion criteria for the literary review encompassed documents centered on concepts, domains or fields of application, instrumentation, and evaluation for each of the terms: neuroscience and ergonomics.

As a concluding insight, the relationship between both concepts was established based on the literary reviews.

4. RESULTS

Next, the results obtained from the application of the methodology are described.

4.1 Ergonomics

The International Ergonomics Association (IEA) established the meaning of ergonomics in 2000 as follows: "the scientific discipline concerned with understanding the interactions between humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance." In that same year, the domains it encompasses were also defined, summarized in Table 1, based on the characteristics analyzed by each of them (International Ergonomics Association (IEA), n.d.).

Table 1. Characteristics of Ergonomics Domains, according to IEA.

PHYSICAL ERGONOMICS	COGNITIVE ERGONOMICS	ORGANIZATIONAL ERGONOMICS
• Anatomical features • Anthropometric features • Physiological features • Biomedical features	• Mental processes: perception, memory, reasoning, and motor response.	• Optimizing sociotechnical systems such as organizational structures, policies, and processes.

As shown in Table 1, cognitive ergonomics is concerned with mental processes. The key topics it addresses for study include mental workload, decision-making, skilled performance, human-machine interaction, human reliability, the impact of environmental conditions on emotions, work-related stress, and training.

Human Factors Ergonomics (HFE) is not a discipline exclusive to a single area; rather, it is an integrative multidisciplinary science centered entirely on the user (in a workplace context, it focuses on the human-machine-work environment interaction). Framed within a systemic approach, it draws from the knowledge, methods, techniques, and tools of various disciplines to understand and address the complexity of the individual and their interactions with other humans, their environment, and other technical technological systems (International Ergonomics Association (IEA), n.d.).

4.2 Cognitive ergonomics and the burden of mental exertion (mental workload)

Within the realm of ergonomics, a pivotal bifurcation emerges: cognitive ergonomics and physical ergonomics. While the latter garners more immediate recognition, the interweaving of these dimensions in practice defies clear separation. This intricate dynamic finds eloquent illustration in the context of product design. The physical ergonomics of a new product must encompass the profound connection it forms with users. These users, recipients of the product's information emissions, seamlessly amalgamate these signals with environmental stimuli. These external cues may stem from third-party sources, ingrained stereotypes, or prior experiences, ultimately informing the user's decisions and actions.

The symbiotic relationship between physical and cognitive ergonomics is so profound that inadequate attention to the former can substantially affect individuals. The repercussions are extensive, ranging from fatigue, overexertion, and stress to human errors and even the alteration of environmental stimulus perception. It is worth noting that these implications reverberate into the psychological realm. Work activities, in essence, blend the demands of physical and cognitive loads. Breaching the thresholds of these loads can lead to adverse health outcomes, as astutely noted by Cañas and Waerns (2003).

Mental workload, a pivotal facet of this cognitive dimension, denotes the spectrum of mental, cognitive, or intellectual demands a worker faces during their laborious day. This intricate construct arises from the interplay between job demands and individual characteristics. An incongruity between these factors yields what is termed an inadequate workload, a concept elucidated by Sebastián García and Hoyo Delgado (2004).

The impacts of mental workload unfold across the short and medium terms, encapsulating various facets:

- Mental Fatigue: A reduction in both physical and mental capacities due to sustained job performance. This manifests in physiological and chronic fatigue levels.
- Monotony: A transient effect stemming from underload, characterized by reduced activation and sluggish task progression.
- Work Stress: A prolonged outcome defined by the World Health Organization as a range of emotional, psychological, cognitive, and behavioral reactions resulting from professional demands surpassing a worker's competencies.
- Errors: An inability to process information correctly, potentially leading to inadvertent omissions or commissions.

Appraising workmental load remains a nuanced endeavor. While direct methodologies, such as questionnaires and evaluations, offer insights into physical load, mental load assessment relies on indirect approaches. Indicators such as worker-expressed fatigue or headaches come into play. These signals, combined with multifaceted assessments, furnish a comprehensive perspective (Sebastián García and Hoyo Delgado, 2004).

Table 2 delineates various methods for mental load evaluation, classified across five typologies, providing an expansive toolkit for a holistic assessment (Sebastián García and Hoyo Delgado, 2004), (Correa Á., 2021), (R. Ignacio and José Juan, n.d.).

Table 2 - Methods for the Evaluation of Mental Workload

<table>
<tr><th>ANALYTICAL METHODS</th><th>SPECIFIC METHODS (SCALES)</th><th>ACCORDING TO PHYSIOLOGICAL EFFECTS ON THE WORKER</th><th>ACCORDING TO PSYCHOLOGICAL EFFECTS ON THE WORKER</th><th>BEHAVIOR-BASED METHODS</th></tr>
<tr><td>Task Elements</td><td>Cooper-Harper Scale</td><td>Measurement of cardiac activity</td><td>Subjective methods (interviews, questionnaires, scales, etc.)</td><td>Performance indicators</td></tr>
<tr><td>Physical Work Conditions</td><td>Bedford Scale</td><td>Measurement of ocular activity</td><td rowspan="5">Objective methods (psychological tests, response time and coordination tests, cognitive alteration tests)</td><td rowspan="2">Operational methods studies</td></tr>
<tr><td>Environmental Work Conditions</td><td>Global load scale</td><td>Measurement of muscular activity</td></tr>
<tr><td rowspan="3">Effects on the Worker</td><td>SWAT</td><td>Measurement of cortical activity</td><td rowspan="3">Double-task method</td></tr>
<tr><td>NASA-TLX (Task Load Index)</td><td rowspan="2">Measurement of evoked potentials</td></tr>
<tr><td>Workload Profile</td></tr>
</table>

4.3 Neuroscience

The Royal Spanish Academy defines Neuroscience as a "transversal science that deals with the nervous system or each of its various specialized aspects and functions" (Real Academia Española, 2022).

However, the experts gathered at the Future Trends Forum in Madrid in 2019 find this definition limiting. They assert that neuroscience emerges with the objective of comprehending the functioning and structure of the nervous system from diverse approaches, employing methodologies and techniques. They attribute three characteristics to it:

- Multidisciplinary collaboration to address the study of the brain and nervous system.
- Existence of multiple neurosciences.
- Close relationship between neuroscience and new technologies. (Fundación Innovación Bankinter, 2021)

While the historical antecedents, initially from a philosophical perspective, date back to the era of Aristotle and Descartes, they later incorporate psychology through the works of Charles Darwin, Schachter and Singer, Freud, among others (De Balanzó, 2015). By the 17th century, the existing connection between the nervous system and other bodily functions, along with the nascent understanding of cerebral structure, facilitated significant advances in human comprehension.

Derived from Galvani's investigations in the 18th century, neurophysiology emerged as a science by establishing the electrical connection to cellular activity in muscular tissue. However, it wasn't until the late 19th and early 20th centuries that Santiago Ramón y Cajal's "Doctrine of the Neuron" theory proposed that "the nervous system consists of independent cells: neurons, which contact each other in specific places." This theory was subsequently confirmed, with one of the most compelling studies being Ross Harrison's, which demonstrated the existence of dendrites and axons as extended neuronal structures. The foundations of electrophysiology laid the groundwork for the discovery of the electrical activity between neurons: synapses.

In that same century, the localization of cerebral functions became a prominent question. Neuroanatomy and neurophysiology converged to determine the origin of each function within the brain's sections. Franz Joseph Gall proposed that the brain contained 35 centers, each related to a mental function. He further suggested that increased utilization of these areas would lead to greater development and enlargement. By the 20th century, in Germany, the work of Vladimir Betz, Theodore Meynert, Oskar Vogt, and Korbinian Brodmann to differentiate the brain based on cellular composition laid the foundation for Brodmann's identification of 52 areas in the cerebral cortex, each with its respective function. Numerous studies on function localization have been published in recent decades, each contributing significantly. Karl Wernicke's theory of connectionism concludes that elementary mental functions, such as simple motor or perceptual activities, are localized in a single brain region. Connections among these diverse areas give rise to complex intellectual functions. Currently recognized as distributed processing, this is considered one of the most significant concepts of modern Neuroscience (Cavada, n.d.).

As we stand on the cusp of a new era, neuroscience continues to evolve, driven by unprecedented collaboration and technological advancements. Its journey from philosophical ponderings to modern breakthroughs underscores its transformation into a dynamic field that constantly reshapes our understanding of the profound intricacies of the human brain.

4.4 Brain activity monitoring: unveiling the intricacies

In the world of neuroscience, a very important way we learn about the brain is by watching its activity. We do this using a method called electroencephalography (EEG), which records the tiny electrical signals the brain produces. This tool is like a key that helps doctors and scientists understand how the brain works. It has used a lot in surgeries involving the brain and in advanced methods for managing pain and unconsciousness. Therefore, EEG is like a special microscope that lets us peek into the brain's electrical world, helping us discover more about how our amazing minds function and helping doctors treat patients better.

The encephalogram (EEG), essentially an electrical symphony of the brain, adeptly portrays its functional states by detecting subtle electrical changes with remarkable sensitivity. This dynamic medium has proven its adaptability in responding to various influences like biochemical, metabolic, circulatory, hormonal, neuroelectrical, and conductivity. The EEG modality, offering diverse dimensions such as surface, cortical, and depth recording, unfolds a tapestry of applications (Gutiérrez, 2001):

- Surface EEG: This entails the strategic placement of surface electrodes on the scalp, meticulously adhering to established positions and patterns. This configuration unveils the rhythmic dance of brain activity, characterized by the Delta, Theta, Alpha, Beta, and even Gamma waves (Guillén, n.d.). The beauty of surface EEG lies in its noninvasive and painless nature.
- Cortical EEG: This, also known as electrocorticographic signal (ECoG), refines the resolution by recording brain activity directly from the cerebral cortex. The method involves implanting a subdural electrode mesh over the exposed cortical area. The current practice involves employing flexible strips containing multipolar electrodes, placed on the brain surface during pre and post surgeries, though it does bear invasive attributes and potential complications (Italmedica, n.d.). Innovative techniques seek to mitigate these drawbacks.
- Depth Recording EEG: This approach delves into intercerebral realms through deep electrodes, a procedure famously known as stereoelectroencephalography. Achieved by placing microelectrodes via biopsy needles, this invasive technique accesses the profound territories of the brain (Parc de Salut Mar, n.d.).

Embarking on the journey of EEG exploration necessitates the companionship of an electroencephalograph, a device adept at capturing the brain's electric symphony via electrophysiological wizardry. Notably, two distinct categories grace this landscape:

- Medical Electroencephalographs: These instruments are hallowed by regulations and certifications, serving as steadfast companions in the diagnosis and treatment of diverse maladies.
- Research Electroencephalography: In the academic world and experimental pursuits across multifarious domains, these devices unfurl the canvas of innovation (MindMetriks, n.d.).

The core of brain functions lies in electrical activity, which is captured as repeating patterns, like oscillating waves. Depending on their strength and how fast they repeat, these brain waves are sorted into categories and given specific qualities

Power, akin to the crescendo of a symphony, denotes the intensity of synaptic interactions at any given instant. In the EEG representation, power manifests as amplitude, a vertical expanse depicting the synaptic vigor, meticulously quantified in microvolts.

Frequency, the heart of this symphony, measures the synchronous activation of neurons, expressed as waves or cycles per second (hertz). A melodious spectrum emerges, comprising Delta, Theta, Alpha, Beta, and Gamma waves, each adorned with distinct properties and entwined with various cognitive states. Refer to *Table 3* for a harmonious synopsis of these waves, their frequencies, distinguishing features, and the states they herald, acknowledging the subtle variations that may arise between scholarly interpretations (Sciotto and Niripil, 2018), (Calderón Martínez, 2016), (Guillén, n.d.).

Table 3. Summary of brain waves according to their frequency.

WAVE	FRECUENCY RANGE (HZ)	FEATURES AND STATE IN WHICH IT MANIFESTS ITSELF
DELTA	0.5 - 3.5 (0.1 – 3.99)	• They are slow waves with a higher amplitude. • Aging provokes the ability to generate them. • During deep (dreamless) sleep. • Related with learning. • Related to unconscious physiological activity such as: heart rate, digestion and the immune system. • In people with a high level of relaxation. • Typical in the brains of infants and young children. • People suffering from serious brain diseases.
THETA	3.5 - 7.5 (4 – 7.99)	• During light sleep. • They appear in states of reflection, creative or intuitive. • Also in people who go through deep emotions, that is to say at an internal cognitive level. • The manifestation of excessive recording can be related to depressive states. • Low activity is related to anxiety or stress problems. • Normal in children. • In adults they can show mental disorders or conditions such as epilepsy.
ALPHA	7.5 – 12.5 (8 – 13.99)	• In people awake, calm, rest and without mental activity, either with eyes open or closed. • Its moderate frequency may be reflecting being a bridge between theta and beta waves. • Excessive recording of alpha waves could cause problems concentrating attention or feeling with little motivation to carry out a task. • Sudden, non-sustained or extremely sporadic registration may indicate difficulties to relax, anxiety, stress and insomnia, since it reflects a

WAVE	FRECUENCY RANGE (HZ)	FEATURES AND STATE IN WHICH IT MANIFESTS ITSELF
		state of apparent relaxation, but with a little alertness. • Its registration in the frontal lobe is associated with anxiety and the occipital area, an optimal state of relaxation. • Favorable state for meditation.
BETA	12.5 – 30 (14 – 29.99)	• They register higher frequency because of greater neuronal activity. • They have a smaller amplitude than alpha waves. • They correspond to a state of vigil. • It can be identified by registering alpha waves with eyes closed and opening them to become aware of the environment by paying attention to the environment (external cognitive process) and making decisions, solving problems or performing a task, either individually or multiple times or to react quickly and unforeseen, which will raise its frequency. • Defined in the parietal and frontal regions. • In people under tension, expectant or performing mental calculations. • An excess of Beta waves can be a sign of anxiety or stress.
GAMMA	30 – 60 (30 - 100)	• Higher frequency waves and in appearance as a short burst type. • They are hard to catch. • They appear in moments of hyperactivity, dangerous situations or high tension. • Also when the person assimilates new information or learns new things. • In people in states of attention or concentration that are too deep that involve cognitive processing and high-level resolution. • Beyond this range or continuously or excessively, they can be a symptom of stress and anxiety. • His low activity may represent learning problems.

5. FUTURE WORK

The findings from the literature review are condensed and shown visually in Figure 1. This diagram displays how information connects the different topics, moving from broad ideas to ones that are more detailed. At the top of the graph is the beginning point, which is the concept of Ergonomics. In contrast, the concept of Neurosciences is placed on the other side. This visual representation helps us see how these ideas are related and how they transition from general to specific.

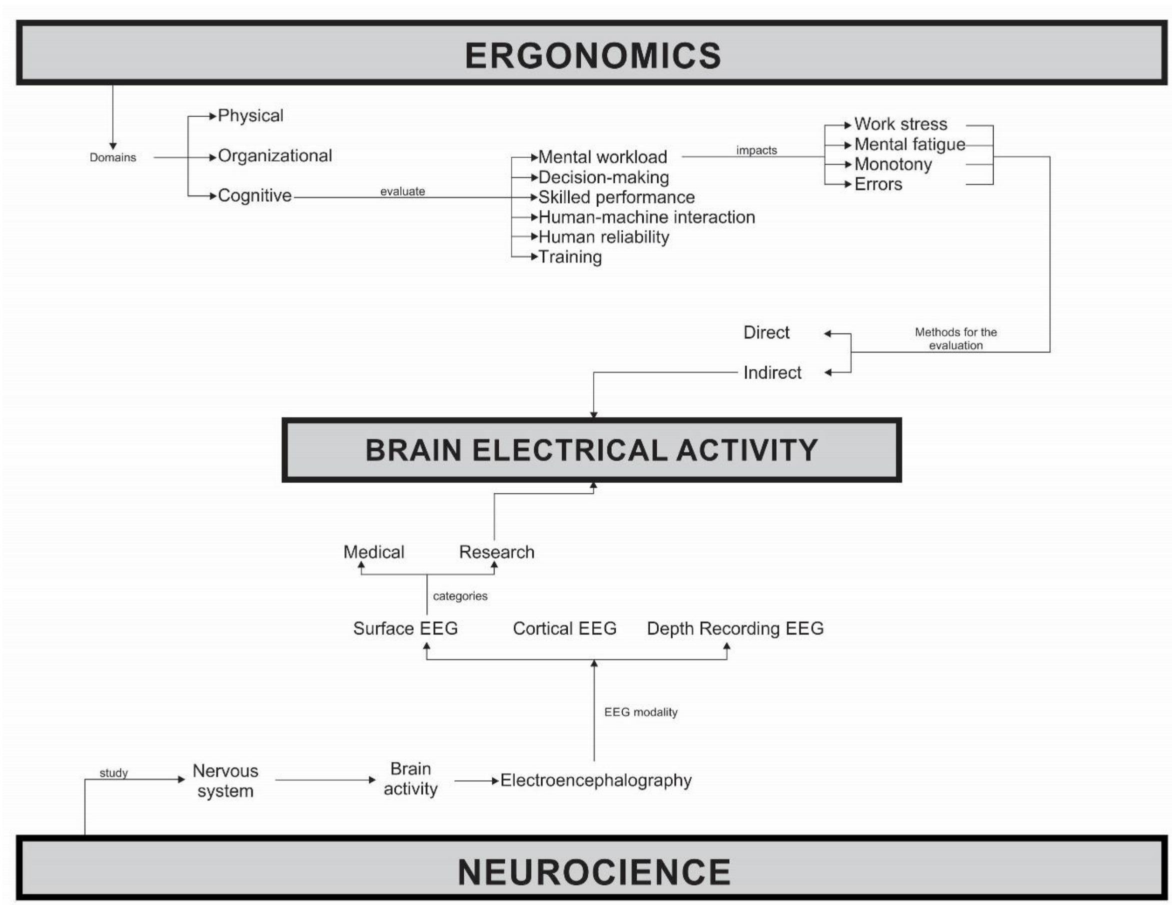

Figure 1. Analysis graph.

From the presented information, the following conclusions are drawn:

- Both neuroscience and ergonomics utilize records of brain activity. Neuroscience employs these records for medical or research purposes, while ergonomics uses them to assess mental workload based on physiological effects in workers. This can involve solely using brain activity for assessment or combining it with measurements of other activities like heart rate, eye movements, and muscle activity.
- Methods for evaluating mental workload involving the recording of brain electrical activity include cortical activity measurement and evoked potential

measurement. The latter generates visual, auditory, or tactile stimuli using tools such as screens and virtual reality devices.

- Specific brainwave patterns, such as Theta, Beta, and Gamma waves, are of interest due to their characteristics and association with tension, anxiety, fatigue, and stress.
- Advancements in technology now provide more affordable electroencephalography (EEG) equipment for ergonomists, not certified for medical use, enabling the development of new studies and research.
- Neuroergonomics emerges from the need and potential to:
    a) Understand the neurological states of workers interacting with their physical and environmental surroundings, better explaining and predicting phenomena studied by ergonomists, including stress, fatigue, and tension.
    b) Measure real-time neurological indices during task performance in work environments to gather more accurate and useful information, facilitating efficient measures to prevent negative effects of this interaction.

Consequently, the relationship between neuroscience, its corresponding techniques and instruments for recording electrical activity, and the goal of assessing cognitive work in ergonomics has been established. This highlights the opportunity to study disorders related to the work context and influence the design of technical and technological elements interacting with workers to eliminate or reduce harmful consequences.

It is important to note that EEG equipment coupled with software, big data generation, and other technologies offer increased feasibility for conducting more precise studies and assessments within the domain of ergonomics. Understanding this framework is crucial for the development of studies and research endeavors.

6. CONCLUSIONS

In conclusion, the literary review presented in this chapter sheds light on the intricate relationship between neuroscience and cognitive ergonomics, underscoring the transformative impact of these fields on occupational safety and health. The convergence of these disciplines has given rise to the emergent field of Neuroergonomics, which holds immense potential for understanding the interplay between the human brain and the work environment.

Neuroscience, a multidisciplinary science, has evolved from its philosophical origins to modern breakthroughs, unveiling the complexity of the nervous system and its functions. The utilization of tools such as electroencephalography (EEG) provides insights into brain activity, enabling ergonomic professionals to gauge cognitive workload and mental states. By integrating neuroscience's insights into ergonomics, professionals gain the ability to design safer and more efficient workspaces, improve human-machine interactions, and prevent adverse effects like stress and fatigue.

The evaluation of cognitive workload through EEG-based methods, as depicted in the study, offers a comprehensive understanding of mental demands. By analyzing brain activity patterns, it becomes possible to identify cognitive states, monitor stress levels, and anticipate potential risks. This intricate web of data and analysis equips professionals with invaluable insights for enhancing workplace conditions and overall well-being.

Furthermore, the advent of advanced neurophysiological technologies presents a realm of possibilities for researchers and practitioners. The utilization of non-medical EEG devices enables ergonomic studies that bridge the gap between cognitive neuroscience and occupational health. By exploring the relationship between brain activity and mental workload, researchers can unveil new strategies to optimize human performance, reduce errors, and enhance worker satisfaction.

In summary, the intersection of neuroscience and ergonomics holds great promise for reshaping the way we approach occupational safety and health. The collaboration between these fields underscores the importance of understanding human cognitive processes and their interaction with the work environment. As technological advancements continue to provide us with new tools and insights, the potential for creating safer, more efficient, and more productive workplaces becomes ever more attainable. The journey towards a harmonious integration of neuroscience and cognitive ergonomics is not only a testament to human ingenuity but also a testament to our commitment to improving the well-being of workers across various industries.

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Bibliometric review on cognitive ergonomics.

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Resumen: La ergonomía cognitiva estudia las interacciones que se dan entre los procesos mentales (razonamiento, memoria, percepción, respuesta motora) de los trabajadores y los demás elementos del sistema hombre-máquina. Lo anterior en los actuales ambientes laborales donde cada vez se maneja mayor cantidad de información para toma de decisiones, y una mayor complejidad en controles y tableros, entre otros varios aspectos, hacen que cobre una mayor importancia la ergonomía cognitiva ya que estos elementos implican una mayor carga mental de Trabajo. Es así como en los últimos años la investigación en este tema ha aumentado significativamente. Por lo que en este trabajo buscamos cuantificar y caracterizar los productos científicos publicados con referencia a la Ergonomía cognitiva, en inglés, español y portugués principalmente buscando darnos una idea de las tendencias y avances en este importante tópico.

Palabras clave: Ergonomía cognitiva, Carga de Trabajo Mental, Desempeño Laboral, Factores Humanos.

Relevancia para la ergonomía: El conocimiento en relación con los temas de investigación que se están llevando a cabo en los últimos años sobre ergonomía cognitiva nos permite como ergónomos darnos una idea de las nuevas investigaciones a realizar así como las tendencias en este campo del conocimiento

y cómo esta impactando directamente en los nuevos sistemas hombre-máquina donde hay una mayor carga mental de trabajo en comparación con la carga física.

Abstract: Cognitive ergonomics studies the interactions that occur between the worker's mental processes (reasoning, memory, perception, motor response) and the other elements of the human-machine system. The above in the current work environments, where more and more information is handled for decision making, and greater complexity in controls and dashboards is found, among several other aspects, makes cognitive ergonomics becomes more important since these elements imply a greater mental workload. This is how in recent years research on this topic has increased significantly. So, in this work we seek to quantify and characterize the scientific products published with reference to cognitive ergonomics, in English, Spanish and Portuguese mainly, seeking to find the trends and advances in this important topic.

Keywords. Cognitive Ergonomics, Mental Workload, Job Performance, Human Factors.

Relevance to Ergonomics: The knowledge in relation to the research topics that are being carried out in recent years concerning cognitive ergonomics allows us as ergonomists to give an idea of new research to be carried out, as well as the trends in this field of knowledge and how it is directly impacting the new man-machine systems where there is a greater mental load compared to the physical load.
The following order in the paper is strongly recommended: Introduction, Objectives, Methodology, Results, Discussion/Conclusions and References

1. INTRODUCTION

Nowadays, according to Gil-Monte (2012), one of the most significant issues concerning occupational health is associated with emerging psychosocial risks and are grouped into five areas:

1. New ways of labor contracting are distinguished by the emergence of less favorable labor contracts in conjunction with the tendency to schedule production, subcontracting, and job insecurity.
2. In relation to the working population aging and the delay in job retirement,
3. Work activities intensification, differentiated by the need to manipulate more information and workload in conjunction with greater pressure from senior management.
4. Strong emotional demands at work, along with an increase in psychological harassment and violence
5. Imbalance and conflict between work and personal life.

As a way to solve the problems previously exposed, the discipline of ergonomics has grown significantly in recent years. Its focus has expanded to new knowledge in all its domains, including physical ergonomics, cognitive ergonomics, and organizational ergonomics. This work is concentrated on Cognitive ergonomics which focuses on mental processes, such as perception, memory, reasoning, and motor response, and how these elements affect interactions between workers and other elements of a man-machine system (Parasuraman, 2003). Bibliometric studies present advantages since they reveal the relevance of a research field in relatively little time, these analyses have proven useful for researchers' decision-making and measuring research productivity (Matcharashvili et al., 2014).

Studies relating to cognitive ergonomics have grown significantly in recent years as can be seen in the following figures:

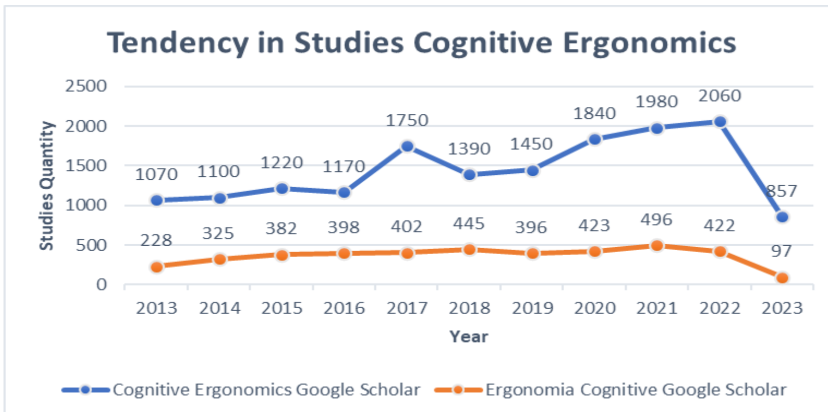

Figure 1. Results obtained at Google Scholar database using the terms "Cognitive Ergonomics" and "Ergonomía Cognitiva" in the last 10 years (Authors).

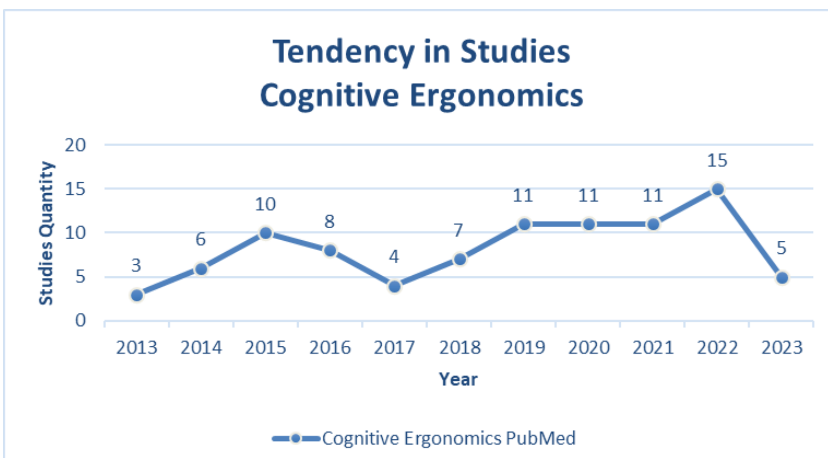

Figure 2. Results were obtained in the PubMed database using the terms "Cognitive Ergonomics" in the last 10 years (Authors).

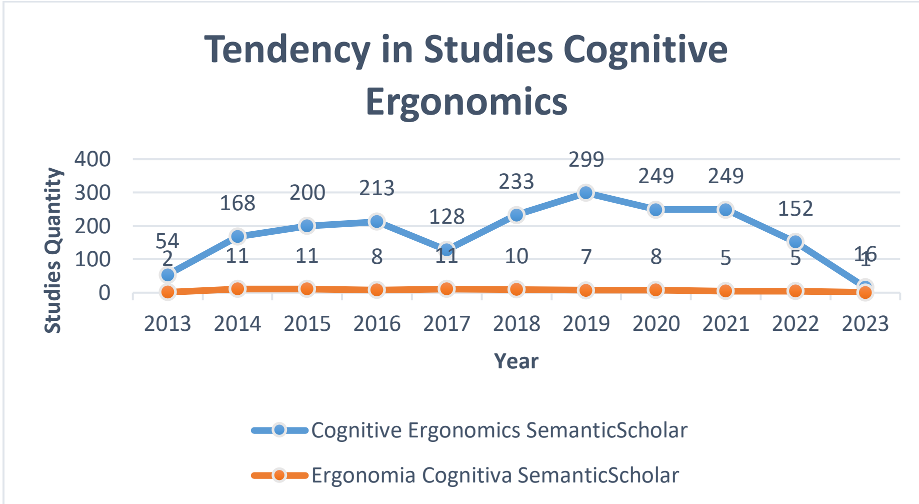

Figure 3. Results obtained at SemanticScholar database using the terms "Cognitive Ergonomics" and "Ergonomía Cognitiva" in the last 10 years (Authors)

2. OBJETIVE

To quantify and characterize scientific literature published in different databases about cognitive ergonomics and its categorization on work performance, worker well-being and health, mental workload, product design, communication, and other issues.

3. DELIMITATION

As a delimitation of this work, the term "Cognitive Ergonomics" in English and Spanish was searched in 5 different databases: PubMed, Google Scholar, LILACS, SciELO, and SemanticScholar. The period analyzed included products from the last five years including 2023. The inclusion and exclusion criteria were that they should be related to the cognitive ergonomics topic, cites were not included and research articles, book chapters, books, thesis, dissertations, and conference papers were accepted.

4. METHODOLOGY

The methodology implies 3 stages: In the first one the searches results are evaluated one by one and those that meet the objective of the study, satisfied the inclusion and exclusion criteria, and to which we have access be analyzed a second stage begins when results are included in a database in Excel, in which the categorization is made according to variables raised by Ardanuy (2012) such as Type of product (Article, thesis, Conference Report or Poster), name, year of publication, language, Country where the research is carried out, Population related to the research, Number of subjects involved in the research, Database of origin, the main theme developed, citation in APA format and source, the final stage consist in the analysis of the database.

5. RESULTS

As a result of the bibliometric search, 11665 papers were found. 83.04% used the term “Cognitive Ergonomics” and the rest used the same term in Spanish (Ergonomía Cognitiva). 87.36% of the results were found in the Google Scholar database followed by SemanticScholar with 11.38%. To date, seven hundred and twenty-eight results have been analyzed, and from this five hundred and eighty are relevant to the investigation, from these three hundred and eighty-three were written in English (66%), one hundred and thirty-three in Spanish (21.22%), seventy in Portuguese (12.07%) and only four other products in other language (0.72%). Using AtlasTi© the most common words found in results found in English and Spanish were obtained first in all the results regarding the language (Fig. 4). The most common word is design in English, followed by work in Spanish, ergonomics, and work in English, and work and research in Spanish, next words English words as cognitive, human, mental, information, performance physical safety, user and research can be found, and in Spanish: ergonomics, business, study, development, health, analysis to mention some.
Idioma

Figure 4. Most common words found in all the results obtained (Authors)

Doing the same analysis to only English written results the ten most important words were: design, ergonomic, cognitive, work, human, system, product, study, research, and performance (Fig. 5).

Figure 5. Most common words in results written in English (Authors)

In the analysis of only Spanish written results, the ten most important words were: Work, research, design, organization, ergonomics, cognitive, development, information, products, and system. (Fig. 6).

Figure 6. Most common words in results written in Spanish (Authors).

Researchers from fifty-five different countries, from five continents (Figure 7) have made research about cognitive ergonomics most of the countries are from Europe (25) or America (14).

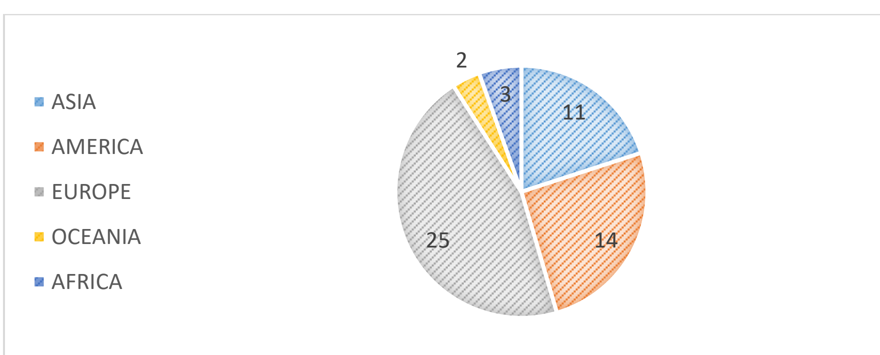

Figure 7. Characterization by continent.

The American Continent has more than half of the products related to cognitive ergonomics, two hundred and ninety in total, 37.24% in Spanish, 38.97% in English and 23.8% in Portuguese. As can be seen Brazil been the only country that speaks Portuguese in the continent in very prolific in the topic.

Table 1. The percentage from the total results is classified by continent.

CONTINENT	PERCENTAGE
Asia	7%
America	55.43%
Europe	36%
Oceania	1.29%
Africa	.74%

Fourteen main topics were found, the percentage related to its appearance in the results is shown in Table 2.

Table 2. The percentage of the different main topics were found.

Topic	PERCENTAGE
Performance Improvement	20.26%
Mental Workload	18.60%
Use of technology	11.42%
Ergonomics Analysis	9.21%
Worker's **wellbeing**	7.55%
Ergonomic Design	6.63%
Systematic Reviews	3.68%
Training	3.13%
Information Design	2.76%
Education	2.76%
Labor Risk	2.39%
Design and Communication	1.47%
Interior Design	0.55%
Ergonomic rest breaks	0.36%

5. CONCLUSIONS

Bibliometrics is considered a methodology that allows to recognize and quantify trends in scientific production related to the topic of interest, in the case of this study has identified the growing tendency in recent years concerning cognitive ergonomics and also a significant number of products results of research related to this topic, the vast majority in English, from industrialized countries, and most of them in the

American Continent. It is also worth mentioning that many articles are related to health workers (doctors and/or nurses) and in comparison a much less considerable number of publications in Spanish and/or Portuguese of which many of which are master's or doctoral theses which leads us to conclude that in Spanish-speaking countries especially in Latin America, research regarding this transcendent topic is taking place mostly in universities either by Professors-Researchers or by graduate students.

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ERGONOMIC EVALUATION OF A PIZZERIA THROUGH THE USE OF LCE and LEST

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Resumen: La ergonomía como principio básico busca la óptima relación de los diversos factores involucrados en el trabajo del operario con su ambiente productivo, para lograr llevar esto a cabo se utilizan algunas herramientas para tal fin que permiten un balance idóneo en el sistema hombre-maquina, en este caso se utilizó LCE y LEST, Esto hace que algunos aspectos sean profundamente analizados como inicio para cualquier evaluación ergonómica, dicho sea de paso, algunos de los aspectos físicos del lugar de trabajo, así como la interrelación que se tiene del operario con su entorno de trabajo, para evitar consecuencias adversas como daños físicos e incomodidades personales. El análisis permitió algunas recomendaciones para eficientar el trabajo del personal y su consiguiente aumento en la productividad

Palabras clave: Ergonomía, Lista de comprobación ergonómica, LEST

Relevancia para la ergonomía: El trabajo manual trae consigo una variedad de consecuencias como lo pueden ser: dolor de espalda, dolor de cuello, inflamación de muñecas, brazos y piernas y tensión ocular, etc.

La ergonomía puede ayudar a mejorar las condiciones de trabajo; atendiendo a las capacidades de los operarios para permitir que éstas se adapten a las personas. El hacer cualquier mejora ergonómica brindará mejores resultados, se contará con menos lesiones, mejora el entorno laboral, e incrementará la eficiencia con su consiguiente aumento la productividad.

Cabe destacar que cada trabajador debiera tener la habilidad para identificar y reconocer los riesgos ergonómicos que existen en su puesto de trabajo y ver la manera de solucionarlo, pero no siempre es así lo que deriva en situaciones dañinas para él y para su actividad laboral.

Un aspecto importante es que la ergonomía está centrada en las personas, es decir, las personas son más importantes que los objetos o los procesos productivos, por ello, cuando se dé un caso donde se plantee cualquier tipo de conflicto de intereses, siempre deberá sobresalir la importancia de los trabajadores.

En la actualidad, se puede observar una tendencia creciente en considerar las condiciones de trabajo como un elemento importante en la competitividad en una determinada región, o incluso de un país, de manera evidente, la ergonomía juega un papel muy importante para lograr este propósito, de ahí la importancia de divulgar este tipo de análisis del trabajo para la sociedad.

Abstract: Ergonomics as a basic principle seeks the optimal relationship of the various factors involved in the work of the operator with his productive environment, to achieve this some tools are used for this purpose that allow an ideal balance in the man-machine system, in this case LCE and LEST were used, this makes some aspects deeply analyzed as a starting point for any ergonomic evaluation, Incidentally, some of the physical aspects of the workplace, as well as the interrelationship between the operator and his work environment, to avoid adverse consequences such as physical damage and personal discomfort. The analysis allowed some recommendations to make the work of the staff more efficient and its consequent increase in productivity

Keywords: Ergonomics, Ergonomic Checklist, LEST

Relevance to Ergonomics: Manual work brings with it a variety of consequences such as: back pain, neck pain, inflammation of wrists, arms and legs and eye strain, etc. Ergonomics can help improve working conditions; attending to the capacities of the operators to allow them to adapt to people. Making any ergonomic improvement will provide better results, fewer injuries, improve the work environment, and increase efficiency with its consequent increase in productivity. It should be noted that each worker should have the ability to identify and recognize the ergonomic risks that exist in their workplace and see how to solve them, but this is not always what leads to harmful situations for him and his work activity.

An important aspect is that ergonomics is focused on people, that is, people are more important than objects or production processes, therefore, when there is a case where any type of conflict of interest arises, the importance of workers should always stand out. At present, there is a growing trend in considering working conditions as an important element in competitiveness in a certain region, or even a country, obviously, ergonomics plays a very important role in achieving this purpose, hence the importance of disseminating this type of analysis of work for society.

1. INTRODUCTION

Ergonomics aims to take care of the health of the worker, preventing situations that put their physical or emotional integrity at risk, either by eliminating or minimizing exposure to the different risks to which they are exposed in the performance of their work. Ergonomic evaluation methods allow the identification and assessment of risk factors present in workplaces and then, based on the results obtained, propose redesign options that reduce the risk and place it at acceptable levels for the worker (Cuesta, et al., 2012) For the application of the methods the evaluator will make direct observations in the execution of the work activities, in addition to this, he will apply the questionnaires already designed, generating optimal results for both workers and the industry Escalante (2009).

In any case, ergonomics can help improve working conditions; attending to the capacities of the operators to allow them to adapt to people. Applying any ergonomic improvement at work will provide good results, improve physical performance, have fewer injuries, smooth personal relationships and optimize the work environment, increasing efficiency with its consequent increase in productivity making the workplace more comfortable, and safer. At present, a growing tendency can be observed to consider working conditions as an important element in competitiveness in a certain region, or even of a country, obviously, ergonomics plays a very important role in achieving this purpose.

The case study company is from the food industry dedicated mainly to the preparation of pizzas in an industrial way and its efficiency depends to a large extent on the work carried out by its employees based on the way in which they develop their activities, so the application of this method is to take the first steps so that ergonomic evaluations are carried out assiduously and define the conditions in which workers are working. to provide them with better working conditions. That is why an ergonomic evaluation was necessary to determine the ergonomic risks, address them and determine the possible adaptations to the conditions in which the activities are carried out.

The present work uses the ergonomic checklist as a means to identify anomalous situations within a pizzeria, which gives us an important guideline for based on this list the current conditions were determined and give rise to what is to be achieved with the analysis of the results to which workers are exposed in the performance of their activities, a descriptive situation is presented to logically seek the recommendations that could be given to each of the positions presented in the study and once the conditions to which the workers are exposed are determined, we proceed to apply an instrument that helps determine the actions to them and in a methodological way apply the LEST method to determine the impact of each One of the parameters determined in the study and propose a plan to implement the elimination of risks for work derived from the current conditions, managing to take into account the largest number of variables that could infer directly in this circuit of information and control taking into account the aspects present in the performance of the work.

2. OBJETIVE

Carry out a detailed analysis in different areas of Pizzeria los Arcos km. 101 using the Ergonomic Checklist (LCE) and the Laboratory of Economics and Sociology of Work (LEST) to recognize anomalous conditions and make relevant recommendations to improve the workplace, as well as the physical and psychosocial conditions of the environment.

Delimitation: In the ergonomic checklist, the focal point analyzed is the production area, that is, what the kitchen and warehouse of "Pizzeria Los Arcos Campo 101" entails; It should be noted that it was decided that the question asked in this document was "Does it apply in the company?", this to understand more specifically whether or not it develops the points of the list in the company. The LEST field sheet contains information from 3 different workers, in which it was analyzed how each one performs their work, varying between people with different activities as well as levels of responsibility. This demonstrates the variability of responsibilities within the company's

3. METHODOLOGY

1. To carry out the study, an observation and analysis were carried out using the ergonomic checklist in the different departments of the company, focusing mainly on the production area, basically the kitchen and warehouse during working hours.
2. Using the ergonomic checklist, a thorough analysis of the existing conditions of the company was carried out, showing in a general way the situation observed in the company, for which some of the images of the exposed cases are presented.
3. With the use of LEST, three different workers are evaluated with different degrees of responsibility and personal participation either in the development of their activities and interaction with different personnel.
4. Finally, the results obtained with the data collection obtained from the previous points are shown, allowing in the same way to make a recommendation for each of the aspects considered for improvement.

4. RESULTS

As shown in the following table, 78% of the elements considered do not require any type of action, and the remaining 22% indicate some of the actions that although none is very urgent, only 6% indicate that this condition should be addressed as soon as possible to normalize the general index of the company, these elements relate to the security and visibility of controls in the activities.

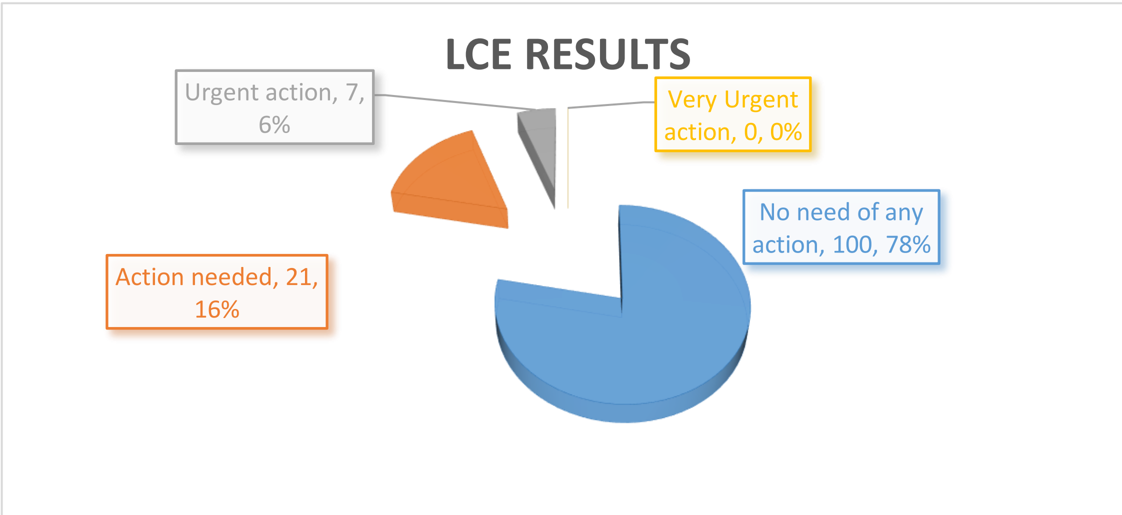

Figure 1 Results of the ergonomic checklist

On the side of the analysis using LEST of the chosen workstations as shown in the following graph, the first place shows that both the load and the physical environment result in a harmful condition for the worker, which indicates the need to attend promptly these elements since they could be decisive to allow irremediable damage to the worker.

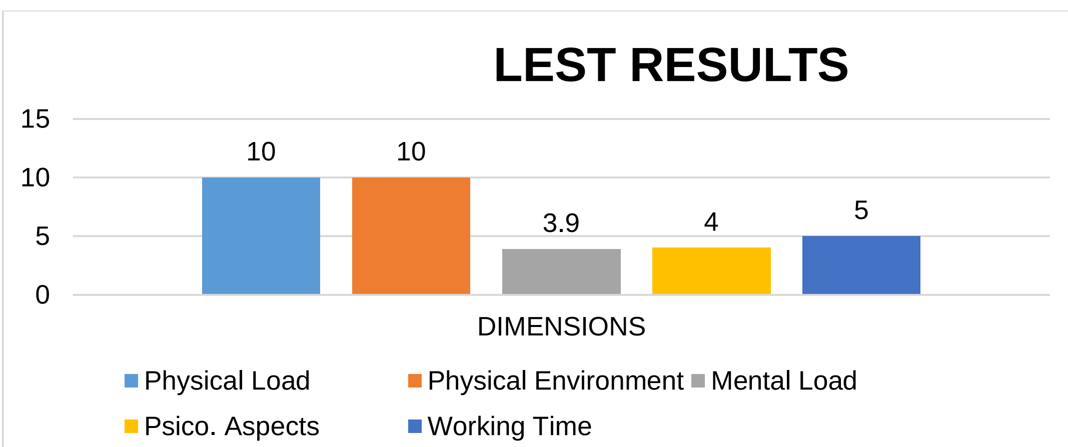

Figure 2. Man-Machine system #1: Making pizza dough, inventory control, repairs LEST results

Although the following man-machine system shown (preparation of recipes) does not show an excessive lack of control in the dimensions attended, can cause strong discomfort and even fatigue when carrying out the activities required by it, caused by the same physical environment in which they are carried out, definitely requires attention directly the load of the physical environment to make the workplace more conscious concerning the worker's wellbeing.

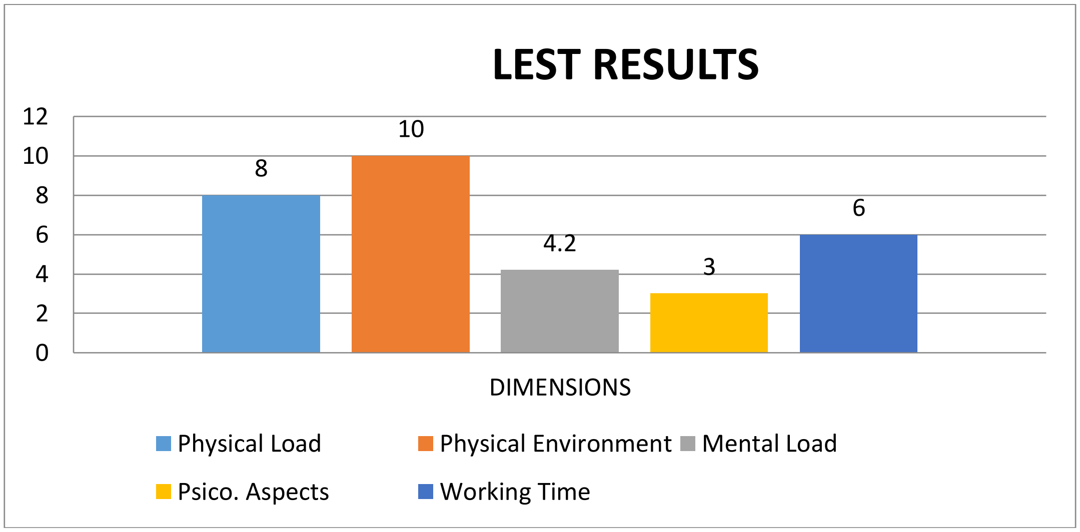

Figure 3. Man Machine system #2: Recipes preparation, manage work team LEST results

The last workplace analyzed apparently (as indicated in the following Figure) is the one with the lowest evaluation which indicates that even as in the previous analyses, the physical environment is the one that can cause greater discomfort and fatigue, but the other dimensions taken into account in some way stabilize the work of the station.

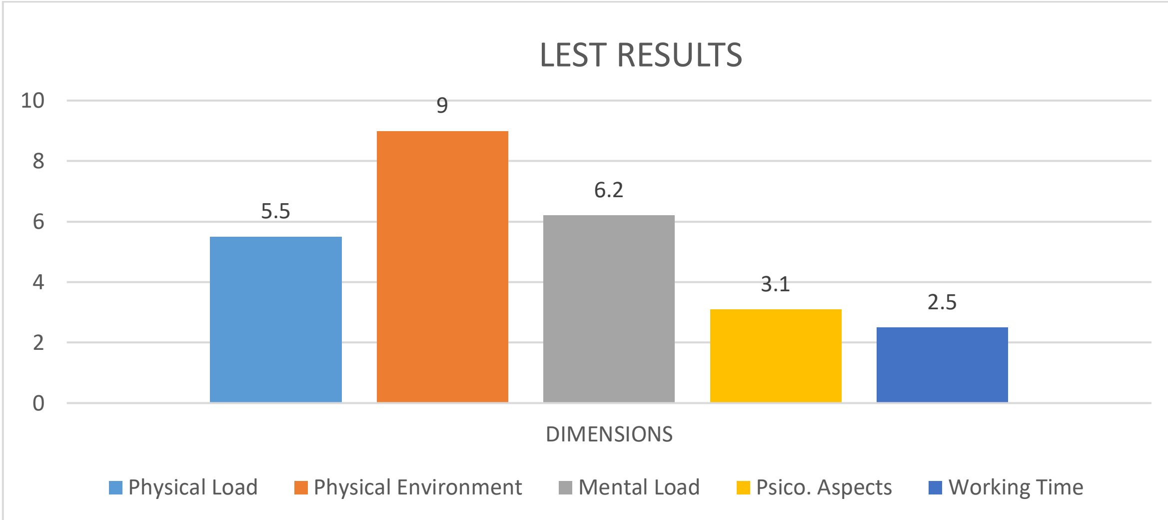

Figure 4. Man-Machine system #3: Take and deliver orders, collect, and make cash cuts. LEST results

5. CONCLUSIONS

After having analyzed each of the previous positions it is shown that the burden by the physical environment is the dimension with the greatest source of negative effects in the labor systems analyzed, so it is concluded that this must be addressed at its root to determine the necessary corrective actions either trying to reduce the impact by situations out of control or address the physical conditions in more detail than it would determine. seeking an improvement in the workplace.

With respect to the three workstations, it is evident that in the positions analyzed the physical environment requires more punctual attention, as shown in the figure shown below.

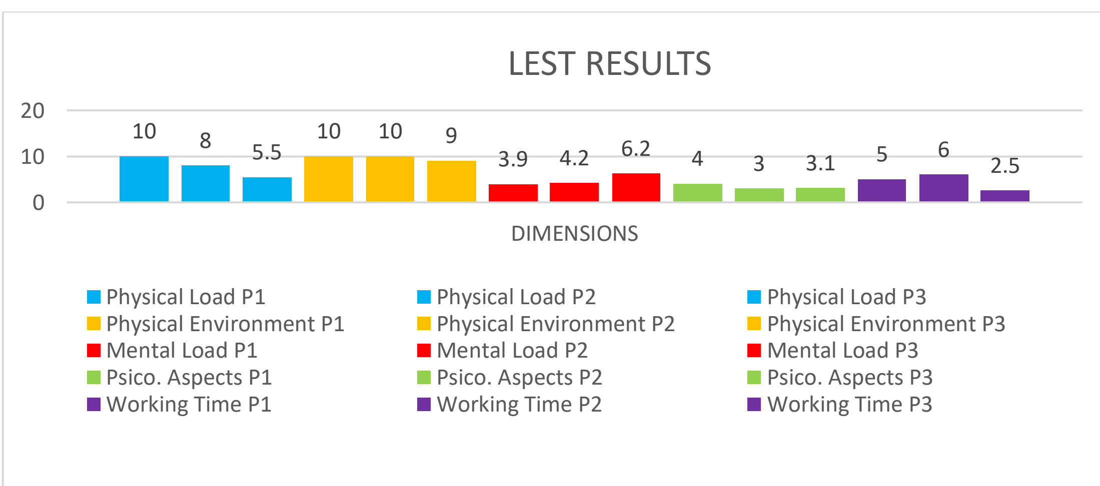

Figure 5. LEST global results

Contribution to Ergonomics:
The ergonomics are based on the comfort, safety, and functionality of the worker, which allows them to attend punctually to each of the points observed in the workplace and thus achieve the optimization of the processes integrating both the worker and his work environment, if this perspective is used it will always be in a condition that the improvements in the processes go hand in hand with the well-being of the personnel involved In this, allowing a closer relationship between the operator and his work environment

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COMPARATIVE ANALYSIS OF TWO ASSISTIVE DEVICES FOR GAIT SUPPORT IN ELDERLY

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Resumen
Este artículo presenta en forma sucinta un ejemplo del análisis comparativo de dos andaderas, objetos muy utilizados actualmente por los adultos para desplazarse con seguridad ante situaciones derivadas de alguna secuela de enfermedad, un accidente o por haber perdido habilidades derivadas de la edad u otra situación.

El análisis de productos o de objetos es la etapa inicial del proceso de diseño, por ello es iimprescindible dominar esta fase para que se conozcan a fondo los requerimientos de diseño que derivan en el concepto de diseño que habrá de desarrollarse hasta lograr un producto final que cumpla con las necesidades planteadas. En el análisis se observan paralelamente los factores de diseño y se destacan los ergonómicos para obtener resultados útiles que se apliquen en proyectos. A su vez el análisis de productos puede ser una herramienta didáctica muy útil para encauzar a estudiantes en sus primeros años de formación académica, como apoyo muy importante para desarrollar proyectos con mayor profundidad al concluir la carrera y desde luego que pueda convertirse en un hábito en el desempeño profesional.

Palabras clave: Diseño, ergonomía, andadera, análisis comparativo.

Relevancia para la Ergonomía

El análisis de objetos se puede considerar como una técnica muy completa derivada del proceso de diseño para conocer a fondo los productos con base en enfoques combinados donde el diseño y la ergonomía confluyen para lograr una visión integral y ofrecer productos adecuados a la población elegida, en este caso a los adultos mayores que necesitan atención especializada. Se recomienda publicar los resultados y difundirlos en el ámbito académico y en el profesional para generar datos confiables que coadyuven tanto a la formación de futuros profesionistas con bases sólidas y actualizadas en el contexto de la ergonomía y diseño.

Abstract
This article succinctly presents an example of the comparative analysis of two walkers, objects currently widely used by adults to move around safely in situations resulting from an illness, an accident or loss of skills due to age or any other situation.

The analysis of products or objects is the initial stage of the design process, so it is essential to master this phase in order to have a thorough understanding of the design requirements that result in the design concept to be developed until a final product that meets the proposed needs from the beginning. In the analysis, design features are observed in parallel and ergonomic factors are highlighted in order to obtain useful results to be applied in design projects. In other way, product analysis can be a very useful didactic tool to guide students in their first years of academic training, also as a very important support to develop projects with greater depth at the end of their studies and obviously it is relevant that it can become a habit for professional performance.

Key words: design, ergonomics, walkers, comparative analysis.

Relevance to Ergonomics
Object analysis can be considered as a very complete technique resulting from the design process to gain in-depth knowledge of products based on combined approaches where design and ergonomics converge to achieve an integral vision and offer products suitable for the chosen population. In this case older adults in need of specialized care. It is recommended to publish the results including the academic and professional contexts to generate reliable data that will contribute to the training of future professionals with solid and updated bases in ergonomics and design issues.

1. INTRODUCTION

This paper presents a comparative analysis of two walking aids used mostly by elderly who require support to move around independently and safely. This device is known as walker or in similar category as rollator. This is a very accessible object or product that is currently used in several places, either indoors or outdoors, to help people with motor impairments. It is significant to achieve the analysis from design and ergonomics perspective to be able to adequately address design problems where ergonomics is a strategic topic.

The article is divided into different stages, based on the design process where analysis is the first and most important phase.

The design process consists of distinguishing and separating the parts of the whole - design problem - until arriving at its principles or elements: design requirements. These principles or elements are specified in terms of the essential characteristics that make up the substantive requirements. The explicit statement of the problem, as a unitary description of the design context is based on a set of assumptions that correspond to the facts allowing us to obtain design concepts, provides a structure to approach and interpret the design problem in a given historical moment, within a geographical space and in a specific culture. (Simon, 2009).

The experts agree that this technique is the best option.

2. OBJECTIVES

To learn through comparative analysis the advantages and disadvantages, from design and ergonomic approach of two different models of walkers known as auxiliary devices to help adults with physical limitations, in order to develop design and ergonomic guidelines intended for academic and professional issues.

3. DELIMITATION

This analysis focuses on two models of walkers, as it is known in Mexico, as an auxiliary device for ambulation that consists of a light structure with four legs that serves to assist standing for walking. The target population identified in this analysis is older adults who require this product for mobility. This paper presents a comparative analysis of interaction with the product observed from the field of design and applied ergonomics, based on personal experience in both disciplines, as well as comments from some users.

4. METHODOLOGY

- Comparative analysis based on design methods: description, observation, analysis and evaluation of products.
- Analysis of users in different conditions based on user-centered design.
- RULA technique as support in postural analysis.
- Description and analysis of tasks. User interaction with each of the products. Based on the ergonomic design approach.
- Record of personal experience in the use of the walker.
- Photographic record and analysis of the images.
- Definition of terms: postural stability, assistive devices for ambulation, people with motor disabilities, elderly people, confidence, autonomy and safety.

- Glossary.

5. COMPARATIVE ANALYSIS

At the beginning of the process, it is important to know the objects, the two walkers chosen, in detail in order to be able to analyze the most important parts and their implications in the user-object relationship.

5.1. Description of folding walker.

In first place, we chose among different models, the most common and known of the walkers. Because of its price, availability and ease to handle. It is known as **“Folding Walker”.** The **folding walker** is an assistant moving device that is foldable. This **walker** has four legs and all four legs stay in contact with the ground when the user is moving. (Figure 1). To move forward, the walker must be lifted.

Figure 1. Folding walker with four legs and a one button release in each leg, highlighted with a red circle. See Figure 3.

The adult folding walker has a lightweight aluminum frame and a one button release for great security. The walker is foldable for easy transport and storage.

Product specifications and features:

- Lightweight aluminum frame
- Round aluminum tube 19 mm diameter
- Extending legs to adjust height
- One button folding system.
- Comfortable handle grips of soft foam. Figure 2: (**A**)
- Non-slip black tips at the end of 4 legs.
- Front horizontal reinforcement of steel tube with dark finish. Figure 2: **(B)**

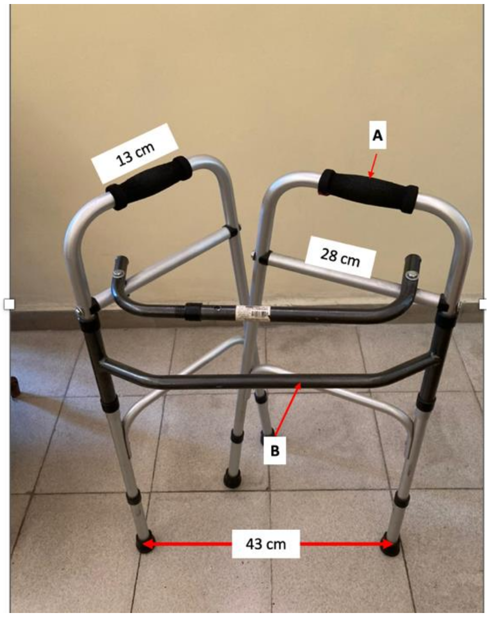

Figure 2

- Height
  Five adjustable heights, every 2.5 cm
  Range of adjustments 10 cm,
  Minimum height: 80 cm
  Maximum height: 90 cm

Features:

Lightweight: 2.15 kg
Users' weight limit: 135 kg

- Risks and constraints:
  Attention:
  When a tall user weighing 90 kg, adjusts the walker to the maximum height, rests it on the floor; when moving he/she exerts a force forward and as a result of that force the front legs bend, due to a poor fit. (Figure 3).

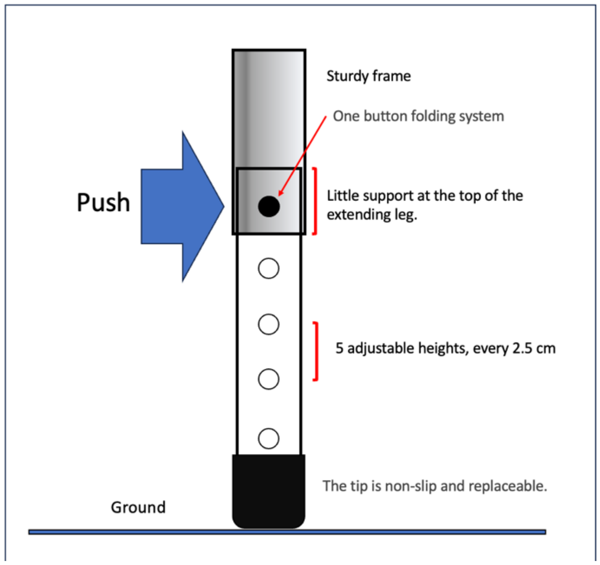

Figure 3.
Extending leg with 5 adjustable heights at every 2.5 cm

This folding walker is very useful because it is very simple to move under different circumstances.

Users should ask others for help in adjusting the four legs to suit them in height and walking position. The round tube lacks references to locate the button folding system (Figure 3) when trying to align them at the first attempt.

How does it fold?

The side structures are folded towards the center, the mechanism is a simple button that releases the tubes that run inside towards the center. (Figures 2 & 4).

The user must press the button with left or right finger.

Figures 4a and 4b.

It should be noted that there are two comfortable handle grips of soft foam where the user places his/her hands to support himself/herself and move the walker. Two pieces of soft foam are located around the tube in the straight horizontal part that are 13 cm long. (Figures 2. A and 4).

Figure 5.

It is important to mention, that this walker is lightweight, folds easily, can be lifted with one hand and has no protruding parts. (Fig. 5).

A major disadvantage is that the folding button requires a certain amount of force and precision grip, which is not easy for weak people.

5.2. Description of wheel-walker.

Product specifications and features:

- Lightweight aluminum frame
- Round aluminum tube 25 mm diameter
- Extending legs to adjust height
- Two buttons folding system. One on each side. Trigger release
- The front legs are supported with 5 inch wheels

- Handle grips of rigid plastic. Figures 7a and 7b
- Non-slip black tips at the end of 2 legs.
- Front horizontal reinforcement of steel tube with light gray finish. Figure 7

- Height
  Eight adjustable heights, engraved with a number, every (1”) 2.5 cm
  Range of adjustments 22.8 cm
  Minimum height: (30”) 76.2 cm
  Maximum height: (39”) 99 cm

- Weight
  Lightweight: 2.90 kg
  Users’ weight limit: 135 kg

Figure 6. Wheel walker

Figures 7a and 7b. Trigger release system

This wheel walker offers better maneuverability, provides support and stability while walking within the expressed weight limits. This model offers different features for users with other requirements. These users have more strength in their hands to be able to press the buttons to fold each side separately. Once the walker is folded, it can slide on the wheels because the tubes of the rear legs are higher up. The wheel walker is better for maneuverability without lifting it. No protruding parts either. (Figure 8).

Height adjustment

It is difficult to match the perforations since in a round tube the alignment is easily lost. This model of walker has engraved on the 4 tubes that form the legs, the numbers from 1 to 8 near the perforations so that you can easily adjust the appropriate height without any problem. This is a detail that designers provide to help users adjust it. The first steps of a person must be carefully observed to avoid any incident. (Figure 8).

Figure 8

Both walkers have the same width, which is important for the user to be able to lean on the walker when getting out of the wheelchair. (Figure 9).

Figure 9

5.4. Anthropometric analysis.

Four individuals were chosen to voluntarily participate in this brief descriptive and comparative analysis of two walkers as walking aids. The users have different conditions which are briefly discussed.

This part of the analysis requires consulting the anthropometric data that are frequently used in our academic environment; published by the University of Guadalajara: *Dimensiones Antropométricas de Población Latinoamericana*. Authors Avila, Prado and González (2001). Data on the "Elderly population of both sexes in the 60 to 90 years age group".

Table 1

Static anthropometric measurements. Elderly. Women. 60 to 90 years old.
Avila, Prado y González (2001).

	5th Percentile	50th Percentile	95th Percentile	
Stature	1398	|500	1615	mm
Weight	44.1	63.7	85.60	kg
Standing elbow height	849	926	1007	mm
Body breadth	428	495	569	mm
Forward reach	508	571	634	mm
Grip width	71	77	84	mm
Ball Grip	36	43	49	mm

Table 2

Static anthropometric measurements. Elderly. Men. 60 to 90 years old.
Avila, Prado y González (2001).

	5th Percentile	50th Percentile	95th Percentile	
Stature	1519	1635	1746	mm
Weight	46.2	68.0	95.2	kg
Standing elbow height	923	1000	1091	mm
Body breadth	439	506	586	mm
Forward reach	549	620	687	mm
Grip width	79	86	94	mm
Ball grip	38	44	51	mm

Figure 10
Hand grip details in both woman and man compared with anthropometric data.

The second walker, with plastic hand grip measures only 4 inches (10.2 cm), compared with the soft hand grip measures 5 inches (12.5 cm).

Table 3
Static anthropometric measurements of two elderly users and the grip measures of each walker

Grip width (Avila, 2001)	71	77	84	mm
User 1: woman *		**75**		**mm**
Walker Hand grip length		**125**		**mm**
Grip width (Avila, 2001)	79	86	94	mm
User: man**			**110**	**mm**
Wheel-Walker Hand grip length			**101.6**	**mm**

(*) (**) These widths were obtained by directly measuring the hands of the users.
Figure 10 shows how each one, the woman and the man, grab the handle.
The woman has smaller hands while this masculine user has larger hands.

5.4.1. Walker Height versus Posture

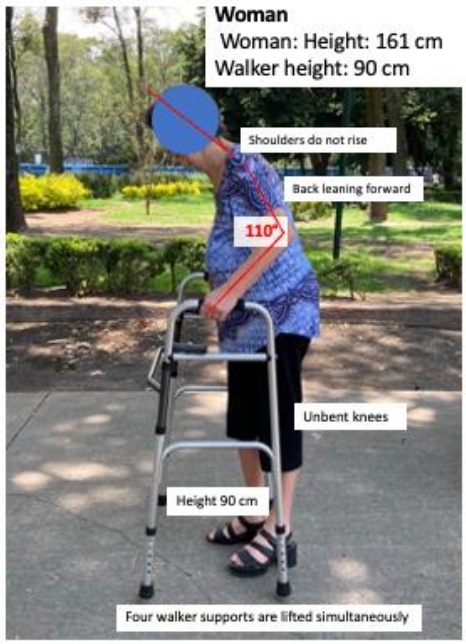

Figure 11

Sequence of movements to start walking

Figure 12

Figure 13
Walker height 90 cm and user height is172 cm. Weight is 88.5 kg.

The user is continuously supported on the walker without lifting it, as the front wheels help to maintain balance and walk safely. Easy-to-maneuver wheels that provide greater mobility and convenience.

The postures were observed and analyzed based on the images obtained with the cell phone camera. They were then transferred to a drawing program on a personal computer to place scales on the images and corroborate the angles; this technique offers sufficient precision to know the general data.

5.5. User Analysis

Users of walkers are people of both genders, within the group of elderly, who find themselves in trouble to walk because they have lost abilities or skills due to age and / or disease. They try to be independent and autonomous in many daily activities, so they look for some device that helps them to move safely, with stability and balance especially in unacquainted surroundings.

In addition, it is very important to include emotions in order to achieve a comprehensive analysis of the person, not only from the technical approach.

According to Ortiz Nicolas (2018), a person can experience positive and negative emotions while interacting with a product. From this perspective, the users answered succinctly to issues that concern emotions.

5.5.1. User one.

70-year-old woman who has sequelae of an accident. She has a shorter left leg and requires special shoes. She has poor strength in her left arm and hand.

She uses the walker to move around indoors and short distances outdoors, as a complement to the wheelchair.

Table 4
Personal data of female user

Stature	161	cm	
Weight	57	kg	
Grip width	75	mm	Right hand
Hand length	170	mm	
Grip width	65	mm	Left hand
Hand length	160	mm	
Age	70	years old	

She uses the simple lightweight walker with four legs, adjusted to the maximum height, always under the supervision of another person, due to the importance of avoiding falls.
Emotions: Anguish. Distrust. Fear.

5.5.2. User 2.
60-year-old male, uses the walker indoors after knee surgery, so he must not support his right leg. He used the walker to adjust to the maximum height. As a result, the extensions of the front braces were weakened and bent due to pushing while walking. Although the specifications of the walker indicate that it can support 130 kg, this was not the case, as there were forces that could be exerted on it. (see Figure 3).

Table 5

Stature	180	cm	
Weight	95	kg	
Grip width	75	mm	Right hand
Hand length	170	mm	
Grip width	65	mm	Left hand
Hand length	160	mm	
Age	60	years old	

After looking for an appropriate device he found the wheel walker and decided to buy it, since it combines a more reinforced structure with a larger diameter tube and has two wheels on the front, which offers greater stability and maneuverability.

At the beginning distrust and at the end it was corroborated that it was not adequate for his conditions.

Negative emotions: fear, insecurity and distrust.

Table 6

Stature	163	cm	
Weight	63	kg	
Grip width	80	mm	Right hand
Hand length	175	mm	
Grip width	75	mm	Left hand
Hand length	170	mm	
Age	60	years old	

5.5.3. User 3

60-year-old woman with an orthopedic boot on her right foot in the process of recovering from a metatarsal fracture. the use of the walker was only for 4 to 6 weeks, she gradually improved and became less dependent on the walker. Although the medical indications refer to avoid supporting the foot.

The walker helped her to move around safely and confidently, allowing her to support her right leg as little as possible.

Positive emotions: confidence and surprise. A little bit afraid.

Table 7

Stature	163	cm	
Weight	63	kg	
Grip width	80	mm	Right hand
Hand length	172	mm	
Grip width	75	mm	Left hand
Hand length	160	mm	
Age	60	years old	

5.5.4. User number 4

Man 84 years old. He uses the wheel-walker with two front wheels. It helps him to move safely in unfamiliar and irregular environments. It complements the cane. In addition, this walker provides greater certainty of moving safely due to its technical specifications: larger diameter tube and thicker wall which increases the resistance of the material that forms the structure.

Transformations in anthropometry, according to Kroemer (2006), variations in stature are evident because of aging-related due to the posture and shrinking of spinal discs; in weight because nutrition, metabolism and health differ.

Positive emotions were expressed while using this walker: Stability, safety and independence.

Table 8

Stature	172	cm	
Weight	88.5	kg	
Grip width	110	mm	Right hand
Hand length	190	mm	
Grip width	105	mm	Left hand
Hand length	185	mm	
Age	84	years old	

6. RESULTS

The results obtained from this comparative analysis of products in the classification as orthopedic cover several issues that are addressed through each of the factors, among which are the user-object relationship considering age, sequelae of disease, surgery or accident, posture and movements, detailed description of the parts of the device to show and define its operation, conditions of use indoors and outdoors highlighting advantages and disadvantages in everyday life. Present the results graphically supported with images and other techniques representative of the design profession considering ergonomics contents.

It is included is a brief sketch of the emotions the users experienced and asked about directly, without any in-depth explanation of the topic.

Nowadays is important to develop new understanding of pleasant as well as unpleasant experiences resulting from human-product interactions as some authors recommend to achieve a whole vision, which may result of the overall study including design and ergonomics.

7. CONCLUSIONS

To demonstrate that object analysis is a didactic tool to interest students in design and ergonomics, as well as a support for teachers to develop creative abilities and skills that facilitate the interpretation of information and find solutions to problems that encompass both disciplines. It could be interesting to include another and unexplored point of view that includes emotions.

8. CONTRIBUTIONS TO ERGONOMICS

Object analysis can be considered as a technique to evaluate products and further publication of contents that helps to choose the most appropriate for the target population in this case of elderly, because it is based on recognized methods of ergonomics and design.

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ERGONOMIC REDESIGN OF A TIRE DEMOUNTING BAR

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Resumen: Los daños musculares en operadores son ocasionados por el mal manejo de herramientas o por el mal diseño de ellas, en una llantera los operadores están expuestos a diversos riesgos por las distintas actividades que realizan, las cuales son de un riesgo elevado ya que se requiere de mucha fuerza muscular en algunos casos, y de optar posturas inadecuadas ante ellas. El montar y desmontar llantas es una de las actividades más frecuentes a realizar, por lo tanto, hay un porcentaje alto de que el operador este inseguro y que esto le vaya afectar en su salud más adelante, desde dolores, alguna lesión o hasta una enfermedad. El presente estudio forma parte de un rediseño de una barra desmontadora de neumáticos, en la cual se realizarán algunas modificaciones que sean un aporte ergonómico para el operador. El objetivo de este rediseño es facilitar el trabajo, al igual que evitar fatigas y daños musculares a corto o largo plazo.

Palabras claves: Barra desmontadora, Diseño, Protección, Riesgos ergonómicos, neumático.

Relevancia para la ergonomía: Cabe mencionar que el presente artículo, destaca una serie de muestras, aportaciones y finalidades con el cual fue elaborado, siendo esta una investigación enfocada en las actividades que ejecuta un operador en una llantera con su barra desmontadora de neumáticos, puesto que logramos observar una gran cantidad de problemas de salud como dolores lumbares, cansancio, irritación de ojos, dolor de cabeza, lumbalgia, dolor de articulaciones, hernia, entre otros, que se producen en un corto periodo de tiempo, reduciendo la eficacia y productividad del trabajador al final de una jornada laboral.

De esta manera surge la idea de rediseñar la herramienta de trabajo principal del operador, para tener una mayor comodidad de agarre y manipulación al momento de utilizarla, creando en ella una estructura ergonómica, aumentando la eficiencia y productividad del trabajador, además de disminuir los problemas de salud, cuidando tanto su integridad física como mental.

Abstract: Muscular injuries in operators are often caused by improper tool handling or their inadequate design. In a tire shop, operators are exposed to various risks due to the diverse activities they perform, many of which involve a high level of muscular effort and necessitate adopting improper postures. Mounting and dismounting tires stand out as among the most frequent tasks, thereby increasing the likelihood of operator insecurity and subsequent health implications, including discomfort, injuries, or even long-term ailments. This study constitutes a component of the redesign process of a tire demounting bar, incorporating modifications that contribute to ergonomic enhancements for the operator. The primary aim of this redesign is to streamline the work process, concurrently alleviating short and longterm muscular fatigue and injuries.

Keywords: Demounting bar, Design, Protection, Ergonomic risks, Tire**.**

Relevance to Ergonomics: It is noteworthy that this article highlights a series of samples, contributions, and purposes for which it was developed. This research is focused on the activities carried out by an operator in a tire shop using their tire demounting bar. Through this study, we were able to observe a significant number of health issues such as lower back pain, fatigue, eye irritation, headaches, lumbar pain, joint pain, hernias, among others, occurring over a short period of time. These health issues ultimately lead to reduced effectiveness and productivity for the worker at the end of a workday.

Thus, the idea of redesigning the operator's primary work tool emerges, aiming to provide better grip and manipulation comfort during usage. This involves creating an ergonomic structure for the tool, enhancing the efficiency and productivity of the worker while also mitigating health problems. This redesign approach seeks to safeguard both the physical and mental well-being of the operator.

1. INTRODUCTION

According to a published article by Ricardo Menéndez Mansilla from the University of Concepción (EID) in Puerto Montt, Chile, titled "Ergonomic Study on Tire Mounting and Dismounting Work in the Mechanical Maintenance Area on August 10, 2020," operators in tire shops involved in tire mounting and dismounting activities often overlook both safety and occupational health aspects. Therefore, an ergonomic analysis was conducted on these operators to identify physical, cognitive, and psychosocial alterations to which they may potentially be exposed during their work tasks. Utilizing various methodologies, such as the LEST method, the analysis was carried out to evaluate the different conditions to which the operator is exposed within the human-workstation system. This analysis revealed several consequences experienced by the workers, including lumbar discomfort, fatigue, and reduced productivity.

The published article by Rosa Isabel Gómez Rangel from the Universidad Autónomous Metropolitana, Mexico City, titled "Health and Work Among Employees in a Tire Shop in Mexico City, Chapter 3, October 2011," sheds light on the various physical, psychosocial, and psychological risks to which tire shop workers are exposed, profoundly affecting their health. This exposure leads to symptoms, discomfort, illnesses, and injuries that, if not addressed promptly, can cause irreversible damage. These include fatigue, eye irritation, headaches, lower back pain, joint pain, hernias, among others. The article suggests proposed measures to mitigate such risks, such as the use of belts, safety shoes, earplugs, and suede or leather gloves.

Based on this, the present document presents a redesign of a manual tool, a "tire demounting bar," used by tire technicians or operators in tire shops, for the tasks of tire assembly and disassembly. These tasks exhibit similar issues across different risk levels due to the force applied while performing various activities in a tire shop. It is of paramount importance to consider that this work area involves a significantly high level of effort, which becomes more perilous due to the nonergonomic postures adopted by operators based on the dimensions of the tires they are working on. This leads to short-, medium-, and long-term physical damage, deteriorating the worker's productivity levels in terms of efficiency and effectiveness in carrying out their tasks.

The alternative prototype for the tire demounting bar is a redesigned tool for ergonomic purposes, intended to facilitate work and counteract fatigue. Its features include a solid steel bar to maintain stability and rigidity, with an added curvature of approximately 100 degrees at one end, which enhances the applied force. The entire body of the bar is covered with non-slip material, except for the spatulas at its ends, to improve grip and provide comfort during operation.

Process Description: The operator responsible for carrying out tire dismounting, and mounting operations performs a series of repetitive movements as part of their work (dismounting the tire from the rim). This procedure is executed as follows:

The tire demounting bar is grasped simultaneously with both hands. The right hand is positioned on the curve of the bar to assume a straight and firm posture. Meanwhile, the left hand supports beneath the same curve to position the spatula from one end of the bar between the tire and the rim. Once the hands and spatula are correctly and appropriately positioned, an absolute or necessary force is applied to disengage the tire bead, allowing the operation to be repeated multiple times until the tire is fully dismounted.

2. OBJECTIVE

2.1 General Objective: To ergonomically redesign a tire demounting bar.

2.2 Specific Objectives:

- Create a bar with a curve and cushion for ergonomic and practical grip to enhance the operator's work.
- Apply anthropometry for tool redesign.
- Conduct an anthropometric chart.

3. METHODOLOGY

Author John Elliot conceptualizes the following: action research provides a solution to the issue of the relationship between theory and practice (ELLIOT, 2002).

For the creation of the ergonomic demounting bar redesign, field research will be employed, conducted through a descriptive study. Given the study's characteristics, an inductive method will be employed as a redesign proposal for an ergonomic tire demounting bar is put forth. The project will unfold as a practical investigation, generating actions focused on the implementation proposal of this type of bar in tire shops.

For the redesign of the ergonomic demounting bar, anthropometric measurements were taken from 28 tire shop operators.

3.1 Anthropometric Chart

Below is the anthropometric chart conducted on 28 workers in the tire mounting and dismounting area.

Tabla No. 1 Anthropometric Chart

ANTHROPOMETRIC MEASUREMENTS							
Operator	**Height (cm)**	**Weight (kg)**	**Hand length (cm)**	**Palm length (cm)**	**Palm width (cm)**	**Grip diameter (cm)**	**Floor to waist distance (cm)**
1	175	65	19.5	10.5	9	4	100
2	170	102	20	11.5	10	3.5	98
3	160	85	17	10	8.5	3.5	95
4	165	69	17	9	8.5	3.5	97
5	173	74	19	10	9.5	4	100
6	185	90	19.5	10	9.5	4	110
7	178	78	18.5	9.5	9	3.5	100
8	162	60	17	8.5	8	5	103
9	163	76	17	11	8	7	108
10	165	78	18.5	11	10	6	105
11	182	98	19	11	10	6	117
12	165	68	16	8.5	8.7	6	99
13	183	84	20	12	9	6	115
14	195	100	21	13	8	7	102
15	165	70	18	10	9	5	98
16	178	84	16	10	9	4	105
17	182	106	19	10	9	6	101
18	170	90	19	12	10	4.2	99

19	187	99	18	9	10	5	106
20	180	94	19.2	10.5	9.2	4.1	109
21	182	68	20	13	8	6	110
22	183	94	20	11	9	6	112
23	189	69	19	10	9	5	103
24	170	65	18	10	8	5	100
25	195	97	21	13	8	5	102
26	168	82	17	9	12	6	56
27	166	65	17	10	9	5	109
28	183	99	16	11	10	6	118

The above measurements were considered in order to carry out the ergonomic redesign of the tire demounting bar, as it is of paramount importance to understand the variation in measurements among the 28 operators, including their height, weight, hand length, palm length, palm width, grip diameter, and floor to waist distance. Appropriate percentiles were analyzed to ensure the tire demounting bar design is feasible for any of the 28 operators.

Tabla No. 2 Percentiles

PERCENTILES							
Operator	Height (cm)	Weight (kg)	Hand length (cm)	Palm length (cm)	Palm width (cm)	Grip diameter (cm)	Floor to waist distance (cm)
0.05	162.35	65	16	8.68	8	3.5	95.7
0.5	176.50	83	18.75	10	9	5	104
0.95	192.90	101.3	20.65	13	10	6.65	117.65
Highest point	195	106	21	13	12	7	120
Lowest point	160	60	16	8.5	8	3.5	95
Average	175.68	82.46	18.44	10.5	9.10	5.05	105.11

As observed in Table 2, the 0.05 percentile for height is 162.35 cm, while the highest 0.95 percentile for the same category is 192.9 cm, with an average of 176.50 cm. In terms of weight, the 0.05 percentile is 65 cm, the highest percentile is 101.3 cm, and the median is 83 cm. For hand length measurements, the 0.05 percentile is 16 cm, the 0.95 percentile is 20.65 cm, and the median is 18.75 cm. In the case of palm length measurements, the lowest percentile is 8.86 cm, the highest is 13 cm, and the median is 10 cm. Regarding palm width measurements, a lower percentile of 8 cm, a higher percentile of 10 cm, and a median of 9 cm are observed. For grip diameter, the lowest percentile is 3.5, the highest is 6.65, and the median is 5 cm. Lastly, for floor to waist distance measurements, the lowest percentile is 95.7, the highest is 117.65, and the median is 104.

Figures:

Below, the anthropometric data points of the 28 operators are graphically depicted.

Stature.

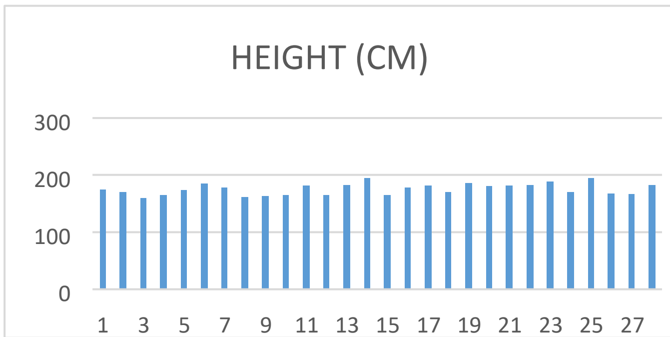


Fig.3.1.1. Height

Observing these measurements, it can be seen that all the studied operators exceed 150 cm in height, with minimal variation among them.

WEIGHT

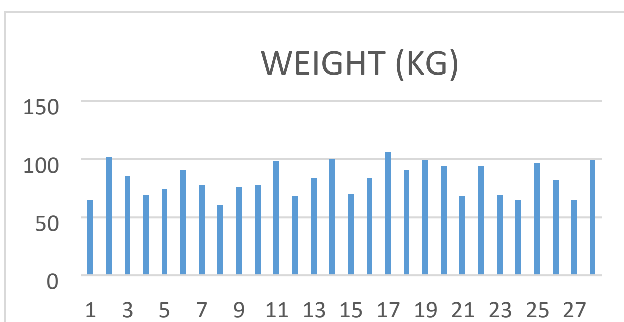


Fig.3.1.2. Weight

These data revealed a noticeable variation in weight, with a difference of 42 kg between the lowest and highest measurements.

Hand length.

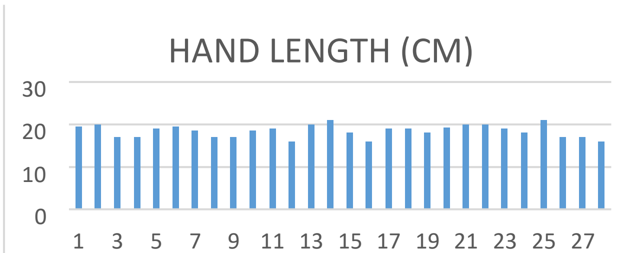
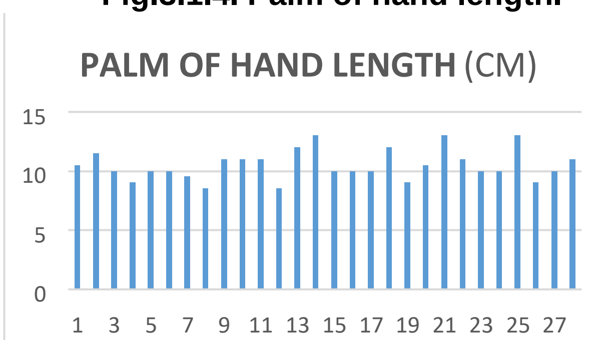


Fig.3.1.3. Hand length.

Observing the data for hand length measurements, the values range between 15 cm and 21 cm, with some variations in lengths evident.

Palm of hand length.

Fig.3.1.4. Palm of hand length.



In the case of palm length measurements, a significant variation in sizes is observed, ranging from the lowest measurement of 8.5 cm to the highest of 13 cm.

Palm of hand width.

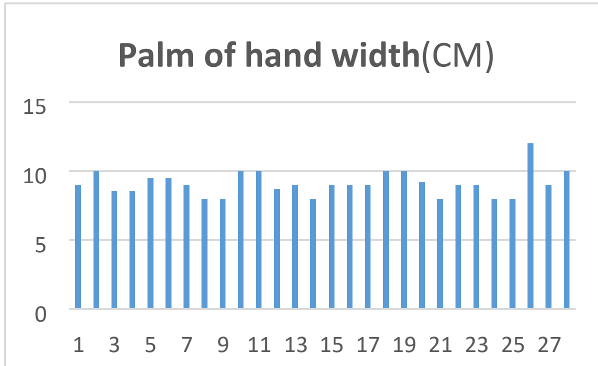


Fig.3.1.5. Palm of hand width

Grip Diameter.

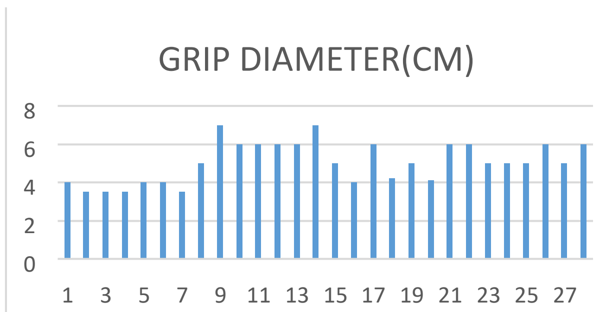


Fig.3.1.6. Grip diameter.

A significant variation in grip diameters is observed, with a lower measurement of 3.5 cm and a higher one of 7 cm.

Floor to waist distance.

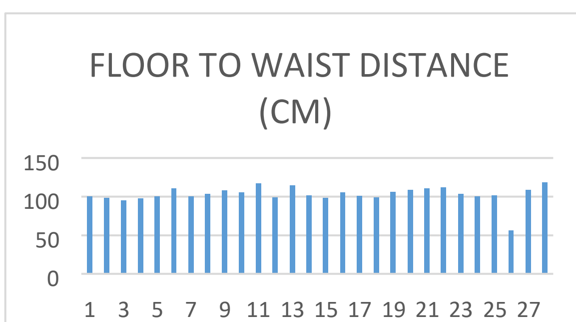


Fig. 3.1.7. Floor to waist distance.

Analyzing the measurements, there isn't much variation among the measurements, but in the case of one of them, it can be observed that it is at a lower point.

3.2 Procedure for the ergonomic redesign of the tire demounting bar.

Taking into consideration the 5th percentile of anthropometric measurements, the procedure for redesigning the demounting bar is outlined below. (See Table No. 2).

Step 1. Measurement of longitudinal dimensions of the original demounting bar body for redesign purposes.

Fig. 3.2.1 Original tire demounting bar

Step 2. For the prototype redesign, 3 meters of ⅜-inch steel rod were acquired, along with a 20 cm steel flat bar (6.3 mm thick, 50.8 mm wide), and 2 round sponges with a circumference of 11 cm and a length of 49 cm. The longitudinal measurement of the prototype is 1.12 m, with a grip diameter of 3.5 cm.

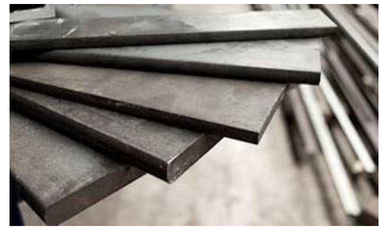


Fig.3.2.2 Steel rod **Fig. 3.2.3 Steel**

flat bar

Fig. 3.2.4 Sponges

Step 3. We began by cutting the 3 pieces of ⅜-inch steel rods (each 92 cm long) using an angle grinder and a metal cutting disc. This was followed by 2 cuts of the same size from the steel flat bar (6.3 mm thick, 50.8 mm wide).

Step 4. Once the cuts are complete, we proceed to position the 3 spliced rod pieces (2 on the sides and the 3rd one over the pair of rods) in preparation for welding (using a welding machine set to 50 amperes and high ground, with E6013 electrodes).

Step 5. We weld between each joining of the 3 rods with a 5 cm bead, leaving 5 cm gaps between each unwelded section.

Fig. 3.3.5 Welding Process

Step 6. Upon completing the welding and joining of the 3 pieces of ⅜-inch steel rods, we proceed to bend the bar. Considering one end of the body of the bar, at the beginning of the curve, it measures 72 cm. While keeping the bar straight, a 30° angle is generated using a steel pipe and a mason's clamp.

Step 7. After completing the bend on the bar, we place each of the previously cut steel flat bars at each end and weld them once again to join the pieces with the bar.

Step 8. Right after finishing the welding, using an angle grinder and a 4 ½inch abrasive metal disc, we remove all slag from the entire bar and shape the steel flat bars into spatula forms.

Step 9. Finally, we insert the sponges from one end using adhesive and proceed to paint.

4. RESULTS

An ergonomic tire demounting tool is introduced, offering tire shop operators the opportunity to achieve an improved quality of work and personal life. A redesign of the ergonomic bar is proposed, aiming to provide protection and ease of use during work, thereby enhancing the operator's job performance.

Original Bar.

Fig. 4.1

Fig. 4.2

Redesigned bar.

Fig. 4.3

Fig. 4.4

5. CONCLUSION

The prototype redesign of the tire demounting and mounting tool facilitates the operator's task due to its ergonomic redesign aimed at enhancing grip, the angle of use, and the posture of tire shop operators. This leads to more efficient and effective work. Furthermore, the utilization of an ergonomic tool is of utmost importance to prevent health issues, given that over time the process is repeated frequently and involves exerting a high level of force, resulting in a high level of risk for the operators.

The tools used for tire and wheel dismounting are quite useful today, given the diversity of vehicles, both light and heavy-duty, which require maintenance depending on their use and load-bearing capacity. In large cities, the use of vehicles for transportation and mobility within various points of the cities and metropolises is indispensable.

The aforementioned prototype was constructed using 3 meters of ⅜-inch steel rod, a 20 cm steel flat bar (6.3 mm thick, 50.8 mm wide), and 2 round sponges with a circumference of 11 cm and a length of 49 cm. Its longitudinal measurement is 1.12 m, with a grip diameter of 3.5 cm.

The redesign costs were as follows: $250 for a 9 m length of ⅜-inch steel rod, $70 for the 20 cm steel flat bar, $25 for the cutting disc for the angle grinder, and a total cost of $200 for welding the complete bar.

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DESIGN AND IMPLEMENTATION OF A DIDACTIC CONTROL PANEL TO EVALUATE THE OPERATION OF DRIVES IN DIFFERENT SCENARIOS

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Resumen
El presente proyecto está enfocado en el diseño de un tablero de accionamientos de seguridad, el objetivo de este, es que sea aplicado como un instrumento para prácticas en la materia de Ergonomía. Actualmente en la materia se tiene un manual de prácticas que abarca tópicos afines a Ergonomía ocupacional, tableros, controles, antropometría, condiciones físicas, etc. Gran parte de la información es impartida de forma teórica, por lo que se busca incorporar nuevos elementos académicos al programa, que conduzcan a mejorar la experiencia de aprendizaje mediante el uso de recursos prácticos (Tablero de accionamientos de seguridad).
La metodología seleccionada conduce a la realización de un tablero de accionamientos de seguridad y el diseño de una práctica que permita evaluar la importancia y funcionalidad de los componentes al ser operados por cualquier alumno que esté interesado en conocer los diferentes tipos de accionamientos en la industria maquiladora.

Palabras clave: accionamientos de control, controles, dispositivos de control, tablero.

Relevancia para la ergonomía: La principal aportación de este proyecto al área de ergonomía, es contribuir en la capacitación académica de los futuros profesionistas que cursan las asignaturas de ergonomía e higiene y seguridad, ya que se contará con un tablero que les ayudará a los docentes a abordar de una manera más ilustrativa y didáctica, lo referente a los tableros y controles.

Abstract: It This project is focused on the design of a safety actuators board, the objective of which is to be applied as an instrument for practices in the Ergonomics subject. Currently, the subject has a manual of practices that covers topics related to occupational ergonomics, boards, controls, anthropometry, physical conditions,

etc. Much of the information is taught in a theoretical way, so it seeks to incorporate new academic elements to the program, leading to improve the learning experience through the use of practical resources (Safety Drives Board).

The selected methodology leads to the realization of a safety drives board and the design of a practice that allows evaluating the importance and functionality of the components when operated by any student interested in learning about the different types of drives in the maquiladora industry.

Keywords. control drives, controls, control devices, control panel.

Relevance to Ergonomics: The main contribution of this project to the area of ergonomics is to contribute to the academic training of future professionals studying the subjects of ergonomics and health and safety, since there will be a board that will help teachers to approach in a more illustrative and didactic way, the subject of the boards and controls.

1. INTRODUCTION

Drive mechanisms play a critical role in a wide variety of industries and applications. These devices are responsible for converting energy into motion, enabling machines and systems to perform specific tasks (Mora, 2018). They are used from process automation to motion control, energy efficiency, safety and technological innovation, these devices play a key role in the efficient operation of mechanical systems and in driving productivity and technological advancement (Moreno & Tarazona, 2020).

This project is targeted to the future professional who has in his graduate profile the need to know the different controls that exist in the industry and in a variety of scenarios of common use, such as schools, hospitals, workplaces, and others. Many of these controls are implemented with the purpose of protecting the integrity of people by notifying and/or stopping machines if there is a dangerous situation. In this way they provide safety to individuals, equipment or simply are the means for proper man-machine communication (Oborne, 1990).

Under this perspective in the careers of TecNM (Tecnológico Nacional de México), in the subjects of Hygiene and Safety and Ergonomics within their educational programs, they have practices to instruct young people in the knowledge of different drives, providing them with training in the understanding of their functions, for proper use and integration of the design of control panels.

The design of this board is directed to the practices within the manufacturing laboratory of the Tecnológico Nacional de México Campus Cd. Juárez (ITCJ) to be carried out in a practical, efficient and giving students to know the most used controls in the industry in a physical way and within their reach.

2. GENERAL OBJETIVE

Design and implement the use of a didactic board with the most commonly used controls in the maquiladora industry, to carry out the laboratory practices of the ergonomics and hygiene and safety subjects at the ITCJ, in accordance with the provisions of the NOM-004-STPS-1999 standard.

3. DELIMITATION

The board that was designed contains the most commonly used drives in the maquiladora industry (since this is where ITCJ graduates commonly enter the labor field) and that through surveys it was determined that they are less known by Industrial Engineering students. The board has only didactic purposes for the subjects of ergonomics, hygiene and safety.

4. METHODOLOGY

The project has a non-experimental cross-sectional methodological design. The approach will be of decomposition, from the existing guidelines in relation to Ergonomics and Safety and Hygiene programs about safety controls, the general principles for the design of the control panel will be described. According to the type of data, it is mixed, since a survey and an interview are used as instruments for collecting and analyzing the information.

The methodology used for the design of the dashboard was known as DESIRE (Design Thinking Innovation and Research), which consists of 5 phases: Empathy, Definition, Ideation, Project Prototyping and Testing (Latorre et al., 2020).

In the first phase, empathy, the needs were identified for the development of a study on safety controls in the Ergonomics and Hygiene and Safety programs of the Tecnológico Nacional de México Campus Cd Juárez. The cognitive immersion technique was used, which includes a questionnaire directed to students of the industrial engineering career. The opinion of the students was gathered to determine the existing level of knowledge about safety controls. Techniques such as the study of trends and surveys will be used to identify the safety actuation devices currently used in the industry, which will be considered in the design of the control panel. In addition, a virtual survey will be conducted (Annex 1 - Instrument 02) directed to industrial engineering students of the Instituto Tecnológico de Ciudad Juárez. The objective of this survey is to identify the devices of which they have less knowledge in terms of functionality and importance. This information will be used in the design phase of the dashboard. security in the mentioned programs.

In the second phase, **definition**, techniques such as the study of trends and surveys were used to identify the safety drive devices currently used in the industry, which will be considered in the design of the control panel. In addition, a virtual survey was conducted, directed to industrial engineering students of the Instituto Tecnológico de Ciudad Juárez, to identify the devices of which they have less knowledge in terms of functionality and importance. This information will be used in the design phase of the control panel.

In the third phase, ideation, we used the Moodboard technique and the Council of the Wise, where we compiled a set of design models of boards used in other subjects, and the opinion of experts in the subject of ergonomics. Subsequently, with this information, a sketch of the board was made.

In the fourth phase, prototyping, in this phase we proceeded to build the control panel in physical form with the safety devices that were selected in the virtual survey with the students, and considering the suggestions obtained in the ideation phase.

In the fifth phase, Testing, the constructive interaction technique was used to gather information about the students' experience of use when operating the board, through a laboratory practice.

5. RESULTS

The results **of the first phase empathy,** were obtained through a 5-question questionnaire to 4 teachers who teach ergonomics subjects at the ITCJ. The main findings of this instrument are summarized below:

It is proposed to have didactic material in the laboratories to reinforce with practices the theory reviewed in the classroom.

Incorporate practices to the program, update the information of the subjects and consider constantly updating the didactic material.

Consider constantly updating the didactic material according to the current work environment.

In the second phase definition, through a virtual survey of 17 types of drives, the least known by the ITCJ student community were selected to be included in the design of the board, as shown in Figure 1.

In the third phase, ideation, we used the Moodboard technique and the Council of the Wise, where we compiled a set of design models of boards used in other subjects, and the opinion of experts in the subject of ergonomics. Subsequently, with this information, a sketch of the board was made, it is show in figure 2.

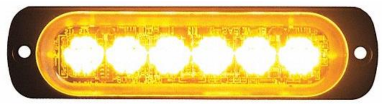
In the fourth phase, prototyping, Once the final layout of the components was captured in a design, the next step was to materialize it. Below is a sequence of figures describing the manufacturing process.

Once the list of necessary components was defined, we proceeded with the construction of the structure; composed of extruded with approximate dimensions of 20 x 2 x 22 inches (length, width, height). The distribution of the components will be positioned on a lexan plastic base, see figure 3 and 4.

Having the structure assembled together with the lexan plastic base, the next step was to make aesthetic improvements in terms of the visualization of the board, it was decided to paint the structure and to relocate the safety actuators. The total list of components is fourteen actuators, each of which was mentioned in the previous phase of the research. Figure 5 and 6.

For the connection of the components, it was decided to use a 24v power supply to energize each of the LED lights incorporated in the board. The principle of operation and functioning of the elements that make up the board will be described in the work instructions. See Figure 7.

Double protruding pushbutton



ceiling light

LED light turret

LED lights

Inductive approach sensor

Buzzer

Anti Tie Down Device

Interlock Magnetic

Mechanical Numbering

Figure 1. Actions less well known by the ITCJ student community

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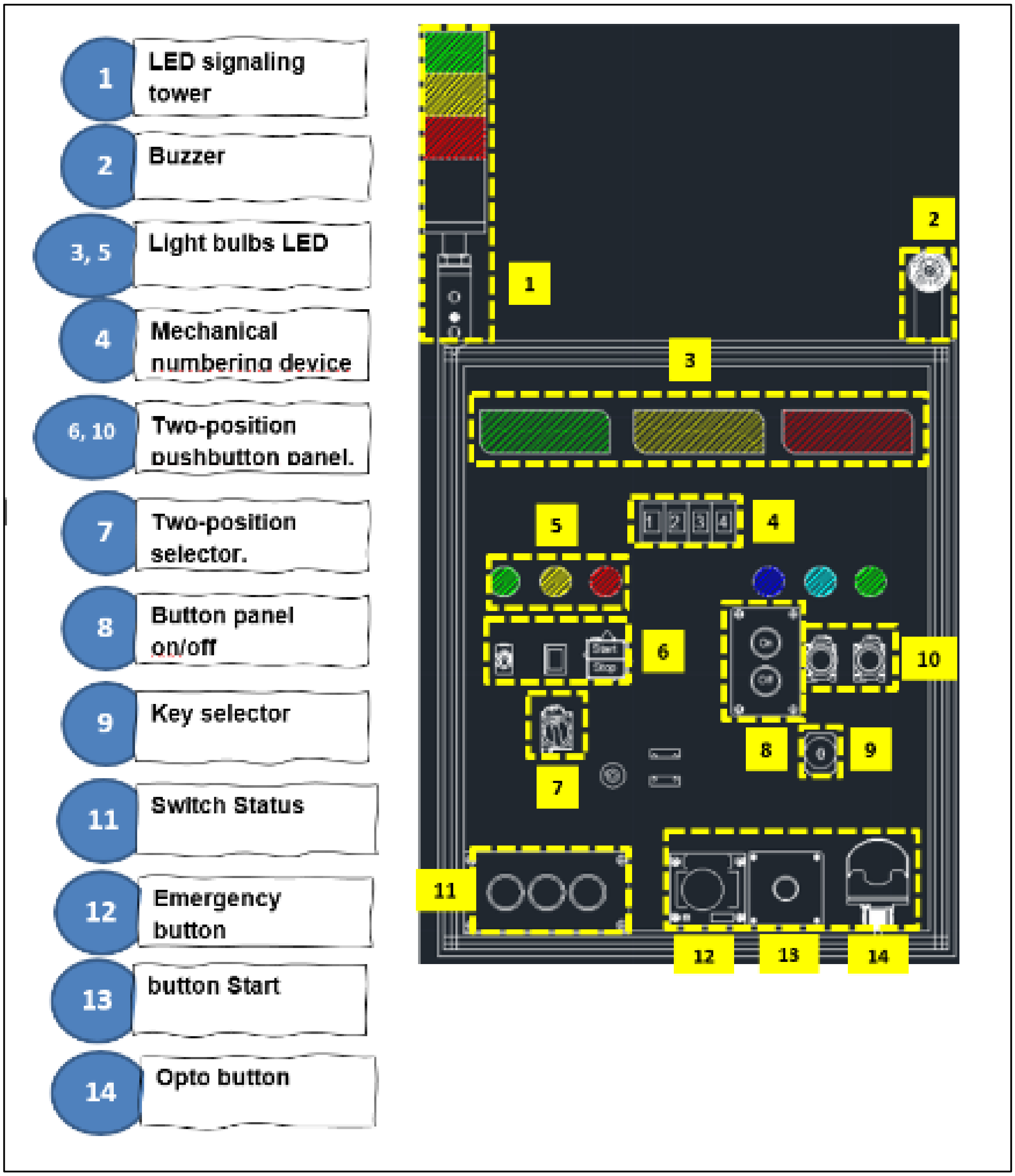

Figure 2. AutoCAD control panel layout

Figure 3. Board structure

Figure 4. Physical layout of components

Figure 5. Drives on structure

Figure 6. Paint application on structure

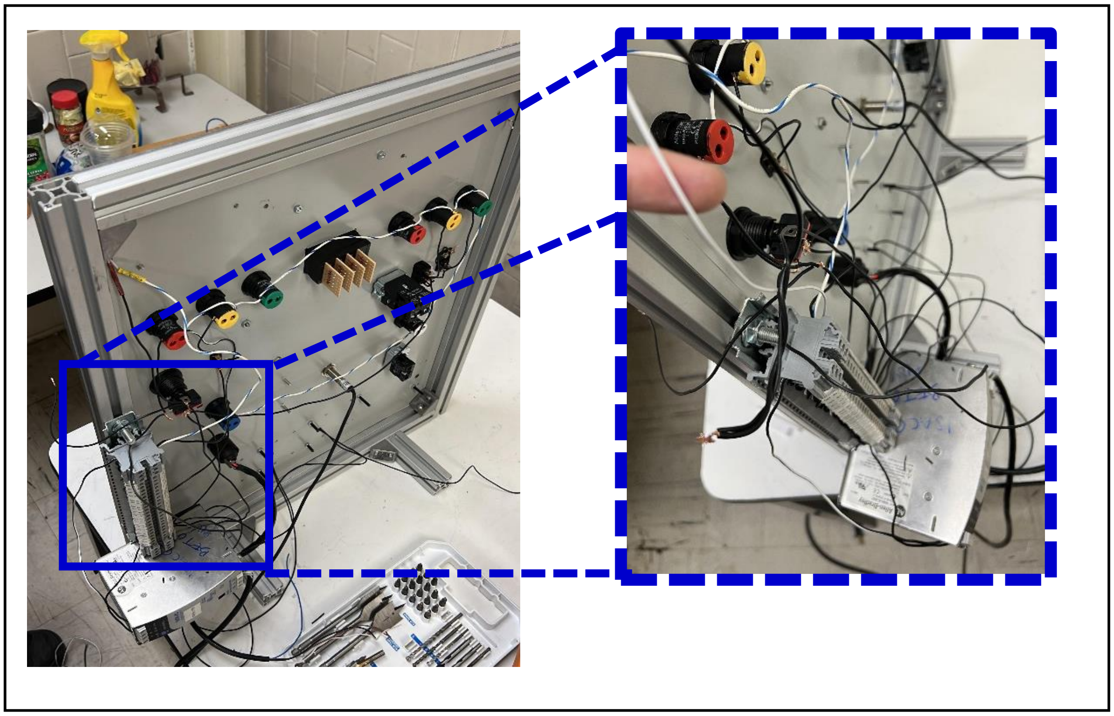

Figure 7. Connections of the electronic components with 24V power source

Finally, a series of tests were carried out to verify that the safety actuators were correctly connected and that each one of them works when actuated by the person.

At the end of the fabrication of the board, a practice was designed to be implemented in the Ergonomics course. The purpose of this is to enrich the theoretical information of the program and that the students' knowledge is reflected in practice; to cover information regarding the importance and main characteristics of the drives commonly used in the automotive industry.

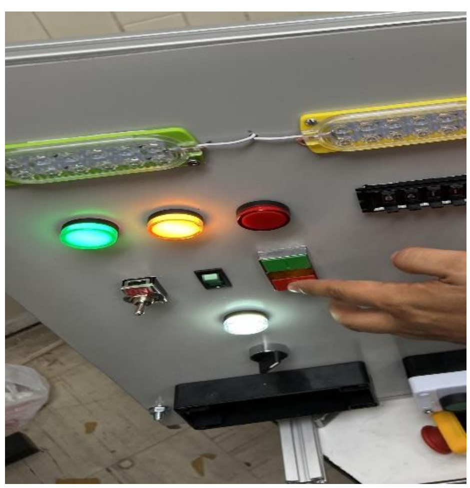

Figure 8. board function tests

In the fifth phase, testing, the results are not yet available since the board will be used in the next school semester August-December 2023 in the subjects of ergonomics and industrial hygiene and safety at the ITCJ.

4. CONCLUSIONS AND RECOMMENDATIONS

In accordance with the objectives set out in the research, it can be concluded that each of the points were covered satisfactorily, since when investigating the type of safety actuators that were included in the board, surveys were previously conducted with students and teachers where areas of opportunity were detected that could be applicable to enrich the didactic material that is currently available at the Institute.

Based on the results obtained in the surveys (quantitative and qualitative), a security action board was designed that considers the opinion of the students regarding the knowledge and functionality of each of these components. Once the above was materialized, a practice about controls and boards was designed where the industrial engineering students should develop it to put into practice the knowledge acquired and with this, enrich the didactic content of the Ergonomics and Hygiene and safety subjects of the Instituto Tecnológico de Ciudad Juárez.

Recommendations: The present project seeks to enrich the material that is currently being taught in the Ergonomics and Health and Safety subjects, so there is a field of opportunity to continue including more updated and/or valuable information for the professional training of the Institute's students.

It is suggested to carry out tests to assess the level of knowledge that students have on the subject of safety panels and controls, in order to detect whether the practice designed in this project meets the purpose for which it was developed. It is also important to mention that the practice manual that currently exists in the Ergonomics program has valuable information, but possible improvements were detected, which can be applicable to improve the academic experience for students. Incorporate boards or design booths that complement in a practical way the topics of physical conditions and occupational ergonomics where lighting, noise, etc. can be tested.

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ANALYSIS AND ERGONOMIC DESIGN IN THE PRODUCTION PROCESS OF THE SHRIMP FREEZER COMPANY IN GUASAVE, SINALOA

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Resumen: El presente proyecto es una investigación que se desarrolló para generar un análisis y diseño de condiciones ergonómicas en el proceso productivo de la empresa congeladora de camarón. Su actividad principal es la producción y procesamiento de camarón a nivel nacional, el frezado de camarón es el proceso principal en la estación de llenado de taras con camarón se presentan problemas de rotación de personal, lesiones musculoesqueléticas con base a esto se propone, realizar un análisis y diseño de condiciones ergonómicas de la estación de trabajo, para tener una mayor productividad y disminuir lesiones, rotación y problemas de calidad de producto. Todo a través del análisis y métodos de evaluación ergonómica y así lograr el diseño de condiciones ergonómicas. Se espera reducir los tiempos muertos, y la rotación de personal y las lesiones musculoesqueléticas de la estación de llenado de taras en la empresa.

Palabras claves: Método RULA, Diseño ergonómico, DTA, Congeladora de camarón.

Relevancia para la ergonomía: La ergonomía es la interacción entre los seres humanos y otros elementos de un sistema. Este estudio aporta información que contribuye a la mejora de las condiciones de trabajo del sector Acuícola.

Abstract: This project is an investigation that was developed to generate an analysis and design of ergonomic conditions in the production process of the shrimp freezing company. Its main activity is the production and processing of shrimp at a national level, shrimp spawning is the main process in the shrimp filling station, there are problems of personnel turnover, musculoskeletal injuries based on this, it is proposed to carry out a analysis and design of ergonomic conditions of the work station, to have greater productivity and reduce injuries, turnover and product quality

problems. All through the analysis and ergonomic evaluation methods and thus achieve the design of ergonomic conditions. It is expected to reduce downtime, staff turnover and musculoskeletal injuries at the company's tare filling station.

Keywords: RULA method, Ergonomic design, DTA, Shrimp freezer.

Relevance to ergonomics: Ergonomics is the interaction between human beings and other elements of a system. This study provides information that contributes to the improvement of working conditions in the Aquaculture sector.

1. INTRODUCTION

Sinaloa is the most important agricultural state in Mexico. Additionally, it has the second largest fishing fleet in the country. (Government of the State of Sinaloa, 2017). One of the predominant activities is Aquaculture, which is practiced throughout the state. There are a total of 907 Crustacean Aquaculture Production Units (UPAs) served by CESASIN, which are equivalent to 7,304 culture ponds of various types and sizes, installed in 67,345.63 ha of water mirror (OSIAP-SENASICA, 2021). Due to its size, Guasave occupies the eighth place with respect to the other municipalities in the state; It has an area of 3,464.41 square kilometers, which represents 5.9 percent of the state area and 0.17 percent of the national area. There are more than 442 locations in the municipality, where 100 shrimp aquaculture farms are located. (Guasave M., 2021).

Aquaculture Los Ahumada S.S.S S. de S.S. is a company dedicated to the breeding, processing and commercialization of shrimp nationwide. Currently the company has a process, which is divided into 7 operations, among which are the following: reception of raw material, beheading, classification, rest, spawning, packaging and shipment. The headless area is made up of 3 activities, the first is the collection and distribution of the shrimp, in which there is a conveyor belt through which the shrimp from the reception area passes, in addition crates are used for their collection and it is distributed with the help of personnel, using the technique of dragging tares with a weight of 35 to 50 kg of product. The second activity is headless, this is divided into production lines, which are made up of steel tables, with capacities of 6 people each. The number of employees per line ranges from 18 to 30, in this activity staff of both sexes work, the majority are female, with an age range between 18 and 68 years. The third activity is the registration and distribution of the shrimp to the next area, for which a computer with internet service is used, a scanner for the registration of the buckets, crates for the distribution of the shrimp in the process. The entire area works between 8 to 10 hours a day. The main problem that arises is the low productivity in the product distribution area using the technique of dragging tares with a weight of 35 to 50 kg, causing staff turnover, upper and lower back pain, low productivity, and delays in the process.

2. OBJECTIVE

Carry out an analysis and application of ergonomic methods in the station for filling tares with product from the shrimp freezer, to identify and evaluate possible musculoskeletal injuries, and design ergonomic conditions in the work station.

3. METHODOLOGY

1.- Carry out a diagnosis of the company's production process through tours, where the characteristics of the workers and work station that harm the health and safety of the operator are identified. Through the identification of STPS Standards and ergonomic principles.

2.- Identify the area for filling tares, as the station that presents the greatest risk to the well-being of the worker. For this, evaluations are carried out for the identification of musculoskeletal injuries and cumulative trauma disorder through ergonomic evaluation methods.

3.- Design the area for filling defects with ergonomic and safety conditions in the production process.

4. RESULTS

When carrying out the analysis carried out in the area of tare filling, it was identified that the movements carried out by the operators are inadequate and are risk factors in their health and safety, for this the ergonomic design proposal is presented that should be considered in the production process.

Data collection was carried out for 3 weeks to later present the design proposal, which will benefit the workers, eliminating unnecessary movements or operations when executing the tasks, to provide workers with better working conditions and efficient productivity.

Figure 1. Shrimp tare filling workstation.

Table 1. Identification of Official Mexican Standards of the STPS.

List of official Mexican Standards applied to the production process of the company			
Company: Acuicola Los Ahumada.			
Line of business: hrimp milling company (filling tares)			
Date: May 22,2023			
Standard	**Yes**	**No**	**Observations**
Official Mexican STANDARD NOM-011-STPS-2001, Safety and hygiene conditions in workplaces where noise is generated.		**X**	In the facilities there is no mediator to reduce the noise that the machinery generates, in the same way the worker does not use personal protection.
Official Mexican STANDARD NOM-001-STPS-2008, Buildings, premises, facilities and areas in workplaces-Safety conditions.		**X**	The company does not have security conditions in any of its work areas.
Official Mexican STANDARD NOM-004-STPS-1999, Protection systems and safety devices in machinery and equipment used in workplaces.		**X**	The operators do not have any protection when using the machinery to carry out their activities. Some personal protective equipment is not adequate for the type of activity they perform.
Official Mexican STANDARD NOM-030-STPS-2009, Preventive health and safety services at work-Functions and activities.		**X**	Employees do not have preventive health and safety services within the company.
Official Mexican STANDARD NOM-024-STPS-2001, Vibrations-Safety and hygiene conditions in the workplace.		**X**	Employees are exposed to high levels of vibration without any vibration.
NOM-016-STPS-1993, Relative to safety and hygiene conditions in workplaces regarding ventilation.		**X**	The personnel is exposed to high levels of humidity without having any means to regulate ventilation.

Table 2. Ergonomic principles applied to workstation 1

Principles	**Remarks**
Principle 2: Use the elbow height as a reference.	Working at the wrong height leads to vicious positions and unnecessary strain. Elbow height: Work is carried out at the height of the elbow whether sitting or standing, above or below the elbow the effort is greater. Considering the current situation in the company, which has three work tables with a height of 50, 75 and 90 centimetres, our corrective action is to design these tables at the height of the elbow of the worker, which is 112 centimetres, so that the worker can develop in the best possible way and avoid unnecessary effort.

Principle 4: Find the correct position for each task.	There are very bad habits with respect to some tasks, therefore, on many occasions workers do not look for the correct position to carry out an operation, a very clear example is that on occasions heavy objects are moved, and when they are lifted, they do so incorrectly and the back is subjected to the most pressure. The workshop has a small tool for this task, but it is not commonly used
Principle 6: Minimise fatigue Many times workers overtax their physical capacity by doing activities that can cause muscle damage	In addition, sometimes, due to space constraints in the workshop, workers have to work outside in direct sunlight
Principle 7: Minimise direct pressure.	The workshop has a work belt, which is rarely used, in fact, it is used because they feel a pain in their back. Ideally it should be worn every day to prevent any fractures
Principle 8: Adjustment and change of posture	No matter how much the worker wants to adjust, it is difficult as there is no ergonomic table or stretcher available, which affects the back when carrying out operations under a trolley.
Principle 9: Provide space and access It is of great importance that working space is provided for each element and easy access to whatever is needed.	Therefore, to ensure adequate working space, our corrective action is to make an efficient distribution in which it is proposed that the old iron is stored in drums to prevent them from obstructing the sides of the workshop, as well as moving the engines and transmissions that are in the central part to the storage warehouse, with this we intend to avoid accidents at work and have better space to work comfortably
Principle 12: Improve the organization of the work If the tool trolley were well organized,	The work would be more efficient as we would save time looking for the tool that is needed. Moreover, this principle is not fulfilled because the distribution of space is not the most appropriate.

Duranig the ergonomic assessment, little use of the STPS legal framework was identified. The Official Mexican Standard NOM-025-STPS-2008. It is not applied because of the lighting conditions, there is insufficient lighting for the minuscule work carried out at the workstation.

The Official Mexican Standard NOM-011-STPS-2001, Safety and hygiene conditions in workplaces where noise is generated. The workstation does not control the number of decibels used in the process, exposing the worker to decibels above 90 decibels during the workday. The Official Mexican Standard NOM-001-STPS-2008 does not have a specific distribution for the processes carried out in the workshop. The official Mexican standard NOM-015-STPS-2001 sets out the appropriate conditions for exposure to temperatures. In the workshop they are exposed to 42 to 48 degrees, generating an unsatisfactory thermal environment, causing fatigue and mental exhaustion.

4.1. Application of ergonomic evaluation methods in station 1.

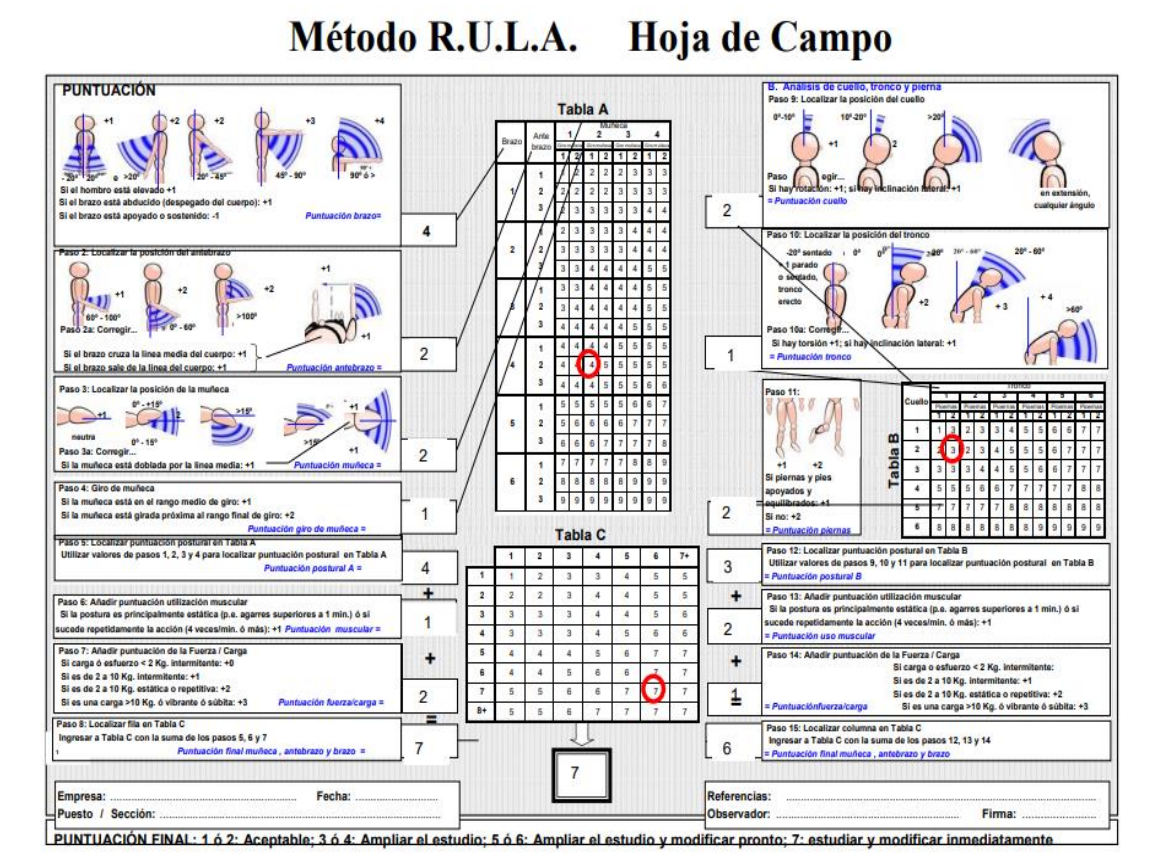

Figure 2. Application of the RULA Method in workstation 1

4.2. Design of ergonomic conditions in the work station 1.

The official Mexican Standards were analyzed and the specifications of standard 036 on manual handling of loads are considered, indicating that the maximum mass that a worker by age and gender can lift or lower is: 25 kg per load, men aged 18 to 45 years old, at the work station they move a load of 35 to 50 kg per tare product. Another ergonomic condition is the anti-fatigue mat to reduce fatigue for those who are exposed to 12 hours of work at that work station. As well as modifying the height of the support bench for tare filling, raising it 10 cm more so that the movement of the load is more comfortable for the movements made by the operator, and not generate a disorder of cumulative trauma, DTA or musculoskeletal injuries in workers.

4. CONCLUSIONS

The ergonomic analysis allowed to identify the risk factors in the workplace. The operator performs the work at an incorrect height because the work tables are outside the elbow height, which is 112 centimeters, in addition to changing the material handling posture to perform the operations.

The Rapid Upper Extremity Assessment (RULA) and ergonomic principles help to have a better perspective of the levels of ergonomic risk that affect the health of the operator in station 1.

The most feasible solution would be to insert an anti-fatigue mat into the work area, seeking to decrease operator fatigue, as well as suggest that the workbench be placed on top of a climbing workbench for easy reach.

The benefits offered by the improvement of the workplace for the worker are very significant in comparison with the design and structure that was considered previously, since in this way the operator is prevented from having a leaning posture, working in an uncomfortable way or presenting any type of accumulated fatigue, which can cause injury. With this modification, the quality of life and the productivity of the operator would increase, since the worker would be located in a more comfortable position, which makes the operator a more productive worker, which is basically what is sought in any company.

Ergonomic analysis identifies risk factors in the shrimp tare filling workstation. Risks and dangerous conditions for the operator were found, through ergonomic principles overexertion, pressure on the body, unnecessary efforts, adjustment and change of inadequate postures were detected, the controls and dashboards do not have a good visualization, generating confusion in the operators when carry out their activities.

The ergonomic evaluation indicates the working conditions to which the operator is exposed when carrying out the tasks. The RULA method evaluates the postures and risks associated with musculoskeletal disorders due to postural load, in the activities of the production process. As a result, it indicates a level 5, which represents a need to redesign the task or work station. Based on standard 036 of the STPS, ergonomic risk factors were analyzed due to the manual handling of loads, and presenting a postural risk in the extremities of legs, arms, upper and lower back. generating fatigue and cumulative trauma disorders.

The improvement proposal for the work area is the placement of anti-fatigue mats, installing a conveyor belt with separators for the assignment of the tares with product to the work tables, assigning a distance closer to the operator and can be within reach , all based on the Official Mexican Standard 001 of STPS for the redesign of tasks. For the worker, these improvements are significant, avoid bad postures or present some type of fatigue and low productivity, and do not cause injuries. With this modification, the operator's quality of life and productivity would be increased, decreasing staff turnover, generating a more productive operator.

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ERGONOMIC STUDY FOR THE REDESIGN OF THE SHOE SHINER WORKSTATION IN THE CITY OF LA PAZ, SOUTHERN CALIFORNIA.

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Summary: The objective of this study is to show the application of ergonomics to design a workstation, according to the anthropometric measurements of boleros that are registered in the municipal register of the City of La Paz, Baja California Sur (B.C.S.) Mexico. The protocol used in this research consisted of taking anthropometric measurements and analyzing each workstation. The results revealed areas of priority improvement in each bolería, with these findings an improvement proposal was designed for the workstation.

Keywords:
Ergonomics, Bolero, Anthropometry, Workstation, Design.

Relevance to ergonomics: This study documents the application of tools and methods provided by ergonomics in productive activities, which are not commonly considered in the commercial field of industrial or academic design.

Ergonomics proposes a systemic and methodical perspective to consider in this case in the design of workstations. Looking for better conditions for the operator to carry out his activity eliminating or mitigating possible impacts on health generated by a bad design and that these translate into a loss of well-being for society that performs a trade in unsuitable conditions.

1. INTRODUCTION

According to the Real Academia Española (RAE) bolero (a) means "Clean boots", in Mexico boleros are designated to those people who are responsible for cleaning and polishing men's and women's footwear.

In the network there are several studies carried out on boleros, for example, the work of Rubio Campos J. (2013) conducted a case study for the city of Monterrey, integrated based on tools such as field mapping, participant observation and semi-structured interviews with leaders of the union of cleaners, as well as with the workers themselves.

Luna S. (2013) contributed the work "Shoe shiners: a job at risk of losing its shine" points out that, according to the Ministry of Labor and Social Welfare, in 2013 there were a total of 156 women and 2 thousand 993 men working as accredited shoe cleaners in Mexico City, preserving, in many cases, A family tradition, as this work is performed by people whose family has done this for years. He also points out that this profession is in danger of extinction because young people do not shine their shoes.

Estrada Ruiz Diego (2013) presented his thesis called "*Proposal for redesign of workstation based on anthropometric measurements of shoe cleaners in the downtown sector of Los Mochis, Sinaloa".* In this research he presents an anthropometric study carried out on shoe shiners belonging to the union constituted in Los Mochis, Sinaloa. With the data obtained, a series of anthropometric charts were constructed for each subject, with their dimensions corresponding to the sitting and standing positions.

This activity is carried out in street stalls within various areas of the City of La Paz, many of these positions are acquired or sent to manufacture by each bolero, which leads to a very limited workstation, they only add the basics, so when they sell it does not fit the dimensions of the new bolero. Faced with this situation, the municipal government launched a call and to regularize this activity that is totally informal, a register was raised, in such a way that, the boleros who accepted to register to pay taxes and become creditors to different aids from the municipal government, are provided with a new itinerant stall.

1.1 Objective

Design an ergonomic workstation based on anthropometric measurements for boleros.

1.2 Delimitation

The study was conducted in the city of La Paz, Baja California Sur, considering the bolero workstations that are registered in the municipal register.

2. MATERIALS AND METHOD

The type of research is descriptive with a cross-sectional research design.

The materials used to conduct this study were the following:

1. Clarita Anthropometer.
2. Scale.
3. Anthropometric measurement sheets.

Figure 1 Anthropometer

Figura 2 Scale

Table 1 Adapted from Medina (2000).

ANTHROPOMETRIC CHART

GENERAL DATA		**Control No.**	10
Name:	David Aviles Ensiso		**Age: 52**
Place of birth:	**From the subject:**	Mazatlan	
	From the father:	Mazatlan	
	From the mother:	Mazatlan	
Gender:	M **Date:** **24/11/2016**	**Shift:** M	**Body side:** Left
Place:	Isabela Católica	**Timetable**	Beginning: 11:03 End: 11:18

Measure	**(cm)**
Eye height from the ground	106.4
Head height from seat	74.7
Back height from seat	51.9
Elbow to seat height	17
Popliteal height	42.5
Maximum arm reach	62.7
Minimum arm reach	37
Sacro-patella distance	57.3
Sacro-popliteal distance	45.5
Width from elbow to elbow	40.5
Width of sitting hips	35.6

REMARKS:			
With shoes?	Yes	Do you have any type of disability?	No
Midsole height	2cm	Specify:	
Feedback:			
Name of anthropometrists		signature(s):	

The method was based on the study conducted by Estrada Ruiz Diego (2013) and consisted of the following stages:

1. Determine the study population: It consisted of 12 individuals registered with the XV. H. City Council of La Paz as shoe cleaners, who work in the city of La Paz, B.C.S.
2. Identify body measurements relevant to design: The following measures were selected for workplace redesign (see tables 1 to 3). Additional dimensions in the standing position were collected for future research.
3. Design for average, range, or extremes: The 5th and 95th percentiles were used in the job redesign.
4. Presentation of the information collected: The anthropometric charts, with the dimensions in standing and sitting position, corresponding to each subject are presented in the Appendices section.
   1. Information processing: The body dimensions of individuals are shown, in a sitting position, standing, as well as various percentiles (see tables 2 to 4).

3. RESULTS

Table 2. Body dimensions in sitting position (subject no. 1 to 6)

	Participants					
Body Dimension	**1**	**2**	**3**	**4**	**5**	**6**
Head height from seat	111.3	124.3	121.9	107.5	118.6	126.4
Eye height from the ground	78.1	87.8	81.7	78.3	85.3	91.2
Shoulder height from the seat	55	65.2	59.5	56.6	58.2	64.4
Elbow to seat height	20.6	25.6	26.6	27.3	22.6	27.9
Popliteal height	43.3	45.5	48.6	43.6	43.6	43.6
Maximum arm reach	70.2	68	67.6	56.1	59.4	68.9
Minimum arm reach	44	45	42.8	34.8	38.5	42.2
Sacro-patella distance	55.9	81	54.4	42.8	61.8	72.6
Sacro-popliteal distance	45.5	49	49.5	39.7	47.9	50.4
Width from elbow to elbow	54.7	56.4	47.5	51.9	63.5	55.6
Width of sitting hips	38.4	42.1	39	43.8	46.3	45.7

Table 3. Average body dimensions in sitting position

Body Dimension	Sum	Average	Standard deviation
Head height from seat	1405.5	117.125	6.166
Eye height from the ground	992.4	82.7	5.064
Shoulder height from the seat	693.9	57.825	3.958
Elbow to seat height	346.5	28.875	13.462
Popliteal height	532.2	44.35	1.833
Maximum arm reach	756.3	63.025	7.467
Minimum arm reach	503.7	41.975	6.966
Sacro-patella distance	714.9	59.575	9.532
Sacro-popliteal distance	567.2	47.2666667	3.431
Width from elbow to elbow	631.4	52.6166667	5.185
Width of sitting hips	489.3	40.775	3.409

Table 4. Percentiles corresponding to body dimensions in the sitting position (percentile 0 to 50)

Body Dimension	0th percentile	5th percentile	10th percentile	25th percentile	50th percentile
Head height from seat	106.4	107.005	107.88	113.025	119.2
Eye height from the ground	74.7	75.25	75.94	78.25	82.85
Shoulder height from the seat	51.9	52.23	52.71	54.9	58.05
Elbow to seat height	17	18.98	20.6	22.1	25.25
Popliteal height	42.1	42.32	42.52	43.15	43.6
Maximum arm reach	42	49.755	56.43	61.875	65.3
Minimum arm reach	34.8	36.01	37.12	38.425	39.8
Sacro-patella distance	42.8	47.42	51.52	55.225	56.8
Sacro-popliteal distance	39.7	41.405	43.02	45.375	48.45
Width from elbow to elbow	40.5	44.35	47.91	51.6	52.4
Width of sitting hips	35.5	35.555	35.88	38.85	40.2

The measures selected based on the 5th and 95th percentile for the design are presented in the following tables 4, 5 and 6:

3.1 Body Dimensions (seated subject)

Table 5 . *Selected percentiles (sitting position)*

Body Dimension	5th percentile	95th percentile
Head height from seat	107.005	
Eye height from the ground		90.21
Shoulder height from the seat		64.76
Elbow to seat height	18.98	
Popliteal height	42.32	
Maximum arm reach		69.485
Minimum arm reach		53.1
Sacro-patella distance	47.42	
Sacro-popliteal distance	41.405	
Width from elbow to elbow		59.595
Sitting hip width		45.97

3.2 *Body Dimensions (Standing Subject)*

Table 6. *Selected percentiles (standing position)*

Body Dimension	5th percentile	95th percentile
Height	155.965	
Eye height from the ground	80.9325	
Maximum arm reach		67.11
Minimum arm reach	32.935	
Width from elbow to elbow		57.605
Waist		38.335
Hip width		38.99
Weight	48	

The redesign proposal for the workplace can be seen in figures 1, 2, 3, 4, and 5, based on different existing designs where a ceiling was taken into account to be placed outdoors and a greater height for the easy reach of the worker. The proposed seat for shoe shiners uses percentiles obtained from anthropometric charts.

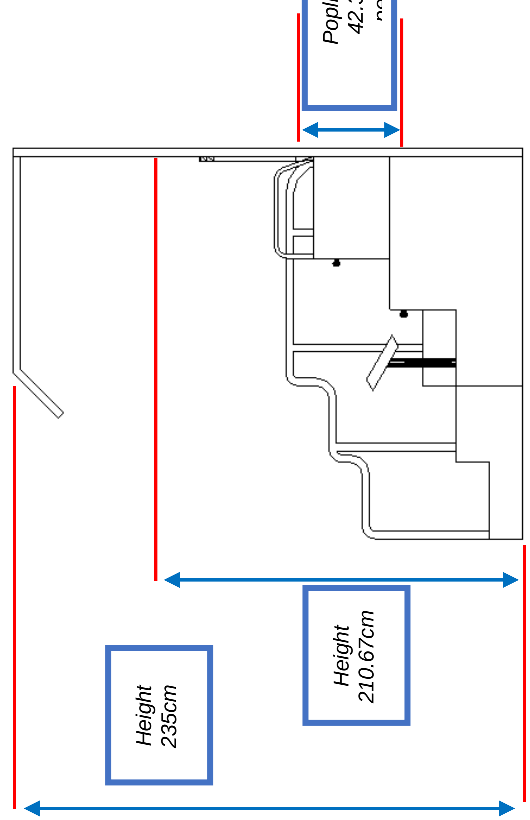

Figure 1 Side view of the station.

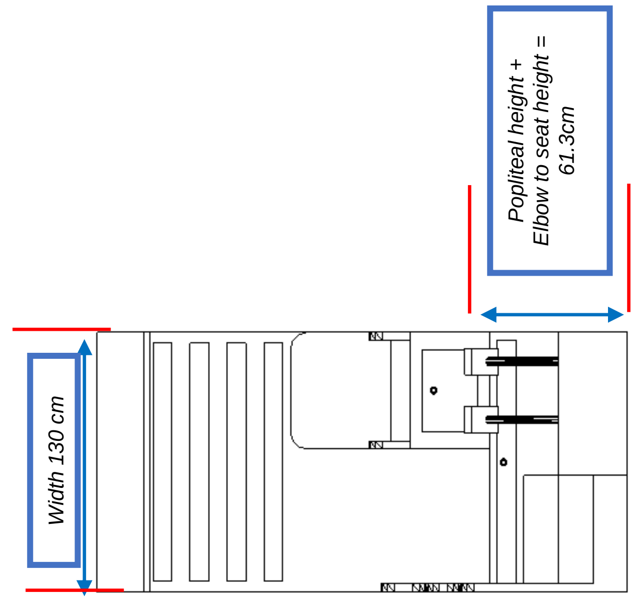

Figure 2 Front view of the station.

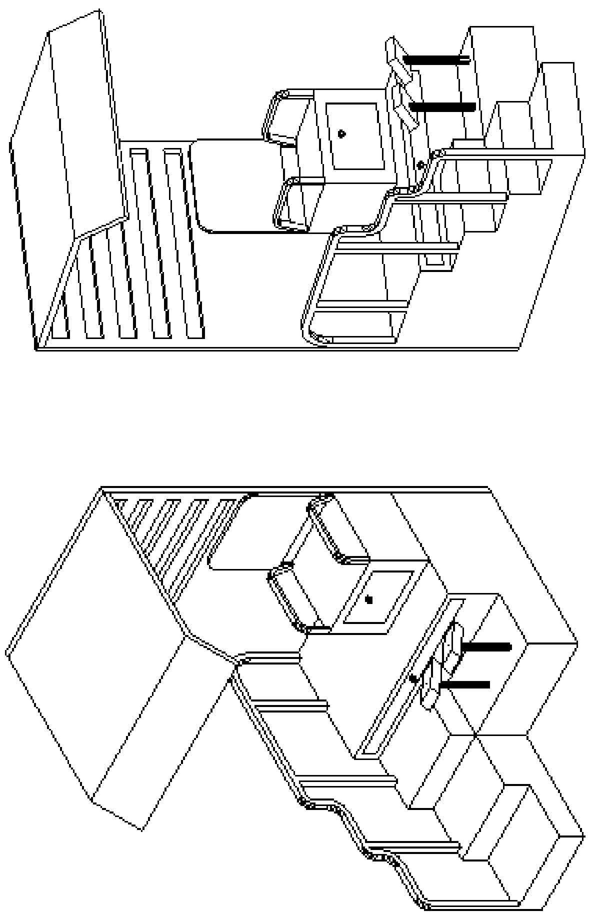

Figure 3 Redesign proposal for shoe grooming workstation. (Station)

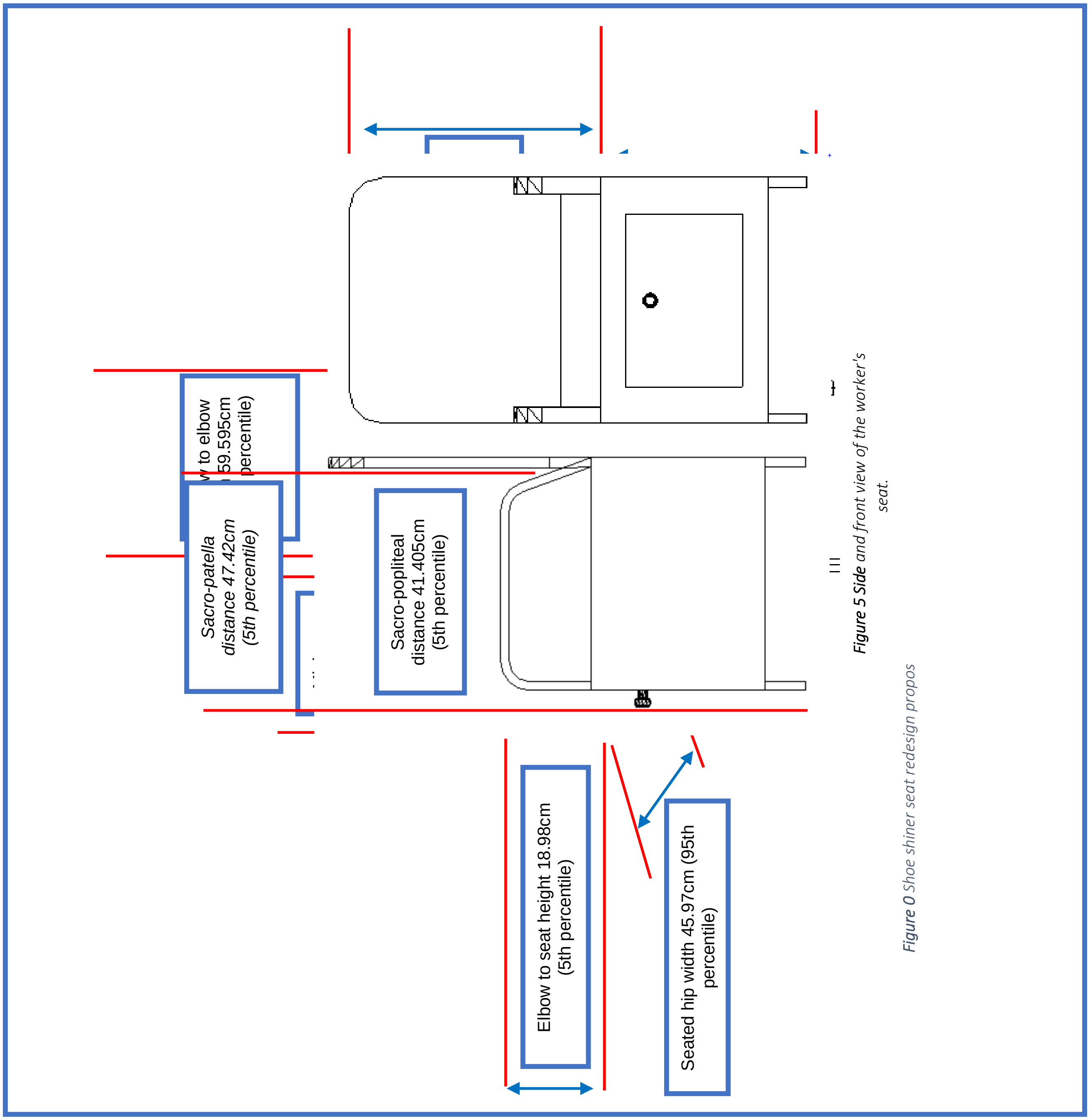

Figure 5 Side and front view of the worker's seat.

Figure 0 Shoe shiner seat redesign propos

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INFORMATION BEHAVIOR IN THE PRODUCTION AREA

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Resumen: El enfoque prevaleciente en la investigación del comportamiento informacional es el constructivista centrado en el individuo como generador de conocimiento. Recientemente han aumentado las críticas a esta postura realizando un giro de lo individual a lo social. Desde esta perspectiva se emplean métodos como el análisis del discurso que busca conocer, a través del lenguaje de los usuarios, cómo se genera y comparte el conocimiento en el contexto social. Este trabajo describe cómo se ha aplicado a la investigación del comportamiento informacional dentro de un contexto escasamente estudiado en ambiente natural, presentando, además, una aplicación en la práctica y se discuten las implicaciones profesionales y metodológicas consideradas. Para ello, la metodología empleada pone en manifiesto diversas consideraciones que deben ser tomadas en cuenta en estudios en ambientes naturales y los resultados exhiben que se pueden aplicar en el área de producción. Para ello, se definió una metodología que buscaba capturar el comportamiento informacional dentro de dicha área de interés. Consecuentemente, se redujeron el retrabajo y los costos operativos y se incrementó el uso de las herramientas abstractas y físicas dentro del área de trabajo. De lo anterior que concluyó que es necesario hacer uso de otros enfoques para resolver problemas en áreas distintas a las inicialmente propuestas del comportamiento informativo, confirmando que dicho comportamiento esta presente en todas las actividades humanas.

Palabras clave: Comportamiento informativo, lenguaje natural, Teoría de la Actividad, área de producción

Relevancia para la ergonomía: El conocimiento del comportamiento informacional dentro del área laboral es un reto ya que conlleva trabajar directamente con los colaboradores dentro de su área de trabajo; además, la comprensión del significado de los diversos términos del lenguaje natural usados dentro de dicho contexto y así, visualizar el proceso de toma de decisiones, fueron tareas demandantes que escasamente se han estudiado. Por ello, dar un significado académico es una aportación sustantiva ya que pone en manifiesto cómo el comportamiento informativo puede tener un impacto real en el proceso de toma de decisiones dentro del área de producción.

Abstract: The prevailing approach in information behavior research is the constructivist, this is one centered on the individual as a generator of knowledge. Criticism of this position has recently increased, calling for a turn towards from an individualistic to a social approach. From this perspective, methods such as discourse analysis has been used, which seeks to know, through the language of the users, how knowledge is generated and shared in the social context. This work also describes how it has been applied to the investigation of information behavior within a context that is scarcely studied in a natural environment. It is also presenting a practical application and discussing the professional and methodological implications. For this, the methodology used reveals various considerations that should be included in studies in natural environments and the results could show that they can be applied for example in the production area. For this, a methodology was defined trying to capture the information behavior within the mentioned area of interest. Consequently, reworking and operating costs were reduced and the use of abstract and physical tools within the work area was increased. From the above, he concluded that it was necessary to use other approaches to solve problems in areas other than those initially proposed for information behavior, confirming that such behavior is present in all human activities.

Keywords. Information behavior, natural language, Activity Theory, production area.

Relevance to Ergonomics: Knowledge of information behavior within the work area is a challenge, since it entails work directly with collaborators in their work area. In addition, understanding the meaning of the various natural language terms used within the production area context and thus visualizing the decision-making process were demanding tasks that have rarely been studied. For this reason, giving an academic meaning is a substantive contribution from this perspective and it shows how information behavior can have a real impact on the decision-making process within the production area.

1. INTRODUCTION

Humanity has undergone significant changes within its areas of interest, some of these are the production processes. In order to respond to the various problems existing in these processes, various strategies have been developed, for example applying techniques, methods and approaches from other knowledge areas to the mentioned context, thus making adjustments that allow solving its problems in order to visualize their solutions in short and medium periods of time. One of the strategies is the use of technologies that allow to facilitate the information exchange in real time. This is because information has been considered as an asset of high strategic value.

For this, an appropriate behavior to evaluate the use of technologies within human activities is information behavior, recognizing that one of its internal behaviors is the information exchange. Informational behavior is related to behavior in direct and indirect relationship with information through its seeking, processing and using within the context of interest. This includes the production, dissemination and communication of information where technologies have been developed to facilitate commented activities (Berrío-Zapata, 2016).

However, the use of these technologies has generated new challenges in form that they suggest influences on the decision-making process within the used contexts. For this reason, it is relevant to have a recognition of the information behavior in the use of the technologies in context. Hence, based on these needs, various activities could be investigated from the method of seeking, processing and using information from the perspective of utilizing technological tools. For example, each participant or collaborator may exhibit different information behavior despite having access to the same technologies and tools to seek, process and use information among other behaviors.

Therefore, in the context under study, various aspects to what was previously indicated were considered, since it has been found that, in itself, the context has a direct influence on the method or methods of seeking, processing and using information. Hence, the flow of information is a relevant factor since occasionally the information may be limited for certain participants and this directly affects the decision-making process or information use. Besides, it was consequently found that there was 80% satisfaction in the information use. That is, 20% of employees perceive that they do not have the required information in a timely manner to be used within their work activities. This could result, in the same line, in other activities in context, but that were not considered in the study because they could imply using other resources that could not be accessed at that time when the study took place.

Another of the factors, that was visualized and considered, was the collaborative aspects within the context and the implications of the work method. This was able to visualize how information was received late taking the form of work orders, the increase in time in accessing information technologies while collaborators exchange information in real time, the delay in the registration of various elements of production activities, among other aspects or factors also considered in context. Particularly, the delay in the measurement of the implicit costs for the handling of information and its deviations. For example, employees point out that 32% of rework activities is caused by lack of information due to the delay in updating the required information in real time. This could be verified in the use of visual aids displaying outdated specifications to the information needs in the production area of new products and/or model changes in the design of products.

In this line, also, is the preventive and corrective maintenance of equipment and machinery used in the process. This could be visualized in the delay times due to model changes, downtimes, among others problematic situations originating from the information behavior; specifically, in the information seeking, processing and using in activities related to these activities carried out by the Maintenance

Department. That is, certain support activities to the production areas. For this, in the present study, the objective was defined to improve information behavior in the assembly and production area by modifying the physical and abstract tools used using principles of Cognitive Ergonomics to facilitate the decision-making process.

Therefore, the study has scope and limitations within the context under study and the area of knowledge (Cañas and Waern, 2001). Within the scope, the study has considered the participants within their work area (Creed, 2022) to understand what is happening and their information needs in context. In the same way, various tools were used in the work areas and they have been considered to improve diverse projects in which the participants have been involved. This included documentation and visual aids used in the work areas. Also, the perceptions and work experiences of each participant were considered (Opi, 2022, Psaropoulou, 2022). On the other hand, within the limitations considered, it is noted that the research was carried out from a qualitative perspective where the data collected was obtained in the form of words, to which meaning is given within the analysis considering the context and, specifically the meaning that collaborators gave in context. The experiences of the applicants within other areas of work were an essential part of the study to visualize the limitations of the study. It is also considering the influence on the decision-making process in the work areas and specifically, on exhibiting the information behavior (Saha and Chatterjee, 2022).

2. LITERATURE REVIEW

1.1 Information Behavior

The origins of information behavior have been located in Library Science and the field of readership. Studies on uses of libraries and how scholars utilized information relative to their work emerged at least 90 years (Wilson, 2010). The research in these fields included the switch from system-centred to user-centred (Wilson, 2000a; Rioux, 2004; Case, 2006); that is passing from giving importance to system to user as principal factor in study. In addition, information behavior served to evaluate technological tools and relations with users. Moreover, same behavior extended the studies to information origins that are in physical or electronic form in libraries or places where users were immersed and used information. This also favored the individuals as origins of information (Wilson, 1981). Similarly, this recognized the importance of contexts such as everyday life and work in diverse areas. For instance, Talja and Hansen (2006) stressed that information behavior can change the course of the relationships between individuals and their information sources in context. This is because information behavior offered a concise relationship with contextual and situational variables, resources and rules to seek, process and use information (Wilson, 1981).

A consequence of that relation is the information behavior is considered as an umbrella term. This is seen when the terms information behavior and information practice are used interchangeably (Savolainen, 2007). However, Savolainen (2007) argues that despite both terms are used in the same form, there is a difference in relation to the approach in which they are conceived. He pointed out that information behavior is conceived in the cognitive approach and the information practice, in the social constructionist approach. That is, information behavior is considered as a product of the mind and information practice, a product of the social interactions between individuals. Therefore, it is important to consider that information behavior and information practice are mutually related, so both the cognitive and the social perspectives are considered in this study in order to give relevance in context. This is because the cognitive approach can help to understand the behavior in context and the social constructionist approach, the collaborative nature of massive production using information behavior as the principal means.

1.2 Activity Theory

This meta-theory helped to discover knowledge within the environment even when individuals are unaware of its existence and provided the theoretical, methodological and practical grounds to study the information behavior in the mentioned context. Here, the awareness of an activity (or behavior) is a product of itself (Wilson, 2008) and works by studying it holistically (Wilson, 2006). Also, this activity results from its continuous realization and its interactions and human experiences with other individual beings and the surrounding environment directly influencing itself. In addition, the activity is aimed at achieving objects or objectives (Mwanza, 2002) to generate results (Kaptelinin and Nardi, 2006). On the other hand, this theory considers that individuals have a social nature and are directly influenced by the culture, language, and behavior of other individuals located in the surrounding organizations, which may be the family, communities, groups, among others (Allen et al, 2011).

These assumptions helped to understand the motivations of commented behavior that can be cognitive (generated inside the human being) and social (generated externally). These motivations determine the goals to be achieved and are affected by existing environmental conditions. The goals, in turn, are composed of actions aimed at achieving goals. Similarly, actions are carried out by operations performed automatically or routinely under stable environmental conditions. Otherwise, if conditions are unstable, trades become stocks to the point where conditions are stable again and stocks are once again converted to trades. This is a cycle of human activity that is repeated in direct relation with the environmental conditions, but capturing its essence is a challenge that was carried out in the routine operation of the context.

In addition, the theory suggests that all activities are governed by the following principles: all human activity is collective, mediated by artefacts or tools, and goal-oriented; there are multiple opinions; it has a history resulting from transformations carried out over time; the tensions and contradictions are the origin of those changes thus developing said activity; and this can have various transformations of expansion resulting in changes and innovations as a result of the accumulation of tensions and contradictions. The latter can be located in each element of the activity (primary); related to each other (secondary); related between the motives/objects of a central element of a system and the motives/objects of a culturally more advanced element (tertiary); and related between the central activity and other close (quaternary) activities (Engestrom, 1987).

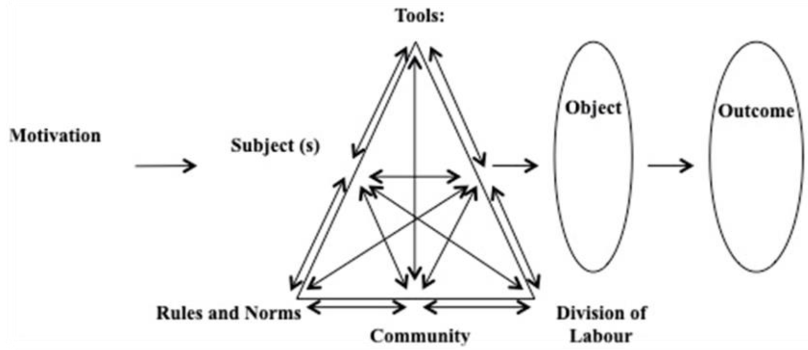

Figure 1. Human activity system

Likewise, the theory gave the basis to find and use each element of the human activity system or behavior under study. These are: which subject(s) carry out the activities, what are their objects, what tools (mental and/or physical) are used to mediate the activity, which community is involved, what rules and norms of interaction they follow, how they divide the work and what is the expected result (Engestrom, 1987), see figure 1. In the same way, this theory helped to make sense and understand the information collected, this is why the activities must be understood through what people do and because it does (Kaptelinin, 2005). Additionally, its understanding was holistic based on its dynamism and complexity with a close relationship with its environment, providing conditions to interpret and study the activities in its natural environment (Denzin and Lincoln, 2000). This was through the support of methodological strategies for the collective case study, increasing their knowledge with analytical and non-statistical generalizations (Yin, 2009).

3. METHODOLOGY

In the search for knowledge of information behavior within the work area, the following considerations were made, that consisted of:

1. Activity Theory was used as the conceptual framework where each element of the human activity system should be discovered within the context. For this, interviews, review of diverse used documentation and routine observation of the activities carried out were utilized. Here, the various problems that were present were also exposed. In the same way, a delimitation of the activities to be carried out was made in order to focus on gathering the data that will be analyzed later. Within this section, the search for indicators that defined the decision-making process was necessary and relevant. Each element was analyzed in order to find

the tensions and contradictions and the relationships between each element within the context in consideration of perceptions of collaborators.

2. Once the data was collected, the analysis began in reference to the human activity system and the information behavior as an activity under study. Each of the factors was discovered within the collected information. Here, the relationships between these elements were discovered and the impact that can be had on the activity under study. Within this analysis, the costs of various elements and their impact within the object of study were considered.

3. The result of the previous stage led to the suggestion of changes in the various physical and abstract tools used to implement the improvements in them, thus seeking to directly or indirectly impact on information behavior. Likewise, the discovery of areas of opportunity revealed that cognitive aspects can be considered to achieve mentioned improvements. Particularly, perceptions were the central part to achieve in order to have a direct impact on the decision-making process as well as the results in the production process.

4. Once the materials were developed in the physical and abstract tools, tests were carried out in their use in order to subsequently seek continuous improvement of them. In the same way, the activities where they were used and in consideration of other users were visualized to understand the context of use and the impact on the decision-making process from the perspective of their use. The individual contribution was relevant in the costs studied as a secondary part of the study. The initial survey carried out on the collaborators was carried out to verify the perception of the improvements to the various abstract and physical tools. Diverse indexes were discovered and gave the basis to future improvements.

4. RESULTS

This section presents the results obtained in each of the stages indicated above. Initially, the human activity system was developed and each element was discovered. Here, the relations between them were seen from the various forms were manifested; besides, those relationships can generate the basis to make changes within the context under study. Here, the use of the considered indicators was manifested within the particular area and its forms of use. The diverse indicators considered to evaluate the impact were the lack of administrative support, the time without use of machinery and equipment in considerations of lack of maintenance, among others.

Subsequently, the information flow was evaluated in reference to the administrative levels declared within the work area. It is how and what information was used in the diverse administrative levels in the organization and what tools were utilized on it. One aspect considered was the analysis of the cost incurred by the staff, or in this case, the research participants or collaborators. In the same way, they were given a questionnaire to evaluate the work from the perspective of a human activity system in direct relationship between other human activity systems or collaborative environment. Another aspect considered was the level of complexity in the management and retention of information within the activity system. Others aspects were the knowledge of the lack of communication and information within the production area.

The various elements found within the human activity system at the individual and collaborative levels were enhanced, particularly the physical and abstract tools discovered and employed in context. The elements that had improvements were the community, the division of labor, the employed tools, and the expected result within the activity.

Finally, diverse indicators were modified as a result of the implementation of the improvements in commented tools. The measured indicators suggested that the information exchange increased, as an element within the information behavior. This brought with it a 10% reduction in weekly rework and operating costs were reduced 1.3%. In the same way, satisfaction in the use of physical and abstract tools such as visual aids increased by 7%. In the same way, user satisfaction increased by 90%; that is, dissatisfaction in the use of information was reduced by 10%. Additionally, various physical tools were replaced seeking to increase satisfaction among the participants, among other indexes.

5. CONCLUSIONS AND RECOMMENDATIONS

The results obtained suggested that, in an effort to make good use of resources, the analysis and improvement of four elements of the human activity system were the best strategy to contribute by improving information behavior. Among the revised indicators were rework activities and costs as operational indicators, on the one hand, and the satisfaction of the users of the physical and abstract tools, as a contributing indicator with the information behavior, on the other.

From them, it was obtained that the stated objective was achieved, integrating each participant within the human activity system at individual and collaborative levels. The information exchange was crucial to visualize the results mentioned above and it is expected that in future research it could be found other improvements.

In the same way, it is seen that the activities carried out to improve information behavior ware the beginning of other activities necessary to increase their area of influence. The considered study area was a part of the company that allowed this study, having other areas of opportunity within it. Among the changes that could arise in mentioned implementation were the use of other technologies for better utilization of existing resources and the consideration of the cognitive limitations and information needs of the future participants or collaborators. In addition, it is suggested to improve the development of work teams focused on information sharing to improve information behavior. In the same way, it is suggested to develop strategies to improve the organizational climate aimed at achieving organizational objectives.

6. ACKNOWLEDGMENTS

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ANALYSIS AND ERGONOMIC DESIGN IN THE PRODUCTION PROCESS OF THE SHRIMP FREEZER COMPANY IN GUASAVE, SINALOA

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Resumen: El presente proyecto es una investigación que se desarrolló para generar un análisis y diseño de condiciones ergonómicas en el proceso productivo de la empresa congeladora de camarón. Su actividad principal es la producción y procesamiento de camarón a nivel nacional, el frezado de camarón es el proceso principal en la estación de llenado de taras con camarón se presentan problemas de rotación de personal, lesiones musculoesqueléticas con base a esto se propone, realizar un análisis y diseño de condiciones ergonómicas de la estación de trabajo, para tener una mayor productividad y disminuir lesiones, rotación y problemas de calidad de producto. Todo a través del análisis y métodos de evaluación ergonómica y así lograr el diseño de condiciones ergonómicas. Se espera reducir los tiempos muertos, y la rotación de personal y las lesiones musculoesqueléticas de la estación de llenado de taras en la empresa.

Palabras claves: Método RULA, Diseño ergonómico, DTA, Congeladora de camarón.

Relevancia para la ergonomía: La ergonomía es la interacción entre los seres humanos y otros elementos de un sistema. Este estudio aporta información que contribuye a la mejora de las condiciones de trabajo del sector Acuícola.

Abstract: This project is an investigation that was developed to generate an analysis and design of ergonomic conditions in the production process of the shrimp freezing company. Its main activity is the production and processing of shrimp at a national level, shrimp spawning is the main process in the shrimp filling station, there are problems of personnel turnover, musculoskeletal injuries based on this, it is proposed to carry out a analysis and design of ergonomic conditions of the work station, to have greater productivity and reduce injuries, turnover and product quality

problems. All through the analysis and ergonomic evaluation methods and thus achieve the design of ergonomic conditions. It is expected to reduce downtime, staff turnover and musculoskeletal injuries at the company's tare filling station.

Keywords: RULA method, Ergonomic design, DTA, Shrimp freezer.

Relevance to ergonomics: Ergonomics is the interaction between human beings and other elements of a system. This study provides information that contributes to the improvement of working conditions in the Aquaculture sector.

1. INTRODUCTION

Sinaloa is the most important agricultural state in Mexico. Additionally, it has the second largest fishing fleet in the country. (Government of the State of Sinaloa, 2017). One of the predominant activities is Aquaculture, which is practiced throughout the state. There are a total of 907 Crustacean Aquaculture Production Units (UPAs) served by CESASIN, which are equivalent to 7,304 culture ponds of various types and sizes, installed in 67,345.63 ha of water mirror (OSIAP-SENASICA, 2021). Due to its size, Guasave occupies the eighth place with respect to the other municipalities in the state; It has an area of 3,464.41 square kilometers, which represents 5.9 percent of the state area and 0.17 percent of the national area. There are more than 442 locations in the municipality, where 100 shrimp aquaculture farms are located. (Guasave M., 2021).

Aquaculture Los Ahumada S.S.S S. de S.S. is a company dedicated to the breeding, processing and commercialization of shrimp nationwide. Currently the company has a process, which is divided into 7 operations, among which are the following: reception of raw material, beheading, classification, rest, spawning, packaging and shipment. The headless area is made up of 3 activities, the first is the collection and distribution of the shrimp, in which there is a conveyor belt through which the shrimp from the reception area passes, in addition crates are used for their collection and it is distributed with the help of personnel, using the technique of dragging tares with a weight of 35 to 50 kg of product. The second activity is headless, this is divided into production lines, which are made up of steel tables, with capacities of 6 people each. The number of employees per line ranges from 18 to 30, in this activity staff of both sexes work, the majority are female, with an age range between 18 and 68 years. The third activity is the registration and distribution of the shrimp to the next area, for which a computer with internet service is used, a scanner for the registration of the buckets, crates for the distribution of the shrimp in the process. The entire area works between 8 to 10 hours a day. The main problem that arises is the low productivity in the product distribution area using the technique of dragging tares with a weight of 35 to 50 kg, causing staff turnover, upper and lower back pain, low productivity, and delays in the process.

2. OBJECTIVE

Carry out an analysis and application of ergonomic methods in the station for filling tares with product from the shrimp freezer, to identify and evaluate possible musculoskeletal injuries, and design ergonomic conditions in the work station.

3. METHODOLOGY

1.- Carry out a diagnosis of the company's production process through tours, where the characteristics of the workers and work station that harm the health and safety of the operator are identified. Through the identification of STPS Standards and ergonomic principles.

2.- Identify the area for filling tares, as the station that presents the greatest risk to the well-being of the worker. For this, evaluations are carried out for the identification of musculoskeletal injuries and cumulative trauma disorder through ergonomic evaluation methods.

3.- Design the area for filling defects with ergonomic and safety conditions in the production process.

4. RESULTS

When carrying out the analysis carried out in the area of tare filling, it was identified that the movements carried out by the operators are inadequate and are risk factors in their health and safety, for this the ergonomic design proposal is presented that should be considered in the production process.

Data collection was carried out for 3 weeks to later present the design proposal, which will benefit the workers, eliminating unnecessary movements or operations when executing the tasks, to provide workers with better working conditions and efficient productivity.


Figure 1. Shrimp tare filling workstation.

Table 1. Identification of Official Mexican Standards of the STPS.

List of official Mexican Standards applied to the production process of the company			
Company: Acuicola Los Ahumada.			
Line of business: hrimp milling company (filling tares)			
Date: May 22,2023			
Standard	**Yes**	**No**	**Observations**
Official Mexican STANDARD NOM-011-STPS-2001, Safety and hygiene conditions in workplaces where noise is generated.		**X**	In the facilities there is no mediator to reduce the noise that the machinery generates, in the same way the worker does not use personal protection.
Official Mexican STANDARD NOM-001-STPS-2008, Buildings, premises, facilities and areas in workplaces-Safety conditions.		**X**	The company does not have security conditions in any of its work areas.
Official Mexican STANDARD NOM-004-STPS-1999, Protection systems and safety devices in machinery and equipment used in workplaces.		**X**	The operators do not have any protection when using the machinery to carry out their activities. Some personal protective equipment is not adequate for the type of activity they perform.
Official Mexican STANDARD NOM-030-STPS-2009, Preventive health and safety services at work-Functions and activities.		**X**	Employees do not have preventive health and safety services within the company.
Official Mexican STANDARD NOM-024-STPS-2001, Vibrations-Safety and hygiene conditions in the workplace.		**X**	Employees are exposed to high levels of vibration without any vibration.
NOM-016-STPS-1993, Relative to safety and hygiene conditions in workplaces regarding ventilation.		**X**	The personnel is exposed to high levels of humidity without having any means to regulate ventilation.

Table 2. Ergonomic principles applied to workstation 1

Principles	Remarks
Principle 2: Use the elbow height as a reference.	Working at the wrong height leads to vicious positions and unnecessary strain. Elbow height: Work is carried out at the height of the elbow whether sitting or standing, above or below the elbow the effort is greater. Considering the current situation in the company, which has three work tables with a height of 50, 75 and 90 centimetres, our corrective action is to design these tables at the height of the elbow of the worker, which is 112 centimetres, so that the worker can develop in the best possible way and avoid unnecessary effort.

Principle 4: Find the correct position for each task.	There are very bad habits with respect to some tasks, therefore, on many occasions workers do not look for the correct position to carry out an operation, a very clear example is that on occasions heavy objects are moved, and when they are lifted, they do so incorrectly and the back is subjected to the most pressure. The workshop has a small tool for this task, but it is not commonly used
Principle 6: Minimise fatigue Many times workers overtax their physical capacity by doing activities that can cause muscle damage	In addition, sometimes, due to space constraints in the workshop, workers have to work outside in direct sunlight
Principle 7: Minimise direct pressure.	The workshop has a work belt, which is rarely used, in fact, it is used because they feel a pain in their back. Ideally it should be worn every day to prevent any fractures
Principle 8: Adjustment and change of posture	No matter how much the worker wants to adjust, it is difficult as there is no ergonomic table or stretcher available, which affects the back when carrying out operations under a trolley.
Principle 9: Provide space and access It is of great importance that working space is provided for each element and easy access to whatever is needed.	Therefore, to ensure adequate working space, our corrective action is to make an efficient distribution in which it is proposed that the old iron is stored in drums to prevent them from obstructing the sides of the workshop, as well as moving the engines and transmissions that are in the central part to the storage warehouse, with this we intend to avoid accidents at work and have better space to work comfortably
Principle 12: Improve the organization of the work If the tool trolley were well organized,	The work would be more efficient as we would save time looking for the tool that is needed. Moreover, this principle is not fulfilled because the distribution of space is not the most appropriate.

Duranig the ergonomic assessment, little use of the STPS legal framework was identified. The Official Mexican Standard NOM-025-STPS-2008. It is not applied because of the lighting conditions, there is insufficient lighting for the minuscule work carried out at the workstation.

The Official Mexican Standard NOM-011-STPS-2001, Safety and hygiene conditions in workplaces where noise is generated. The workstation does not control the number of decibels used in the process, exposing the worker to decibels above 90 decibels during the workday. The Official Mexican Standard NOM-001-STPS-2008 does not have a specific distribution for the processes carried out in the workshop. The official Mexican standard NOM-015-STPS-2001 sets out the appropriate conditions for exposure to temperatures. In the workshop they are exposed to 42 to 48 degrees, generating an unsatisfactory thermal environment, causing fatigue and mental exhaustion.

4.1. Application of ergonomic evaluation methods in station 1.

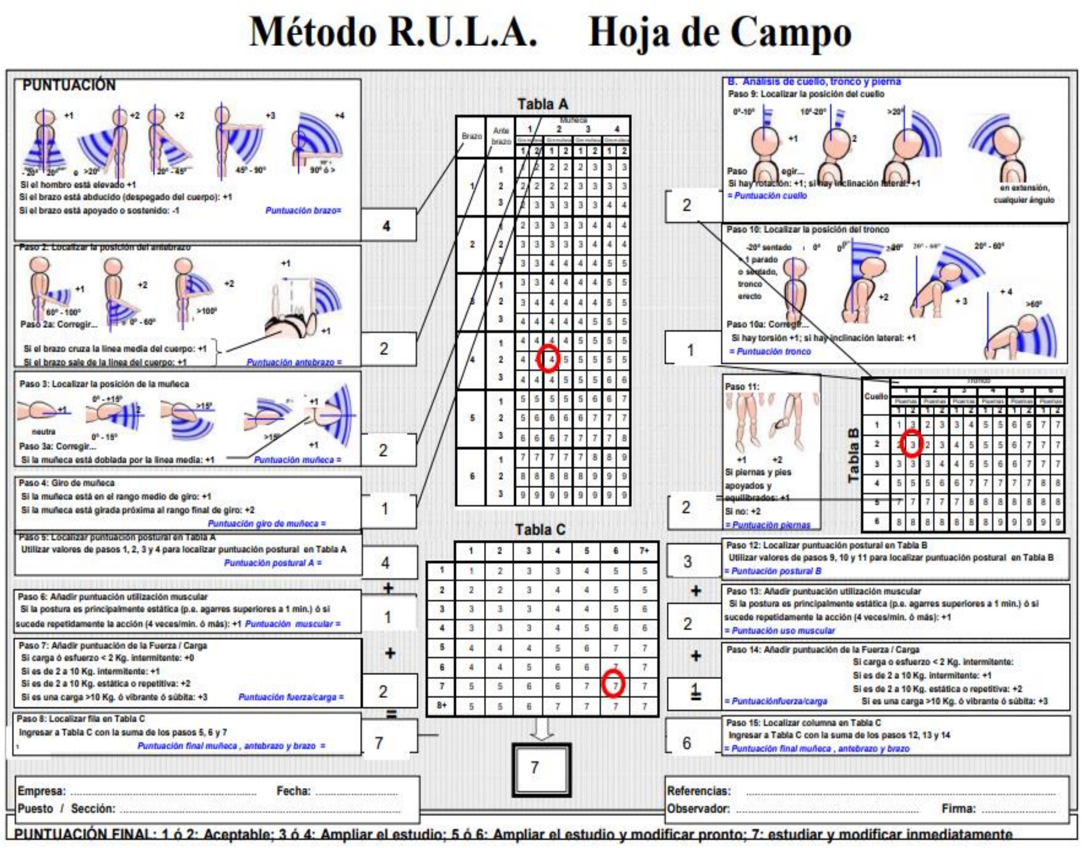

Figure 2. Application of the RULA Method in workstation 1

4.2. Design of ergonomic conditions in the work station 1.

The official Mexican Standards were analyzed and the specifications of standard 036 on manual handling of loads are considered, indicating that the maximum mass that a worker by age and gender can lift or lower is: 25 kg per load, men aged 18 to 45 years old, at the work station they move a load of 35 to 50 kg per tare product. Another ergonomic condition is the anti-fatigue mat to reduce fatigue for those who are exposed to 12 hours of work at that work station. As well as modifying the height of the support bench for tare filling, raising it 10 cm more so that the movement of the load is more comfortable for the movements made by the operator, and not generate a disorder of cumulative trauma, DTA or musculoskeletal injuries in workers.

4. CONCLUSIONS

The ergonomic analysis allowed to identify the risk factors in the workplace. The operator performs the work at an incorrect height because the work tables are outside the elbow height, which is 112 centimeters, in addition to changing the material handling posture to perform the operations.

The Rapid Upper Extremity Assessment (RULA) and ergonomic principles help to have a better perspective of the levels of ergonomic risk that affect the health of the operator in station 1.

The most feasible solution would be to insert an anti-fatigue mat into the work area, seeking to decrease operator fatigue, as well as suggest that the workbench be placed on top of a climbing workbench for easy reach.

The benefits offered by the improvement of the workplace for the worker are very significant in comparison with the design and structure that was considered previously, since in this way the operator is prevented from having a leaning posture, working in an uncomfortable way or presenting any type of accumulated fatigue, which can cause injury. With this modification, the quality of life and the productivity of the operator would increase, since the worker would be located in a more comfortable position, which makes the operator a more productive worker, which is basically what is sought in any company.

Ergonomic analysis identifies risk factors in the shrimp tare filling workstation. Risks and dangerous conditions for the operator were found, through ergonomic principles overexertion, pressure on the body, unnecessary efforts, adjustment and change of inadequate postures were detected, the controls and dashboards do not have a good visualization, generating confusion in the operators when carry out their activities.

The ergonomic evaluation indicates the working conditions to which the operator is exposed when carrying out the tasks. The RULA method evaluates the postures and risks associated with musculoskeletal disorders due to postural load, in the activities of the production process. As a result, it indicates a level 5, which represents a need to redesign the task or work station. Based on standard 036 of the STPS, ergonomic risk factors were analyzed due to the manual handling of loads, and presenting a postural risk in the extremities of legs, arms, upper and lower back. generating fatigue and cumulative trauma disorders.

The improvement proposal for the work area is the placement of anti-fatigue mats, installing a conveyor belt with separators for the assignment of the tares with product to the work tables, assigning a distance closer to the operator and can be within reach , all based on the Official Mexican Standard 001 of STPS for the redesign of tasks. For the worker, these improvements are significant, avoid bad postures or present some type of fatigue and low productivity, and do not cause injuries. With this modification, the operator's quality of life and productivity would be increased, decreasing staff turnover, generating a more productive operator.

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INFORMATION BEHAVIOR IN THE SUPPLY QUALITY AREA

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Resumen Este proyecto fue desarrollado para mejorar el tiempo de investigación y análisis del desempeño de los proveedores que tiene una empresa de giro médico dentro del Departamento de Calidad. Además, esto incluye el proceso de toma de decisiones para evaluar a los proveedores en tiempo en el cumplimiento de un índice corporativo. Similarmente, se espera disminuir los errores por la falta de información o por no saber dónde obtenerla. En el desarrollo de esta mejora se pretende implementar una metodología poco usada en las industrias siendo primordialmente utilizadas en ambientes escolares, científicos o psicológicos. La metodología de la Ergonomía Cognitiva, el Comportamiento Informacional y la Teoría de la Actividad tiene un gran impacto en este proyecto, ya que nos enfocaremos en el ambiente laboral y seguridad mental de las personas y en su búsqueda de información para la toma de decisiones. Los resultados mostraron mejoras en las diversas actividades del sistema de calidad de proveedores, reduciendo así principalmente los costos operativos y el tiempo requerido en las auditorías requeridas para evaluar a estos. Esto trajo consigo la valía de la metodología desarrollada para poder mejorar el comportamiento informativo dentro de dicho contexto.

Palabras clave: Comportamiento informativo, calidad, proveedores, Teoría de la Actividad

Relevancia para la ergonomía: El mejoramiento del comportamiento informativo dentro de procesos de evaluación de proveedores de calidad es un tema que ha sido poco estudiado. El presente estudio ha incluído los elementos principales del sistema de actividad humana donde se consideraron los usuarios del sistema empleado para llevar a cabo dichas actividades y los proveedores en si. Esto permitió encontrar la valía en el empleo de nuevos enfoques en la solución a problemáticas existentes dentro de las organizaciones, buscando mejores soluciones y en el pleno reconocimiento que éstas son temporales. Aunque esto sea temporal, éstas, también, forman las bases para futuras intervenciones que tenga el mismo objetivo señalado.

Abstract: This project was developed to improve the time for research and analysis of the performance of suppliers that a medical company has within the quality department. In addition, this included the decision-making process to evaluate suppliers on time against a corporate index in this line. Similarly, errors due to lack of information or not knowing where to obtain it were expected to decrease. In the development of this improvement, it was intended to implement a methodology little used in industries, being primarily used in school, scientific or psychological environments. The methodology of Cognitive Ergonomics, Information Behavior and Activity Theory had a great impact in this project, since we focused on the work environment and mental safety of people and on their search for information for decision making. The results showed improvements in various activities of the supplier quality system, thus mainly reducing operating costs and the time required in the audits to evaluate suppliers. This brought with it the value of the methodology developed to be able to improve the information behavior within mentioned context.

Keywords. Information behavior, quality, providers, Activity Theory.

Relevance to Ergonomics: The improvement of information behavior within evaluation processes of quality suppliers is a topic that has been little studied. The present study has included the main elements of the human activity system where the users of the system used to carry out commented activities and the providers themselves were considered. This allowed to find the value in the use of new approaches in the solution of existing problems within the organizations, looking for better solutions and in full recognition that these were temporary. Although this was temporary, they also formed the basis for future interventions that should have the same mentioned objective.

1. INTRODUCTION

Currently, companies invest resources to achieve their objectives and depending on them, were the arrangements they make to achieve them using minimum resources. Among the used resources are technological that take various forms as equipment, machines, facilities, software, etc. However, the use of these technologies brings with it challenges in its use. For this, various strategies are deployed to be able to use everything they offer in order to exploit their capabilities. Here, training is a commonly used strategy since it allows to be in direct relationship with the user and the desired technology. In the case of computer systems or software used in organizations, the training aims to develop the skills required for their best use. This is the case of the context considered in this study, which it is an organization in the medical field. This company has strict quality controls in its processes and the evaluation of suppliers is a necessity to ensure this. This is indicated in the various regulations that govern their production processes in direct relation to the market in which they are, or wish to establish them.

One of the competencies or expected behaviors is that related to the seeking, processing and using information in context. In other words, one behavior that is directly related to mentioned activities is the information behavior, particularly, that behavior focused in the context and using the tools that are available to carry out the expected activities. These tools can be physical or tangible and abstract or intangible. This behavior is called information behavior and it is expected to be a crucial behavior in the activities to be done (Eduarte, Alcaina and Meneses, 2018).

In the particular study case in the present investigation, it was the relationship between the information behavior and the evaluation of suppliers using a computer system in the activities. The relationship between these resources was discovered as a result of various existing problems in the supplier evaluation process. This results on increasing the rate of staff turnover developing these activities, that has consequently led to an increase in the time spent for it, going from approximately two weeks to four weeks in average. In addition, a lack of satisfaction was discovered in the use of the system as the main support tool in the process.

These problematic situations generated the pattern to be able to find the appropriate ways to change the course of these activities. For this reason, it was proposed to change the perspective to improve the information behavior in such a way that it would have an impact on these activities within the supplier evaluation process. The use of the cognitive ergonomics approach was employed and the Activity Theory was utilized as a conceptual framework (García, 2017a). On the one hand, cognitive ergonomics helped on understand how the error can be reduced through various activities focused on developing the cognitive abilities of the users. On the other hand, Activity Theory exhibited advantages in the analysis of human activity (or behavior) under study (García, 2017b), such as the information behavior is focused on improving the supplier evaluation process. Among those activities considered errors are: not verifying inventory levels, not verifying the risk represented by the supplier in updating inventories, not evaluating the quality performance of its products, not confirming purchase plans considering required quality levels, not knowing the criticality level of the product provided within the production process, among others failures.

These situations carried out challenges that were addressed throughout the project with the aims of reducing the error and increasing collaborators satisfaction. This was seen as an area of opportunity or tension generated within or between elements of the activity system or between activity systems. That is, the treatment of the problems was visualized as areas of opportunity within the language used in the context under study. For this, it was necessary to create different expectations in the users in such a way that it was expected to create new ways of relating between the users of the system and the organization's providers. It is because there are regulations that indicated the need to strengthen relations between suppliers and their customers in order to improve the quality of the products and services between them (Moreno and Jeno, 2016).

In addition, within the various activities carried out, various problems could be visualized, among which are: the verification of the raw material, the calculation of the risk of non-compliance of suppliers, the measurement of the performance of the quality indicators that the suppliers have, the various activities carried out jointly, among others problematic situations as explained before. Besides, other situations were mentioned requiring activities to improvement better practices within the supplier evaluation system in the use of tools for better performance. For this, the objective has been defined: to improve the information behavior in the area of supplier quality by modifying physical and abstract tools using cognitive ergonomics to reduce the time on the evaluation process of suppliers.

This project showed various limitations. Some of them are those related to the analysis to be carried out on each of the providers in order to evaluate their performance. That is, the project was focused on visualizing its level of risk or noncompliance as a supplier using the evidence that has been generated in relations with the company, that participated in the study.

Other limitations were the information behavior by each of the collaborators, who carry out activities related to the mentioned analysis, the object of study, and the mainly tool used, providing the information required for doing those activities (Valero and Ponjuan, 2014). The system developed to be able to concentrate the information from the material supply processes, to the various production processes was considered the main tool to support information behavior (Infante, 2016) in context.

Also, other physical and abstract tools were considered such as the instruction sheets and the training received to carry out the aforementioned activities. This was also in consideration of the various processes for updating information in the system, limiting the study.

In the same way, various indicators were developed that could evaluate the performance of collaborators and internal processes, differentiating, for example, analysis times, risk calculations, recognition of the type of required evaluation, the types of formats to be used, the type of documentation to be required from each supplier according to the product or service it provided, the commitment to allow follow-up audits, the follow-up in the attention of supplier requests, the cost incurred by supplier follow-up, among others indexes employed.

The aforementioned indicators were also considered within the company to measure the performance of the supplier evaluation system itself; however, in the present study only the indicators of satisfaction in the use of tools and the effectiveness and time spent by the system in support of follow-up activities were used. Moreover, the area of supplier quality was considered in the study.

2. LITERATURE REVIEW

1.1 Information Behavior

The origins of information behavior have been located in Library Science and the field of readership. Studies on uses of libraries and how scholars utilized information relative to their work emerged at least 90 years (Wilson, 2010). The research in these fields included the switch from system-centered to user-centered (Wilson, 2000a; Rioux, 2004; Case, 2006); that is passing from giving importance to system to user as principal factor in study. In addition, information behavior served to evaluate technological tools and relations with users. Moreover, same behavior extended the studies to information origins that are in physical or electronic form in libraries or places where users were immersed and used information. This also favored the individuals as origins of information (Wilson, 1981). Similarly, this recognized the importance of contexts such as everyday life and work in diverse areas. For instance, Talja and Hansen (2006) stressed that information behavior can change the course of the relationships between individuals and their information sources in context. This is because information behavior offered a concise relationship with contextual and situational variables, resources and rules to seek, process and use information (Wilson, 1981).

A consequence of that relation is the information behavior is considered as an umbrella term. This is seen when the terms information behavior and information practice are used interchangeably (Savolainen, 2007). However, Savolainen (2007) argues that despite both terms are used in the same form, there is a difference in relation to the approach in which they are conceived. He pointed out that information behavior is conceived in the cognitive approach and the information practice, in the social constructionist approach. That is, information behavior is considered as a product of the mind and information practice, a product of the social interactions between individuals. Therefore, it is important to consider that information behavior and information practice are mutually related, so both the cognitive and the social perspectives are considered in this study in order to give relevance in context. This is because the cognitive approach can help to understand the behavior in context and the social constructionist approach, the collaborative nature of massive production using information behavior as the principal means.

1.2 Activity Theory

This meta-theory helped to discover knowledge within the environment even when individuals are unaware of its existence and provided the theoretical, methodological and practical grounds to study the information behavior in the mentioned context. Here, the awareness of an activity (or behavior) is a product of itself (Wilson, 2008) and works by studying it holistically (Wilson, 2006). Also, this activity results from its continuous realization and its interactions and human experiences with other individual beings and the surrounding environment directly influencing itself. In addition, the activity is aimed at achieving objects or objectives (Mwanza, 2002) to generate results (Kaptelinin and Nardi, 2006). On the other hand, this theory considers that individuals have a social nature and are directly influenced by the culture, language, and behavior of other individuals located in the surrounding organizations, which may be the family, communities, groups, among others (Allen et al, 2011).

These assumptions helped to understand the motivations of commented behavior that can be cognitive (generated inside the human being) and social (generated externally). These motivations determine the goals to be achieved and are affected by existing environmental conditions. The goals, in turn, are composed of actions aimed at achieving goals. Similarly, actions are carried out by operations performed automatically or routinely under stable environmental conditions. Otherwise, if conditions are unstable, trades become stocks to the point where conditions are stable again and stocks are once again converted to trades. This is a cycle of human activity that is repeated in direct relation with the environmental conditions, but capturing its essence is a challenge that was carried out in the routine operation of the context.

In addition, the theory suggests that all activities are governed by the following principles: all human activity is collective, mediated by artefacts or tools, and goal-oriented; there are multiple opinions; it has a history resulting from transformations carried out over time; the tensions and contradictions are the origin of those changes thus developing said activity; and this can have various transformations of expansion resulting in changes and innovations as a result of the accumulation of tensions and contradictions. The latter can be located in each element of the activity (primary); related to each other (secondary); related between the motives/objects of a central element of a system and the motives/objects of a culturally more advanced element (tertiary); and related between the central activity and other close (quaternary) activities (Engestrom, 1987).

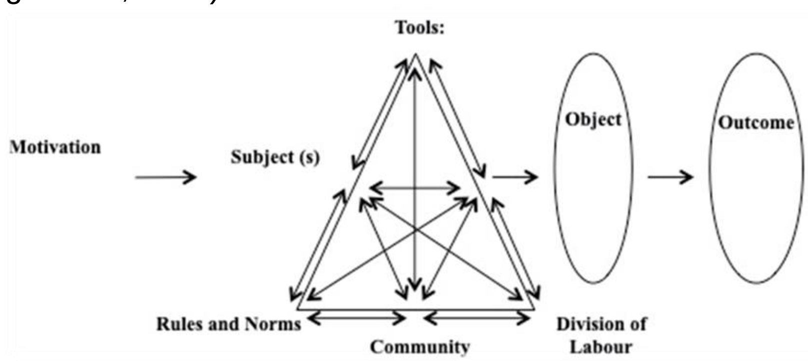

Figure 1. Human activity system

Likewise, the theory gave the basis to find and use each element of the human activity system or behavior under study. These are: which subject(s) carry out the activities, what are their objects, what tools (mental and/or physical) are used to mediate the activity, which community is involved, what rules and norms of interaction they follow, how they divide the work and what is the expected result (Engestrom, 1987), see figure 1. In the same way, this theory helped to make sense and understand the information collected, this is why the activities must be understood through what people do and because it does (Kaptelinin, 2005).

Additionally, its understanding was holistic based on its dynamism and complexity with a close relationship with its environment, providing conditions to interpret and study the activities in its natural environment (Denzin and Lincoln, 2000). This was through the support of methodological strategies for the collective case study, increasing their knowledge with analytical and non-statistical generalizations (Yin, 2009).

3. METHODOLOGY

In the search for knowledge of the information behavior within the area of supplier quality, the following considerations were made, that consisted of:

5. Activity Theory was used as the conceptual framework where each element of the human activity system has been discovered within the context. For this, interviews, review of various documentation used and routine observation of the activities carried out were used. Here, the various problems that were present were also exposed. In the same way, a delimitation of the activities to be carried out was made in order to focus on gathering the data that was analyzed later. Within this section, the search for indicators that define the decision-making process was necessary and relevant. Particularly, those related to the use of the computer system that supported the activities in the area and the various sections or elements of it.

6. Once with the data was collected, the analysis begdan in reference to the human activity system and the information behavior as an activity under study. Each of the factors was discovered within the collected information from the methods. Here. the relationships between these elements were discovered and the impact that can be had on the activity under study. Within this analysis, the indicators of satisfaction using the tools and the effectiveness and time spent in the use of the system by evaluating the suppliers were considered.

7. The result of the previous stage led to the suggestion of changes in the sections or subsystems, among which are the accounting of non-conformities in the suppliers, the elements under study to carry out the evaluation of the supplier and those related to the type of service or product they provided. These tools were declared as physical and abstract tools and in which improvements were implemented, thus seeking to directly or indirectly impact information behavior. Likewise, the discovery of areas of opportunity revealed that cognitive aspects can be considered to achieve commented improvements. Particularly, perceptions are the central part to be achieved in order to have a direct impact on the decision-making process or the use of information that allows the evaluation of suppliers. In addition, the mentioned indicators were the focus in the study.

8. Once the materials were developed in the physical and abstract tools, tests were carried out in their use in order to seek continuous improvement of them. In the

same way, the activities where they were used and in consideration of other users were visualized to understand the context of use and the impact on the decision-making process from the perspective of their use. The individual contribution was relevant for the improvement of the main tool by developing future tools in order to improve cognitive abilities through training. In itself, these activities are to generate processes of continuous improvement from the cognitive perspective and enriching the informative behavior. In addition, the use of the system and making changes in relation to the suggested improvements by the users were relevant to the achieve of the objective.

4. RESULTS

The results of the study were in accordance with the stages indicated above. In the first instance, the human activity system using the Activity Theory as a conceptual framework was developed, where each element of the system was discovered and indicated. This allowed the visualization of the existing relationships between each of the elements and the generation of human activity systems of certain types. Here, suppliers added information enriching the study particularly on giving the basis for creating a secondary activity system on quaternary level. On the other hand, the aforementioned indicators such as satisfaction in the use of tools and the effectiveness and time spent by the system in support of the monitoring activities generated the necessary basis to make improvements in the system used. Each part was improved using the Cognitive Ergonomics paradigm, managing the reduction of the resources used in the activity system.

Hence, the modification of the different parts of the system used in the evaluation of suppliers. Initially, several changes were suggested, including the information capture order, the display order of the directories and information sections, the change of colors in the various sections of the system indicating the suggested order to capture information and the suggested use of the contents, among other changes. Also, it was possible to make changes in the classification of suppliers based on their real evaluation needs and showing the needs of the production processes in real time and according to the sales forecast.

In the same way, on the other hand, satisfaction surveys of users or collaborators were carried out using the system and relations with suppliers, where an increase in the index of 15% indicating strength relationships with suppliers. It was found that the information collected clearly delineated the areas of opportunity and/or desired improvements within the system and aids in the evaluation process of suppliers. From the above, seven areas of opportunity arose inside and outside the company, but within the system of work with suppliers. In this line, the collaborators were participants in the evaluation of the suggested changes and during the implementation phase, thus reducing the implementation time and use of the improvements. This had a direct impact on the improvement of the information behavior, decreasing the service time required in the evaluation activities of the suppliers. The time was reduced and controlled in 10 days on average dedicated to their audits. This represented a substantial reduction in operating costs related to supplier quality costs.

The work carried out on the improvements, in turn, increased the satisfaction not only of the collaborators but also, as a side effect, the satisfaction of the suppliers by using clear information requirements, that could help on improving their service offered to clients. That is, the improvements were focused on the operation of the company and there were additional benefits in the improvement of commercial relations with suppliers. Here, it was a full recognition of the human activity of information behavior inside and outside the organization obtaining benefits in both directions. That is, the recognition of the needs of both parties were a crucial part in the development of the study and the results obtained. This brought with it the recognition of information management that directly impacted in the operation of customer and supplier systems.

5. CONCLUSIONS AND RECOMMENDATIONS

The proposed objective was achieved by improving the information behavior by modifying the physical and abstract tools used in the evaluation of suppliers, thus reducing service times. This brought some improvements in various elements of the activity system used as the basis for the analysis. For example, user satisfaction was one of the main activities of the project and this transcended in a way that the suppliers were benefited from the improvements proposed and carried out. Mainly, a point of interest was the full recognition of the achievement of organizational objectives, which overlapped in a sense that this generated conditions to improve the entire system.

Also, this improved working conditions by reducing service times for suppliers in their evaluation and in the implementation of improvements in the different processes that involved them. That was at the individual and collective levels in reference to the users, and at the organizational level in full recognition of the needs of the organization and its suppliers. Besides, the recognition of the human factor was essential to carry out this study and the various phases that were carried out exhibited this perception.

In the same way, it was discovered that several improvements are needed in other processes supporting the relationships with the suppliers. Therefore, it was mentioned that the basis for these improvements were generated and the human activity system has been modified considering other elements of the organization. In the same way, other activity systems have been developed at other levels for creating systems at various levels to complete an entire viewpoint of the organization and those that are in its level of influence.

6. ACKNOWLEDGMENTS

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IMPLEMENTATION OF AN ERGONOMIC PROGRAM IN THE TORTILLA MANUFACTURING PROCESS OF HERMOSILLO, SONORA

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Resumen: El siguiente trabajo consiste en la aplicación de un programa de gestión ergonómico en la empresa dedicada a la producción de tortillas, con el objetivo de identificar y reducir los niveles de riesgo en las cinco estaciones que del proceso de elaboración de tortillas de harina. Se realizaron visitas al establecimiento para obtener información sobre el proceso de producción de tortillas y se registraron imágenes y vídeos que permitieran observar con claridad los movimientos de cada uno de los trabajadores. Se llevaron a cabo evaluaciones ergonómicas como son los métodos Art, Mac y Rapp Tool, así como el método postural RULA y el método para obtener el gasto metabólico de energía de todas las estaciones, esto con el fin de identificar los factores de riesgo presentes en cada una de las estaciones para proponer mejoras que permitan reducir el nivel de riesgo de las tareas. Las evaluaciones para las estaciones 3,4 y 5 se tomaron en cuenta al trabajador más alto y el más pequeño, con la finalidad de identificar el nivel de riesgo para ambos casos. Como resultados se obtuvieron que la estación 1 en función de RULA y Mac indica un riesgo alto (rojo) en la posición de amasado y Mac riesgo medio (naranja) en el transporte y carga de la cubeta de agua y un riesgo alto (rojo) para la carga y transporte del costal, la estación 2 se categoriza en riesgo bajo (verde) para ambos brazos. La estación 3 cuenta con riesgo bajo (verde) mientras que el transporte de charola muestra un riesgo medio (naranja) según Mac. La estación 4 en base Art indico un riesgo medio (naranja) para el lado derecho y riesgo bajo (verde) para el lado izquierdo, por último, la estación 5 en función del método Art indico un riesgo medio en sus labores a excepción del brazo izquierdo del trabajador de estatura baja. En base los resultados, se plantearon propuestas de mejora con ayuda de una simulación para el rediseño y apoyo de cada una de las estaciones de trabajo.

Palabras clave: Ergonomía, evaluación ergonómica, salud, lesiones, riesgo.

Aportación a la Ergonomía: Aplicación de un programa ergonómico demostrando la importancia y la presencia de la ergonomía en empresas como es una tortillería, analizando y midiendo los niveles de riesgo que se presentan en el proceso de fabricación. De esta manera los trabajadores puedan desenvolverse en un ambiente cómodo que les permite ser eficientes en sus labores.

Abstract: The present study consists of the application of an ergonomic risk management program in the company dedicated to the production of tortillas, with the aim of identifying and reducing ergonomic risk levels in the five workstations of the flour tortilla production process. Visits were made to the establishment to obtain information on the production process and images and videos were recorded to clearly observe the movements of each of the workers. Ergonomic evaluations were carried out such as the British Art, Mac and Rapp Tool methods, as well as the RULA postural method and the method to obtain the metabolic expenditure of energy of all the stations, this in order to identify the risk factors present in each of the stations to propose improvements that allow reducing the level of risk of the tasks. The evaluations for stations 3,4 and 5 were considered the tallest and smallest worker, to identify the level of risk for both cases. As results, it was obtained that station 1 based on RULA and Mac indicates a high risk (red) in the kneading position and Mac medium risk (orange) in the transport and loading and loading of the water bucket and a high risk (red) for loading and transporting the sack, station 2 is categorized as low risk (green) for both arms. Station 3 has a low risk (green) while the transport of tray shows a medium risk (orange) according to Mac. Station 4 in Art base indicated a medium risk (orange) for the right side and low risk (green) for the left side, finally, station 5 according to the Art method has a medium risk in their work except for the left arm of the short worker. Based on the results, proposals for improvement were proposed with the help of a simulation for the redesign and support of each of the workstations.

Keywords: Ergonomics, ergonomic evaluation, health, injuries, risk.

Relevance to Ergonomics: Application of an ergonomic program demonstrating the importance and presence of ergonomics in companies such as a tortilla shop, analyzing and measuring the levels of risk that arise in the manufacturing process. In this way, workers can function in a comfortable environment that allows them to be efficient in their work.

1. INTRODUCTION

1.1. Background

According to the International Ergonomics Association (IEA, 2015), ergonomics is the application of scientific knowledge to design work, systems, products, and environments that fit the physical and mental capabilities and limitations of individuals. Its presence in companies has been increasing due to the prevalence of musculoskeletal injuries caused by poor posture, repetitive movements, among other factors. Its application aims to ensure that workers do not suffer injuries from the postures, movements, or forces exerted during their workday.

An ergonomic risk assessment becomes highly important, as it allows for the identification and control of risks associated with tasks involving repetitive motions, uncomfortable postures, and excessive strain on the human body. When evaluating ergonomic risks in the process, we can pinpoint problematic areas and take measures to reduce or even eliminate risks. In addition to safeguarding the health and well-being of workers, it can also contribute to enhancing worker efficiency and productivity.

The Tortilleria is a microenterprise dedicated to the production and sale of corn and flour tortillas, founded in January 2003. It started as a small establishment operating from a private residence with only one employee.

The objective of this study is to conduct an ergonomic evaluation of the various workstations within the company, identifying and analyzing working conditions in order to detect, prevent, and mitigate potential occupational hazards that could impact both the well-being of the workers and the efficiency of the workplace.

1.2. Process Description

This study focuses on the process of making homemade-style flour tortillas, which consists of the steps illustrated in Figure 1.

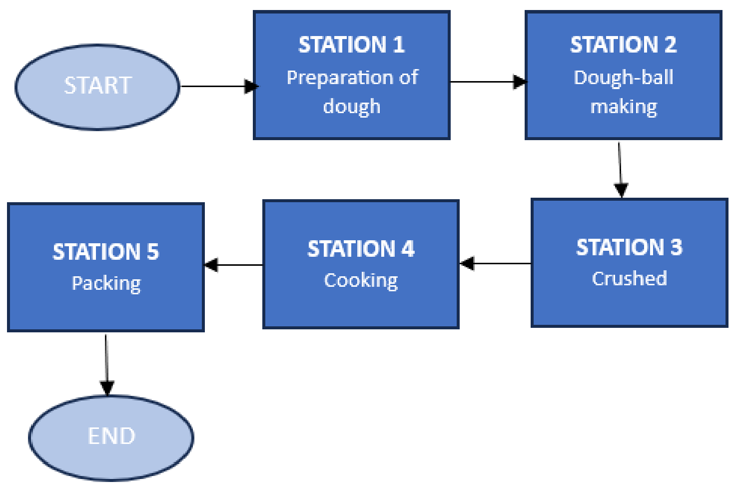

Figure 1. Block diagram: tortilla production process

1. Dough Preparation: Wheat flour, water, salt, and shortening are mixed, and a kneading machine is responsible for thoroughle blending the mixture until the desired consistency is achieved (Figure 2).

Figure 2. Station 1: dough preparation

2. Dough-ball making. With the assistance of a rounding machine, the dough is placed into the hopper to form small, equally sized dough balls, which are then place onto trays. During this step, the dough is loaded into the machine in specific quantities base on its capacity (Figure 3).

Figure 3. Station 2: dough-ball making

3. Ball Flattening: The trays are taken to a machine where each dough ball is flattened. The dough ball is placed in the flattening machine, which automatically presses it just once, resulting in the shape of a tortilla (Figure 4).

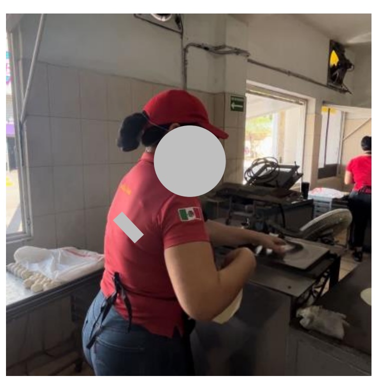

Figure 4. Station 3: crushed

4. Cooking: The tortillas are transferred to a griddle, where they are flipped approximately 3 times each using a spatula to ensure thorough cooking (Figure 5).

Figure 5. Station 4: cooking

5. Cooling and Packaging: Once cooked, the tortillas are transferred to a cooling table, where they rest for a few minutes under direct air. Once they have cooled completely, they are packed in sets of 12 pieces in a clear plastic bag. It is important to note that Tortilleria has no prior history of implementing ergonomic risk management programs in the company, making this the first time such a program is being introduced (Figure 6).

Figure 6. Station 5: packing and cooling

2. THEORETICAL FRAMEWORK

2.1. Ergonomic Evaluation Method

Ergonomic evaluation methods allow for the assessment and analysis of ergonomic risks in workplaces. These methods focus on the relationship between the worker and their work environment, aiming to identify factors that can lead to musculoskeletal injuries, fatigue, stress, discomfort, and other work-related health issues. This is achieved through direct observation of work postures, body movements, physical task requirements, worker-environment interactions, and other relevant factors. Subsequently, redesign options are proposed to mitigate the level of risk (Diego-Mas & Jose Antonio, n.d.).

2.2. Related Works

Researching works with some similarity to the ergonomic risk management project within Tortillería, a compilation of research and applications by the Ergonomists Society of Mexico, A.C was found, focusing on occupational ergonomics. Among its content is the "Analysis and Ergonomic Evaluation of Tortilla Cutting Activity in a Corn Products Factory" in the city of Tijuana, B.C. The objective of this study is to determine the risk level of developing musculoskeletal disorders within the corn products factory. For evaluation, ergonomic assessments like REBA and Suzanne Rodgers are implemented. For the REBA assessment, Ergonautas software is used, while Suzanne Rodgers' method employs an Excel-based evaluation.

The results obtained (Vol, 2022) using REBA indicate a high risk with a score of 10 for the left side and a very high risk with a score of 11 for the right side. This assessment suggests that immediate actions are necessary to reduce the high level of risk. On the other hand, the evaluation conducted using Suzanne Rodgers' method identifies body areas with a high level of muscular fatigue and high priority for modifications, such as shoulders and back. Neck, arms, and elbows are at a medium risk level, while the remaining areas are at a low risk level.

Finally, the team recommends machinery redesign to accommodate the measurements and reach of the majority of the male workforce in this case. Additionally, they propose establishing schedules for machinery use, indicating breaks for workers, and even considering alternating with other operators to reduce task repetitiveness and associated fatigue.

3. METHODOLOGY

The necessary steps were followed for the implementation of an ergonomic program.

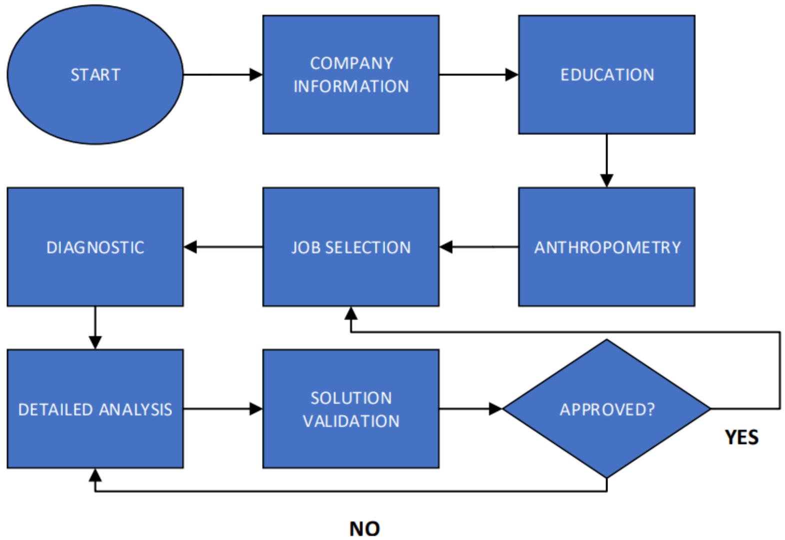

Figure 7. Diagram: ergonomic evaluation process

During the diagnostic phase, the OSHA (Occupational Safety and Health Administration, 2018) checklist was utilized. The conducted diagnosis revealed that all 5 workstations exhibit ergonomic risk factors related to posture, while the first and third workstations present risks associated with manual material handling.

Regarding the level of risk obtained for each workstation, the results are presented in Table 1:

Table 1. Risk level stations 1-5

No. De estación	Nivel de riesgo		
	Bajo	Medio	Alto
1			
2			
3			
4			
5			

3.1. Ergonomic Evaluation Procedures.

Table 2 outlines the methods employed to conduct the ergonomic evaluation for each workstation.

Table 2. Selection of ergonomic evaluation methods.

No. de estación	Operación	Tipo de evaluación	Método
1	Preparación de la masa	DTA, MMM y GME	Mac Tools y RULA
2	Boleado	DTA y GME	Art Tools
3	Prensado	DTA, MMM y GME	Art Tools y Mac Tools
4	Cocción	DTA y GME	Art Tools
5	Enfriado y empaque	DTA y GME	Art Tools

4. RESULTS

Stations 3, 4, and 5 were analyzed for two specific cases: the tallest and the smallest workers, with the intention of identifying the risk level for both scenarios. To determine the risk level, the worst-case scenario was considered, which is the evaluation indicating the highest risk level.

4.1. Ergonomic evaluation

4.1.1 Station 1: Dough Preparation

For the postural aspect (right side), RULA (McAtamney, 1993) was used, resulting in a score of 5, suggesting the need for further study and prompt modifications.

Regarding Manual Material Handling (MMM), utilizing MAC Tools (HSE (Health and Safety Executive), 2003), it is divided into two parts: the first involves lifting a bucket of water (17 kg), transporting it, and lifting it again. The first lift for transport yielded a score of 6, while the transportation scored 9, and the final lift to deposit the bucket scored 8. Although all three activities are of low-risk category, corrective actions are required based on the MAC scores.

The second part involves lifting and transporting a flour sack (44 kg). Like the bucket, this also involves two lifts and one transportation. The first lift for transport yielded a score of 18, transportation scored 21, and the final lift to deposit the flour yielded a score of 14. For the first and second flour sack lifts, scores of 18 and 14 respectively were obtained, warranting prompt corrective actions. The transportation of the flour sack obtained a score of 21, demanding immediate corrective actions.

4.1.2 Station 2: Dough Rounding

In this station, both arms were evaluated for the postural aspect using ART Tools (HSE (Health and Safety Executive), 2010), resulting in a score of 9.5 for both arms. This indicates a low risk level according to the method's scale, but with some factors that could be improved, such as repetition.

4.1.3 Station 3: Pressing

For both ends, both arms were evaluated for the postural aspect using ART Tools (HSE (Health and Safety Executive), 2010), resulting in a score of 6.5. This signifies a low risk level according to the method's scale, but with certain areas for improvement, such as repetition.

For MMM in this station, evaluated using MAC Tools (HSE (Health and Safety Executive), 2003), two types of actions were considered: lowering when picking up a tray from the rack where the dough rests, and transportation to the workstation. The first activity scored 8, and transportation scored 7. Both are considered lower-risk activities, but they require corrective actions.

4.1.4 Station 4: Cooking

Similarly, we evaluated both ends of the operators and both arms for the postural aspect using ART Tools (HSE (Health and Safety Executive), 2010). For the taller operator, the left arm scored 8.25, and the right arm scored 15.75. For the shorter operator, the left arm scored 9, and the right arm scored 16.5.

For both the taller and shorter operators, a low exposure level was obtained for the left side, while the right side had a high level of exposure. Therefore, immediate further investigation is required for Station 4.

4.1.5 Station 5: Cooling and Packaging

For Station 5, there are three tasks: arranging, gathering, and packaging. ART Tools (HSE (Health and Safety Executive), 2010) were used for evaluation, considering both ends and both the left and right arms.

The first activity, arranging the tortillas, resulted in scores of 14 for both arms of the taller operator, and scores of 13 for the left arm and 18 for the right arm of the shorter operator.

The gathering activity yielded scores of 8 for the left arm and 16 for the right arm of the taller operator, and scores of 9 for the left arm and 18 for the right arm of the shorter operator.

Lastly, the packaging activity for the taller operator resulted in scores of 15 for both arms, while the shorter operator obtained scores of 14 for both arms.

Consequently, all evaluations presented a medium exposure level, indicating that Station 5 has a medium risk level and requires further investigation.
Below is a table summarizing the results obtained, with "I" denote the left side and "D" denoting the right side.

Table 3. Results of the ergonomic evaluations

No. de estación	Evaluación		Puntuación final
1	RULA	D	5
	MAC Tools (cubeta)		5-12
	MAC Tools (costal)		13-21
2	ART Tools	I	9.5
		D	9.5
3	ART Tools (estatura alta)	I	6.5
		D	6.5
	ART Tools (estatura baja)	I	6.5
		D	6.5
	MAC Tools (charola)		5-12
4	ART Tools (estatura alta)	I	8.25
		D	15.75
	ART Tools (estatura baja)	I	9
		D	16.5
5	ART Tools (Acomodar-estatura alta)	I	14
		D	14
	ART Tools (Acomodar-estatura baja)	I	13
		D	18
	ART Tools (Juntar-estatura alta)	I	8
		D	16
	ART Tools (Juntar-estatura baja)	I	9
		D	18
	ART Tools (Empacar-estatura alta)	I	15
		D	15
	ART Tools (Empacar-estatura baja)	I	14
		D	14

4.2. Metabolic Energy Expenditure

The results of the application of the AMMA method (SEMAC, n.d.) are presented in Table 4.

Table 4. Results of the AMMA method.

No. de estación	Edad	CTF	GME	Método
Estación 1	30	6.33	3.24	CTF > GME
Estación 2	30	9.11	3.09	CTF > GME
Estación 3	40	5.94	3.1	CTF > GME
	50	5.69	3.1	CTF > GME
Estación 4	40	5.94	2.475	CTF > GME
	50	5.69	2.965	CTF > GME
Estación 5	40	5.94	3.02	CTF > GME
	50	5.69	3.02	CTF > GME

In all workstations, the total metabolic energy expenditure is lower than the physical work capacity, indicating that the work falls within the limits of the workers' physical capacity.

5. PROPOSED IMPROVEMENTS

5.1. Engineering Controls

- Anthropometric redesign of all workstations.
- Step stool for shorter individuals to reach the worktable.
- Footrest mats for all workstations, as operators remain standing throughout their shift.
- Relocate the sink, placing it at 4 meters or less from the dough preparation station.
- Move the sacks closer to the station, reducing the distance traveled to transport the load.
- Use of a shovel at the kneading station to prevent excessive back bending when moving the dough.
- Implementation of the 5S tool to maintain a clean and well-organized workspace.

5.2. Administrative Controls

- At Station 1, where a load equivalent to a 44 kg sack is handled, it's necessary for this sack to be manipulated by two individuals.
- Hire a second person for Station 4, so that between the two workers, they can flip the tortillas for proper cooking, thereby reducing repetitions by a single worker.
- Employ a second person for Station 5. One person would be responsible for receiving and distributing tortillas on the cooling table, while the second person would handle the packaging.

5.3. Personal Protective Equipment

Proper use of the following personal protective equipment to maintain personal hygiene and ensure a manufacturing process free from contaminants:

- Hairnet.
- Cap.
- Face mask.
- Apron.

6. EVALUATION OF IMPROVEMENTS

The evaluation of improvements was carried out through a simulation of the new workstations.

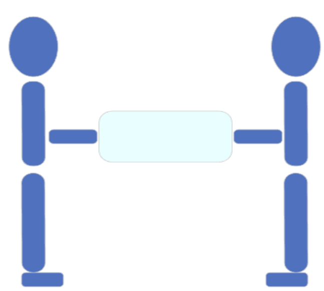

Figura 8a. Simulation station 1 MMM flour bag as a team

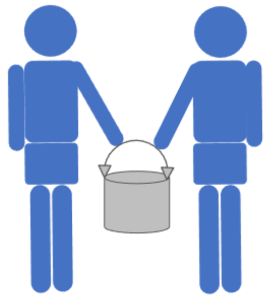

Figura 8b. Simulation station 1 MMM Bucket Loading as a team

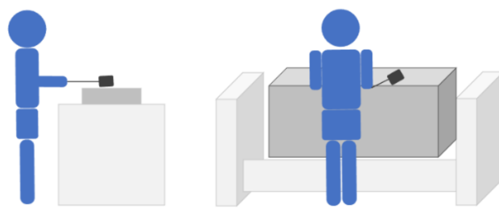

Figure 8c. Simulation station 1: kneading

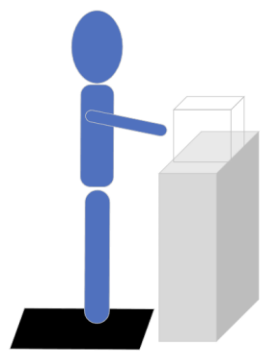

Figure 9. Simulation station 3: pressing

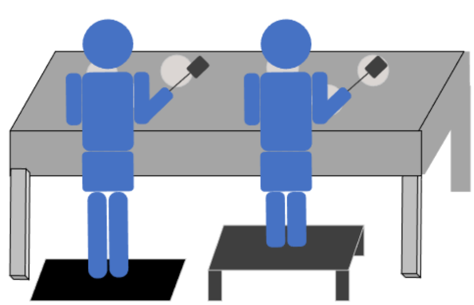

Figure 10a. Station 4 simulation: cooking

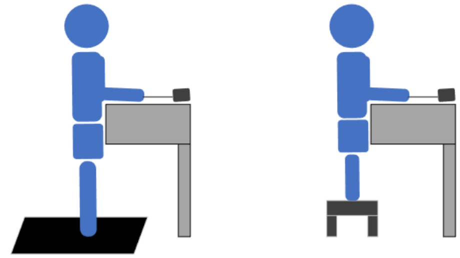

Figure 10b. Station 4 simulation: cooking

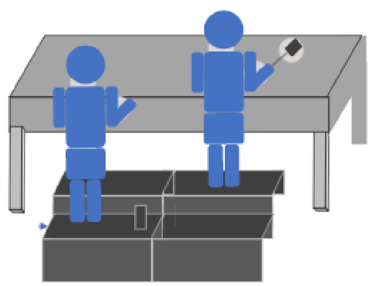

Figure 11. Simulation station 5: packing and cooling

The evaluations for each station were conducted once again, considering the proposed improvements (Table 5). A new method, RAPP Tools (HSE (Health and Safety Executive), 2016), was used.

7. DISCUSSIONS

This evaluation focused on the process of making homemade-style flour tortillas, which is divided into 5 subprocesses: dough preparation, rounding, ball flattening, cooking, and cooling and packaging. The assessment was carried out for ergonomic risk factors such as repetition, postures, and efforts. While improvements were proposed to achieve low risk levels in the workstations, there are still opportunities for further enhancement.

8. CONCLUSIONS

The implementation of the ergonomic program within Tortilleria allowed for the identification of risk factors present in each workstation involved in the flour tortilla-making process. This was accomplished through evaluations using various ergonomic methods, including postural assessments, manual material handling, and metabolic energy expenditure. This process facilitated the identification of workstations with higher risk levels. Thanks to the proposed engineering and administrative control measures, workstations were redesigned with elements that provided operators with more comfortable working conditions, ultimately reducing the level of risk they were exposed to. However, there are still opportunities for improvement in body parts that continue to have a moderate to high risk level.

Table 5. Results of ergonomic evaluations after improvements

No. de estación	Evaluación		Puntuación final
1	RULA	D	3
	MAC Tools (cubeta)		4
	MAC Tools (costal)		10
	RAPP Tools (charola)		4
4	ART Tools (estatura alta)	I	8.25
		D	9.75
	ART Tools (estatura baja)	I	8.25
		D	9.75
5	ART Tools (Acomodar-estatura alta)	I	7
		D	8
	ART Tools (Acomodar-estatura baja)	I	7
		D	8
	ART Tools (Juntar-estatura alta)	I	5
		D	9
	ART Tools (Juntar-estatura baja)	I	5
		D	9
	ART Tools (Empacar-estatura alta)	I	6
		D	7
	ART Tools (Empacar-estatura baja)	I	6
		D	7

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EVALUATION OF ENVIRONMENTAL CONDITIONS IN A MACHINE AND TOOL WORKSHOP.

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Resumen Este artículo presenta los resultados obtenidos del análisis de las condiciones ambientales en el área de trabajo de máquinas herramienta del Laboratorio de Mecánica de la Facultad de Ingeniería. El objetivo de este estudio fue evaluar y mejorar las condiciones ambientales, en términos de temperatura, iluminación y ruido, con el propósito de garantizar la seguridad, salud y bienestar de los usuarios, así como cumplir con los requisitos establecidos por las normas de seguridad correspondientes. Donald & Siu (2001) mencionan que, mediante la evaluación de las condiciones ambientales, se busca proporcionar un entorno de trabajo óptimo y prevenir posibles riesgos laborales. Para esto se dividió el taller y se tomaron lecturas en diferentes puntos, a diferentes horas del día: por la mañana, a medio día y por la noche, con la finalidad de tener datos representativos de las condiciones a que se encuentran expuestos los alumnos e instructores que hacen uso del espacio a diferentes horas del día. Finalmente, se presentan recomendaciones para mejorar las condiciones ambientales del área y prevenir problemas de salud en los usuarios.

Palabras clave: Riesgos laborales, Condiciones ambientales, Temperatura de trabajo, Ruido, Iluminación.

Relevancia para la ergonomía: La evaluación de las condiciones ambientales, mediante la obtención de lecturas de iluminación, temperatura y ruido, contribuye significativamente al bienestar ergonómico de las personas. Al caracterizar el área de trabajo y proponer mejoras, se busca proporcionar un entorno ideal para el desarrollo de las actividades, evitando incidentes de salud para los usuarios. Además, los resultados y la metodología utilizada en este estudio pueden servir como referencia para futuras investigaciones en otras áreas de laboratorios con condiciones similares, fomentando la aplicación de la ergonomía en el diseño y adaptación de espacios laborales.

Abstract: This article presents the results obtained from the analysis of environmental conditions in the work area of machine tools of the Mechanics Laboratory of the Faculty of Engineering. The objective of this study was to evaluate and improve environmental conditions, in terms of temperature, lighting and noise, in order to ensure the safety, health and well-being of users, as well as comply with the requirements established by the corresponding safety standards. Donald & Siu (2001) mention that, through the evaluation of environmental conditions, it seeks to provide an optimal work environment and prevent possible occupational risks. For this, the workshop was divided and readings were taken at different points, at different times of the day: in the morning, at noon and at night, in order to have representative data of the conditions to which students and instructors who make use of the space at different times of the day are exposed. Finally, recommendations are presented to improve the environmental conditions of the area and prevent health problems in users.

Keywords. Occupational hazards, Environmental conditions, Working temperature, Noise, Lighting.

Relevance to Ergonomics: The evaluation of environmental conditions, by obtaining lighting, temperature and noise readings, contributes significantly to the ergonomic well-being of people. By characterizing the work area and proposing improvements, it seeks to provide an ideal environment for the development of activities, avoiding health incidents for users. In addition, the results and methodology used in this study can serve as a reference for future research in other areas of laboratories with similar conditions, promoting the application of ergonomics in the design and adaptation of work spaces.

1. INTRODUCTION

In this article, the importance of environmental conditions in the wellbeing of the students and instructors operating different equipment installed in the machine tools workshop at the Mechanics Laboratory, is studied. The evaluation was conducted following different standards that apply to a machining workshop. The area was divided into zones and a series of noise, light, temperature and humidity readings were taken.

These evaluations were carried out considering the weather conditions that are prevalent in a desertic area such as the Mexicali, Baja California region, particularly during summer when temperatures can reach up to 50°C (122°F), in order to analyze if the working conditions at different times of the day are safe for the users. The readings were performed at 8:00 am (morning), 2:00 pm (midday), and at 8:00 pm (night), given that the work day for this area begins mostly at 8 in the morning and ends at 9:30 at night, and is used by different groups of students throughout the day. With the data obtained, some recommendations were made to improve the environmental conditions of these facilities.

In order to understand the importance of this study, it is convenient to highlight the current conditions in the machine tool workshop. The area contains several equipment for performing metal-mechanical work, of which 8 conventional lathes stand out, which are usually the most used at the same time. The area does not have an air conditioning or gas extraction system, so for cooling and air circulation, there is a portable evaporative cooler and the metal curtain located at the south wall of the work area is opened. For this reason, it is difficult to maintain stable conditions of lighting, noise, temperature and humidity and ensure the well-being of students and instructors working in the area. It is also of interest to note that the work sessions usually last around 3 hours and that the workshop is used at the limit of its capacity (8 lathes at a time) most of the time. It is due to these circumstances that it was decided to improve the environmental conditions of the area.

2. OBJECTIVES

1. Evaluate the environmental working conditions, including temperature, lighting and noise, in the machining workshop at the Mechanics Laboratory.

2. Identify and propose solutions that improve the work area, complying with the requirements established by the applicable standards (NOM'S).

3. METHODOLOGY

1. An inspection of the facilities was carried out and information was collected about the working hours environmental conditions inside the workshop.

2. A matrix of points was prepared that covered different areas of the working space to measure lighting, temperature and noise at different times.

3. Data visualization techniques were used to analyze and graphically represent the behavior of each zone based on the collected values.

4. Based on the results obtained and the applicable standards, concrete actions and recommendations were proposed to improve the environmental conditions of the study area.

4. SCOPE

The study focused on the working conditions for students and instructors operators in the machine and tools area of the Mechanical Engineering Laboratory of the Autonomous University of Baja California (Figure 1). The requirements of the following standards were taken as reference: NOM-011-STPS-2001 (noise), NOM-015-STPS-1994 (temperature) and NOM-025-STPS-2008 (lighting).

Figure 1 Different angles of the area of the machine tool laboratory, in which the analysis is carried out.

5. RESULTS

It was observed that at certain times of the day and in different areas of the workshop, the measured values exceeded the limits established by the reference standards. Specifically, problems related to elevated noise levels, inadequate temperatures, and poor lighting were found. These results highlight the need to implement corrective measures to ensure a safe and healthy work environment.

The values obtained showed variations associated with the areas of the area and time in which they were obtained. In some cases, the data collected even improved from one area to another at the same time. For example, in the case of lighting, the readings taken near the windows were higher than those near the inner wall and were substantially higher in the morning and afternoon than the readings taken at night.

5.1 DESCRIPTION OF THE RESULTS

Figure 2 shows the division into zones of the area of the workshop in which it was worked, as well as its surroundings. It should be noted that the south wall faces the street, while the other three walls adjoin areas within the Mechanics Laboratory. This location highlights the reason for certain variations in the measurements obtained throughout the working day.

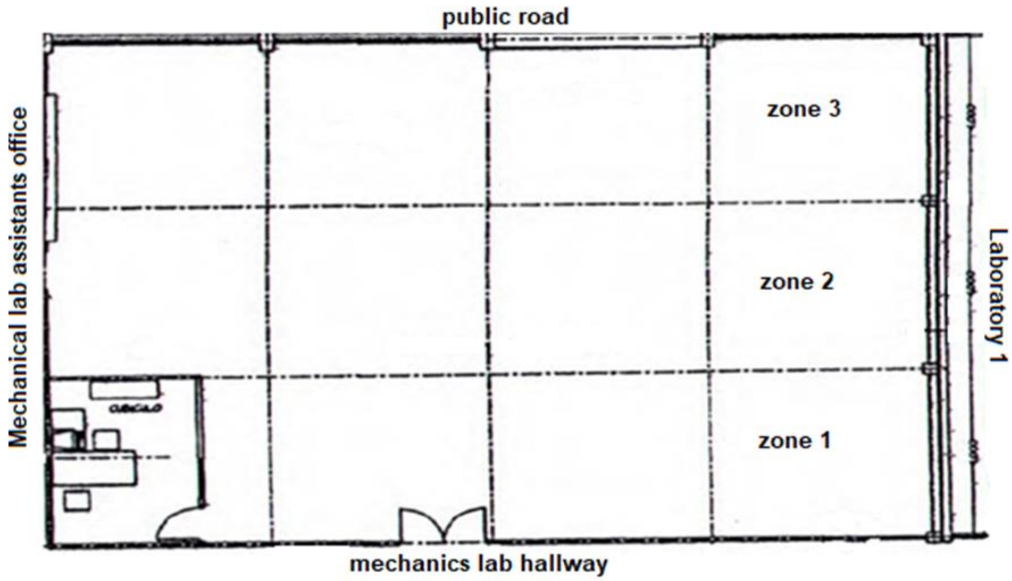

Figure 2 Plan of the machine tool workshop, with its boundaries and divisions by zones.

Once the zones for the measurements were established, the workshop readings were taken. A total of nine readings were performed at three different times. With the values collected, the averages obtained from all the readings were calculated, which are described below. Table 1 shows the averages of the 8 am readings, Table 2 presents the averages of 2 pm and Table 3 the averages of the 8:30 pm readings.

Table 1 Average data obtained in the area at 8 am, the data are in the following units: noise (dB), Light (lux), temperature (°C) and humidity (%).

Average				
Zone	Noise	Light	Temperature	Humidity
1	57	281	29	45 %
2	56	514	30	42 %
3	56	629	29	42 %

Table 2 Average data obtained in the area at 2 pm, the data are in the following units: noise (dB), Light (lux), temperature (°C) and humidity (%).

Average				
Zone	Noise	Light	Temperature	Humidity
1	59	316	30	40%
2	60	521	32	38%
3	60	735	32	37%

Table 3 Average data obtained in the area at 8:30 pm, the data are in the following units: noise (dB), Light (lux), temperature (°C) and humidity (%).

Average				
Zone	Noise	Light	Temperature	Humidity
1	53	170	29	31%
2	53	258	30	30%
3	53	189	30	31%

The tables above show the averages obtained from all readings at different times. Generally speaking, it can be observed that noise and temperature levels remain more or less stable throughout the day. However, humidity and lighting have greater variations, probably due to the time of day and the position in which they were measured; for example, the proximity to windows, metal curtains or the conditions of the spaces adjacent to the Laboratory (refrigerated areas).

When reviewing each indicator in more detail, it can be seen that the maximum values obtained for the variables that were analyzed occurred in the readings taken at 2 in the afternoon which were: Noise = 60 dB (Figure 3), Light = 1287 Lux (Figure 4) and Temperature = 33 °C (Figure 5). However, for the Humidity variable the highest measurement, 45% (Figure 6), was obtained in the readings taken at 8 am.

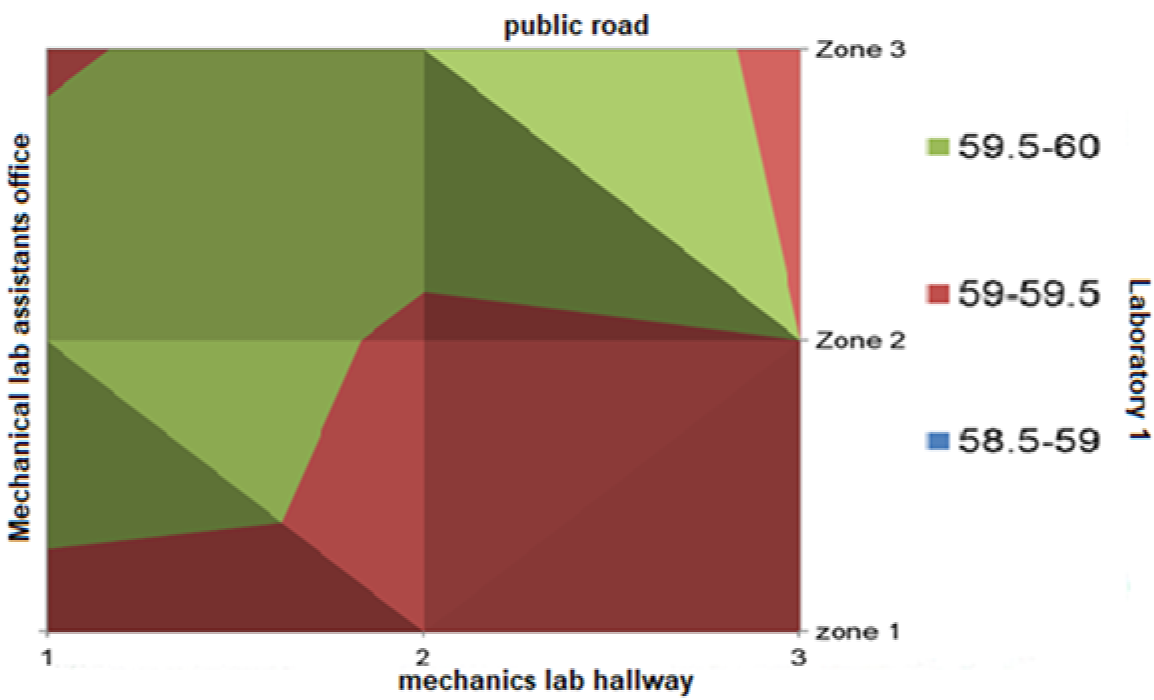

Figure 3 The behavior of the Noise in the workshop area is shown, and the maximum values obtained are presented

Analyzing the graph in Figure 3, it can be seen that the máximum noise level in the área (60dB), which includes the noise generated when all the equipment of the machine tool workshop (compressor, milling machine, conventional lathes, etc.) are in operation, is below the sound level criterion established by NOM-011-STPS-2001, which corresponds to 90 dB (A) for an 8-hour workday.

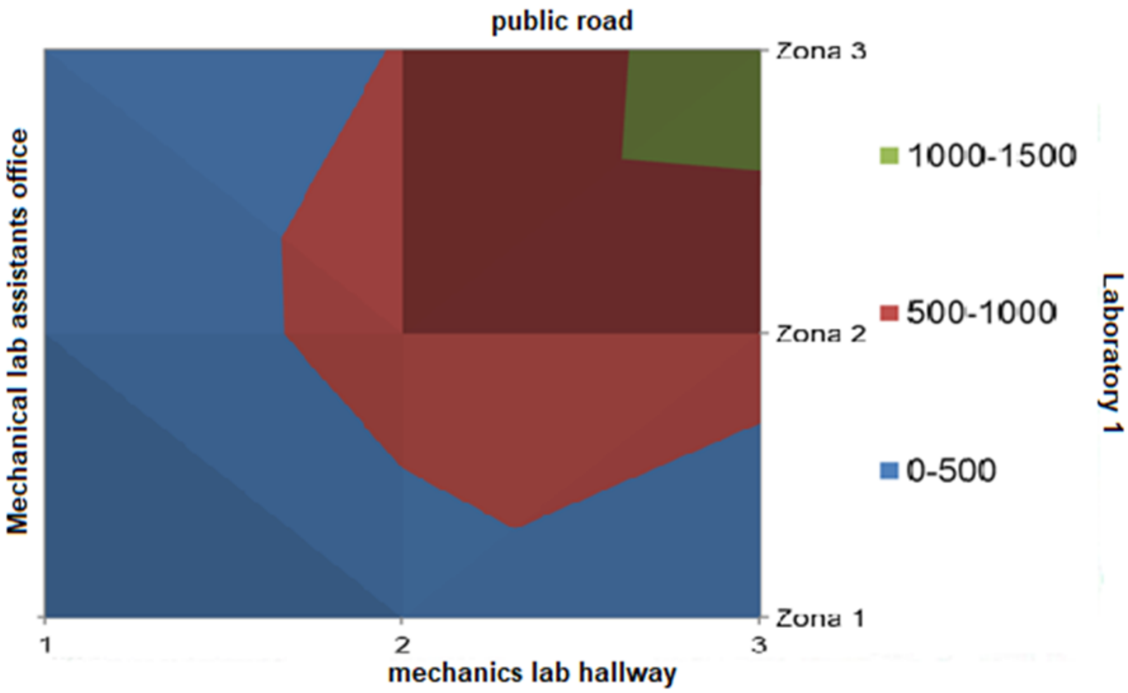

Figure 4 The behavior of the Lighting in the workshop area is shown, and the maximum values obtained are presented

As we can see in Figure 4, the behavior of the lighting varies depending on the hours in which the readings were taken. Similarly, the influence of the design of the workspace (infrastructure) should be considered, in this case the windows for better lighting. This detail is highlighted because, of all the readings taken, the lighting was the value that varied the most in relation to the point where it was obtained and the highest shot was the one that was read next to the windows of the area, both in the morning and in the afternoon. Otherwise it occurred in the readings of the areas taken at night. The values obtained in general for Zone 1 are below the optimal value recommended by the standard for precision workshops which is 500 Lux (NOM-025-STPS-2008), regardless of the time of day, while for Zones 2 and 3, this value is not met only at night. In conclusion, it is required to improve the artificial lighting of the workshop.

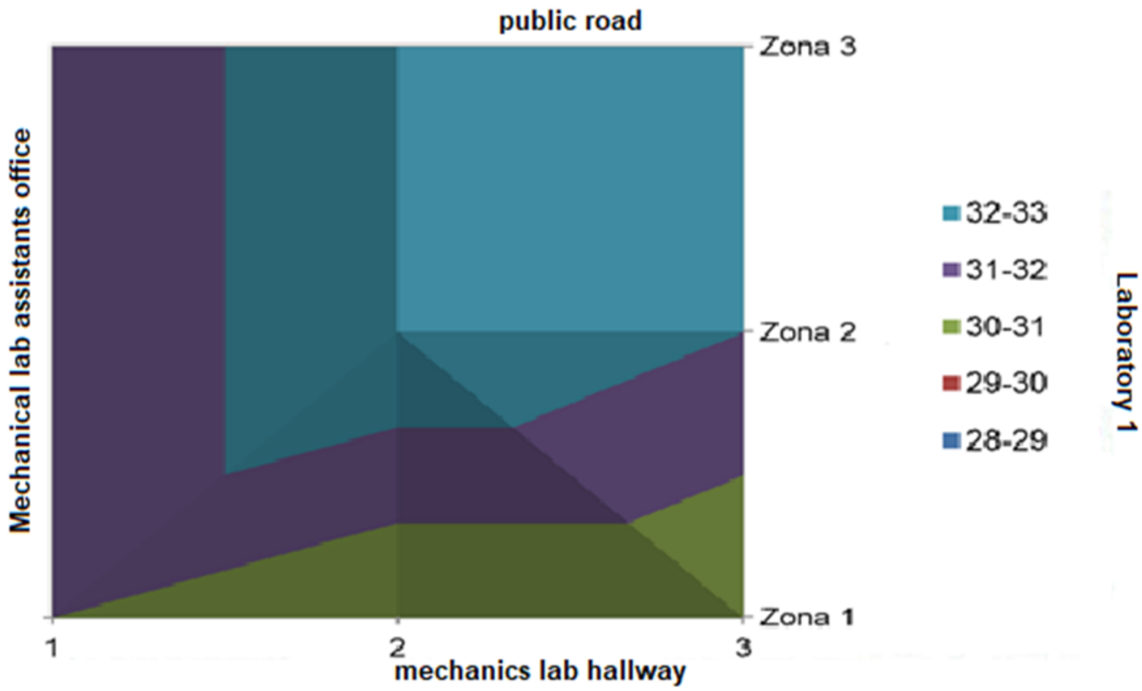

Figure 5 The behavior of the Temperature in the workshop area is shown, and the maximum values obtained are presented.

The graph in Figure 5 shows the behavior of the temperature in the analyzed area, where the highest values obtained were used. These values were collected at a time when the outside temperature was higher, which turned out to be at 2 in the afternoon. This condition directly affects the internal temperature of the area since the evaporative air conditioning system does not work well in these conditions, and the internal temperature cannot be reduced as much as at other times of the day. To make the comparison against the requirements of NOM-015-STPS-1994, the following characteristics were considered: the Work Regime is considered continuous, since students must work uninterruptedly in order to achieve the expected progress during the class sesión. Similarly, the work is classified as moderate, since it requires maintaining the posture for periods of time greater than 15 continuous minutes. Under these conditions, the maximum temperature recommended by the specification is 26.7°C, which is lower than the minimums obtained in the workspace assessment.

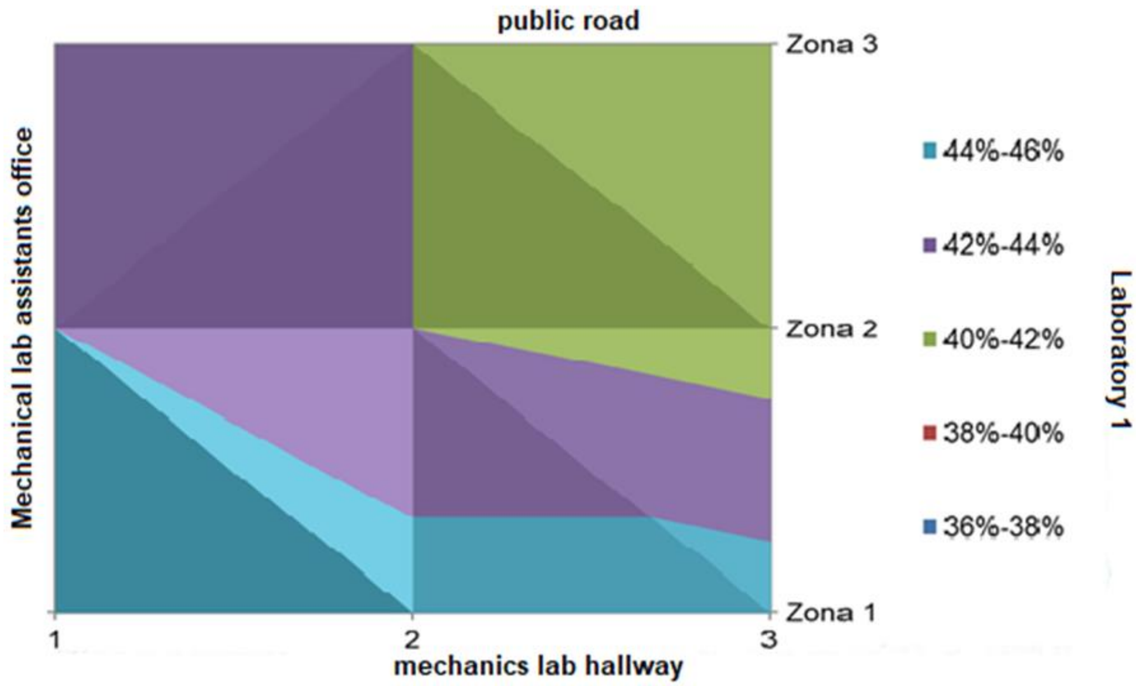

Figure 6 The behavior of the Humidity in the workshop area is shown, and the maximum values obtained are presented.

As an extra data, a graph of the behavior of humidity is attached (Figure 6), since this variable affects the thermal sensation perceived by users and is associated with their well-being. For example, the maximum humidity value was obtained in the morning data collection, giving a reading of 45% humidity in Zone 1, at that time the ambient temperature was at 29°C and the apparent temperature index was increased to 30.3°C. At the same time, in Zone 2 the temperature was 30°C and humidity was 42%, which produced an apparent temperature index of 31.2°C. The greatest temperature increase occurred in Zone 2 at 2 pm, where a temperature of 32 ° C, a humidity of 38% and an index of temperature of 33.3 ° C were obtained. This consideration is important since, due to the type of device that is currently used in the area to cool / circulate the air (cooler), the percentage of humidity in the environment increases and affects the perceived thermal sensation. Due to this situation, it is recommended to change to air conditioning systems so that the air injected into the work area does not contain moisture, coupled with this is the importance of insulating so that there are not too many air leaks from the outside.

6. CONCLUSIONS

This research made it possible to determine the environmental conditions under which the work was carried out in the machine tool workshop. Based on these findings, some concrete options were proposed to improve the values obtained in each area of the workshop, seeking to ensure compliance with labor regulations and preventing users from being exposed to adverse environmental conditions. Some of the recommendations that were given from the analysis of the data obtained for each of the factors analyzed are:

Noise: It is recommended to relocate an air compressor outside the area to reduce noise, in addition to changing to an evaporative air conditioning system (cooler) for a quieter one, as well as taking care of the edge of the tools working with the optimal cutting conditions for each tool.

Lighting: in this case it is recommended to change the mercury lamps that are currently had by LED ones or by lamp that have greater intensity, which cover the top of each machine tool, as well as lower the lamps from the original height for better lighting, since it is an area where you work with precision to perform some machining and taking measurements, ensuring with this a good lighting and elimination of shadows when carrying out the work.

Temperature: This variable is the most problematic throughout the working days, since the climate of the region is warm added to the heat generated by the machines and that which is generated when machining some metal, causes very high temperatures. For this part it is recommended the installation of air conditioning equipment with the ability to maintain the area in the comfort temperature, polarized or reduction of windows, placement of ceiling to reduce the height and isolate the ceiling area and the metal curtain, to reduce the temperature inside the work area.

These recommendations are made to improve environmental conditions in the analyzed area support the importance of maintaining an optimal work environment for the development of work and educational activities.

5. REFERENCES

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NOM-011-STPS-2001, Safety and hygiene conditions in workplaces where noise is generated.

NOM-015-STPS-1994, High or low thermal conditions - Safety and hygiene conditions.

NOM-025-STPS-2008, Lighting conditions in workplaces.

ERGONOMIC REDESIGN OF A WORKSTATION TO REDUCE MUSCULOSKELETAL INJURIES IN ICE BAGGING OPERATORS

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Resumen. En este estudio se presenta una propuesta para rediseñar ergonómicamente un puesto de trabajo para reducir lesiones musculoesqueléticas en operarios que trabajan en embolsado de cubos de hielo. Se determinaron 5 tareas que integran el puesto de trabajo "embolsador de cubos de hielo", a 4 de ellas se les denominan tareas críticas y una tarea despreciable. A las tareas críticas se aplicó el método de evaluación ergonómica RULA (Rapid Upper Limb Assessment) para determinar el nivel de riesgo de esas tareas. Se aplicó el método mediante cálculo manual y posteriormente se utilizó un software con la finalidad de comparar los resultados obtenidos. Se aplicó la metodología de diseño QFD (Quality function deployment) para determinar las variables más importantes con las cuales se presentaron bocetos con propuestas para el puesto de trabajo en el diseño conceptual. Se eligió la mejor propuesta y se simuló el nuevo puesto de trabajo mediante un software de manufactura, posteriormente se realizó la evaluación ergonómica en un software con el propósito de determinar el grado de mejora del puesto de trabajo al que se le aplicaron criterios ergonómicos. Los resultados que se obtuvieron mostraron que la propuesta de rediseño del puesto de trabajo contribuyó a reducir en un 57% las lesiones musculoesqueléticas.

Palabras clave: lesiones musculoesqueléticas, RULA, rediseño, puesto de trabajo, ergonomía.

Relevancia para la Ergonomía. Esta investigación está dirigida a las empresas dedicadas a la venta de hielo que tengan puestos de trabajo de *embolsado de cubos de hielo* similares. Este estudio demuestra que aplicando metodologías de diseño y softwares de diseño y simulación es posible eficientizar la forma de trabajo e invertir menos tiempo. Con la simulación es posible proponer y analizar varias soluciones antes de proceder a implementar la propuesta. También se comprueba que las herramientas computacionales y de diseño son útiles para resolver problemas ergonómicos de puestos de trabajo de empresas.

Abstract. This study presents a proposal to ergonomically redesign a workstation to reduce musculoskeletal injuries in operators who work in ice cube bagging. 5 tasks were identified that make up the "ice cube bagger" job, 4 of them are called critical tasks and a negligible task. The ergonomic evaluation method RULA (Rapid Upper Limb Assessment) was applied to critical tasks to determine the level of risk of these tasks. The method was applied by manual calculation and then a software was used to compare the results obtained. The QFD (Quality function deployment) design methodology was applied to determine the most important variables with which sketches were presented with proposals for the workstation in the conceptual design. The best proposal was chosen, and the new workstation was simulated using manufacturing software, then the ergonomic evaluation was carried out to determine the degree of improvement of the workstation to which ergonomic criteria were applied. The results obtained showed that of workstation redesign proposal contributed to a 57% reduction in musculoskeletal injuries.

Keywords. musculoskeletal injuries, RULA, redesign, workstation, ergonomics.

Relevance to Ergonomics: This research is aimed at companies that sell ice that have similar ice cube bagging jobs. This study demonstrates that by applying design methodologies and design and simulation software it is possible to streamline the way of working and spend less time. With the simulation it is possible to propose and analyze several solutions before proceeding to implement the proposal. It is also verified that the computational and design tools are useful to solve ergonomic problems of workstation of companies.

1. INTRODUCTION

Currently there are many work environments that do not have adequate conditions for the worker to perform their tasks without risks that affect their health, working in an ergonomically inadequate environment is the main cause of illnesses at work, which affects the quality of life and has become an important social and economic cost. Occupational diseases affect the health of the operator both physically and mentally and therefore affect the productivity of the companies. (Asencio, S., Bastante, M.J., Diego, J.A., 2012).

According to the Ministry of Labor and Social Welfare (STPS) in the book Health at Work in Mexico: Advances, challenges, and challenges, (2017), workers spend a third of their time in work activities which require a good state of health. health to be developed and therefore be economically stable, for this reason it is extremely important that work centers are in adequate conditions since this improves opportunities for both professional and personal growth, protection, and prevention of physical and psychological risk factors. In addition to that they can improve interpersonal relationships, self-esteem and produce positive effects on health.

Analyzing the case of Mexico, in 2016, the Mexican Institute of Social Security (IMSS) had 12,622 cases of registered occupational diseases, with 37.1% of these musculoskeletal diseases, that is, 4,683 cases, which places this type of disease as one of the most frequent, being found in 4 out of 10 cases (Security and Health at Work in Mexico: Advances, challenges and challenges, 2017), (IMSS, 2020)

Musculoskeletal disorders are inflammatory or degenerative disorders that occur in various parts of the body such as the upper and lower limbs and occur due to repetitive movements or forced postures, (Stellman, 1999), (López, et al 2020).

The Official Mexican Standard, NOM-036-1-STPS-2018 mentions, in the section on the obligations of the employer that his workplace must have the study of the jobs with an analysis of existing risk factors, as well as an action plan within it which covers the elements with which it is in direct contact to perform the daily tasks of the worker in addition to training the worker on how to prevent risks and work safely, in this way there will be guidelines to prevent the various factors that will be found in the workplace, both technical and administrative guidelines. The health of workers is an essential requirement for family income, productivity, and economic development, (OMS, 2023). Ergonomics is the science that studies man and his relationship with machines and the environment, designs workstations to adapt them to the worker and avoid injuries and accidents in their daily activities, (Obregón, 2016), (Corlett N., Lueder R., 2012).

1.1 Background.

A company dedicated to the sale of ice located in Mexico City, Mexico, sells ice in three forms: flake ice (commonly used to cool foods such as fish and shellfish), block ice (used for shaved ice), and shaved ice, in tubes (used to cool drinks), so named because the ice is formed inside vertical hollow tubes, later, the ice is detached and the tubes are cut to the required length, immediately the ice is discharged into bags with capacities of 5kg and 15kg. Most of the machines are automated to deliver the already bagged product, however, as in the case of this company, the bagging process is manual. The bags with ice in tubes are distributed to convenience stores and supermarkets, among others.

The machine that produces and unloads the ice is located in the ice cube bagging department, an operator has to wait for this unloading with the 5 kg or 15 kg presentation bag, the operator loads the bag throughout the unloading until this ends, and once the product is inside, the bag is moved to the next area, where another operator receives the bag and is in charge of closing it with the help of a machine that places a steel ring around it, once the bag is closed, it is placed on a mobile platform which is responsible for moving the product to the cold area where it will be ready to be distributed.

The problem, the reason for this study, is that the operator must hold the bag during the entire time that the ice unloading lasts, the machine automatically unloads every certain interval of time without there being any switch that the operator could activate to stop the unloading, the operators, not being able to support the weight of the bag, place it on the ground as a support point, however, there is ice loss, which the staff of this department estimates at 25%. Operators are constantly absent from work due to injuries, and most of them are dissatisfied with working in the bagging department because it is arduous, repetitive work, and they generally end their workdays with lower back and shoulder discomfort.

This paper proposes a conceptual redesign of the workstation with ergonomic applications, to reduce musculoskeletal injuries and improve the conditions of operators working in the ice bagging department.

1.2 Description of the tasks of workstation.

In the ice cube bagging process, 5 tasks were determined, which were analyzed separately to determine in which of these there could be some type of injury, these tasks were divided into two types: negligible task and critical task. A negligible task is one that does not cause risk of injury to the operator, while in the critical task activities that could cause some type of injury or discomfort to the worker were considered.

Task 1. Placing the bag.

The process begins when an operator is standing in front of the ice cube machine and must place a plastic bag in a hopper that discharges the required number of ice cubes, Figure 1 illustrates it. Placing this bag is considered a negligible activity, it does not carry any risk because the weight of the bag is practically 0 Kg. There is no probability of risk at this task.

Figure 1. Placement of the bag. Source: Courtesy of the company.

Task 2. Filling the bag.

The operator waits to stand, in front of the hopper, until the bag is filled. The activity is considered critical because the operator constantly leans over to rest the bag on the floor so as not to load it during the entire ice discharge, which favors an injury to the lower back of the body. This task is shown in Figure 2.

Figure 2. Filling the bag with a support point.
Source: Courtesy of the company.

Task 3. Placement of the bag in its closing area.

Once the bag is full, it is loaded and placed on a table where there is another operator (this activity can be carried out by the same operator, but normally, due to the high production, two operators are considered) who is in charge of closing the bag, the movement of moving the bag from the unloading area to the table surface is considered critical since the bag is loaded with a position that could be considered inappropriate. Figure 3 illustrates the placement of the bag for closure.

Figure 3. Placement of the bag in its closure area.
Source: Courtesy of the company.

Task 4. Closing the bag.

Figure 4 shows the bag closing sequence performed in 3 steps. First the bag is placed in the center. Second, the bag is turned from the top to close it, third, the area with the smallest surface of the bag is placed in a machine that staples it with an aluminum ring at the press of a button, with this action the product does not come out. This task is considered critical.

Figure 4. Closing sequence of the bag. Source: Courtesy of the company.

Task 5. Placement of the bag.

The operator loads the bag and places it on a mobile platform. This stage is considered critical because the operator is in a position that could cause a lumbar injury due to tilting. Subsequently, the operator transports the platform to a cold room in which the bags are kept until they are distributed to the points of sale. Figure 5 shows the bag in the cold room.

Figure 5. Transfer of the bag to the cold room.
Source: Courtesy of the company.

The results obtained are indicated in Table 1, 4 critical task and one negligible were determined.

Table 1. Results of the tasks in the ice bagging process.

Tarea	Description	Results
1	Placing the bag.	Negligible
2	Filling the bag.	Critical
3	Placement of the bag in its closing area.	Critical

4.	Closing the bag.	Critical
5.	Placement of the bag.	Critical

Therefore, the tasks that were classified as critical were developed in the RULA method, (Rapid Upper Limb Assessment); this method evaluates the exposure of workers to risk factors that can cause musculoskeletal injuries that affect their health. (Ascencio, Bastante and Diego, 2012).

2. OBJECTIVE

Redesign an ice cube bagging workstation applying ergonomic aspects to reduce musculoskeletal injuries through the RULA ergonomic evaluation method and design and simulation software.

3. METHODOLOGY

3 stages were applied in the development of this research.

Stage 1. Application of the RULA ergonomic evaluation method.

The RULA ergonomic evaluation method was applied to the "critical tasks" of the job by manual calculation to determine the level of risk of the tasks and the action to follow; Later, these results were compared with others obtained in a manufacturing software that has the RULA ergonomic evaluation module to compare the similarity.

Stage 2. Conceptual design.

The QFD (Quality function deployment) design methodology was applied to determine the most important variables of the activity and with the results obtained, sketches were drawn to redesign the workstation and the best proposal was chosen.

Stage 3. Redesign of the workplace.

With the chosen proposal, the new workstation was simulated in manufacturing software, and the RULA ergonomic evaluation method was applied to critical tasks. Subsequently, a comparison of the results obtained before and after having applied ergonomic aspects was made to determine the degree of improvement.

4. RESULTS

4.1 Stage 1. Application of the RULA ergonomic evaluation method.

4.1.1 Evaluation of critical tasks by manual calculation.

To determine the risk level, the Group A score tables were applied: upper extremities such as arms, forearms, and wrists. Group B: lower extremities such as trunk, neck, and legs.

To apply the tables of this method, the angles of inclination of the operator's body were measured using drawing software. With the final score obtained for each task, Table 2 was consulted to know the level that corresponded to it and the action to follow.

Table 2. Action levels according to the final score obtained. Source: Ascencio, Diego and Mas, 2012.

Final score	Level	Action
1 o 2	1	The posture is acceptable.
3 o 4	2	Task changes may be required; it is convenient to deepen the study.
5 o 6	3	Task redesign is required.
7	4	Urgent changes to the task are required.

Table 3. Results of the level of risk and action obtained from the critical tasks, applying information from Table 2.

Task	Description	Final score	Level	Action
2	Filling the bag.	7	4	Urgent changes to the task are required.
3	Placement of the bag in its closing area.	7	4	Urgent changes to the task are required.
4	Closing the bag.	6	3	Task redesign is required.
5	Placement of the bag.	7	4	Urgent changes to the task are required.

4.1.2 Evaluation of critical tasks in simulation software.

The workstation that includes the machine that unloads the ice was simulated; the tables on which the bags are placed; the machine that closes the bags; the mobile platform where the bags are placed after closing them; the operator and the ice bag, when it is open and once it has been closed; the floor was included. Information is entered with the angles of the operator's body, his movements, and a load of 5 kg. A simulation was performed for each critical task where 4 different views are shown.

Task 2. Filling the bag.

The simulation of task 2 can be seen in Figure 6. The result of the method is shown in Figure 7, where a final score of 7 was obtained, according to Table 2, corresponding to action level 4, that is, an urgent change is required in this task.

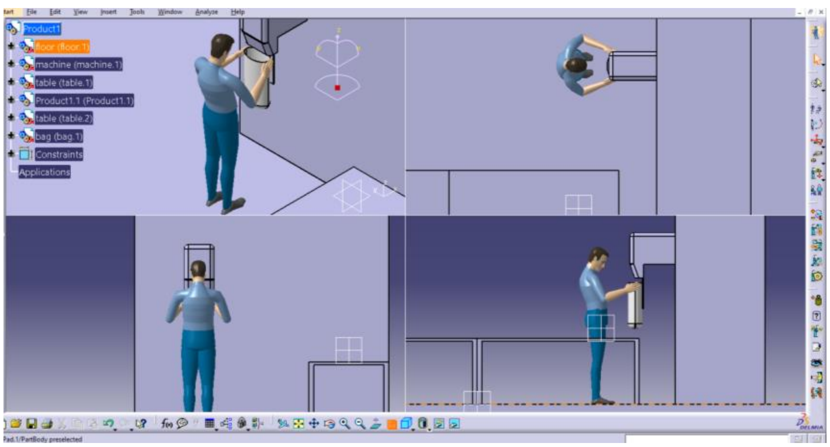

Figure 6. Simulation of filling the bag.

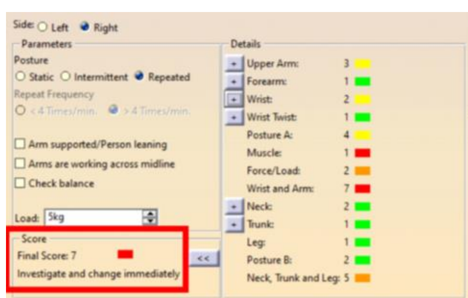

Figure 7. Results of the application of the RULA method for task 2.

Task 3. Placement of the bag in its closing area.

The simulation was carried out where the operator places the bag in the area where a machine will proceed to close it, (Figure 8).

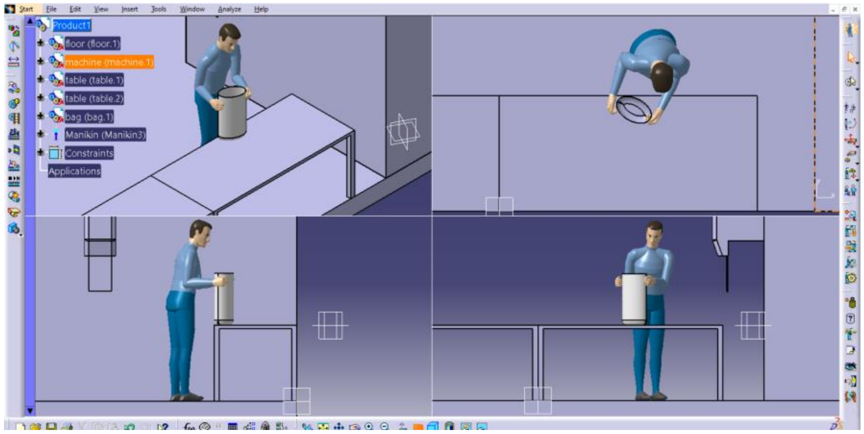

Figure 8. Simulation of placing the bag in the area where it will be closed.
The results of the method can be seen in Figure 9. This activity has a final score of 7, according to Table 2, the level is 4, which means that an urgent change is required in this task.

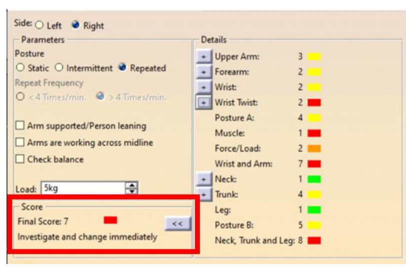

Figure 9. Results of the application of the RULA method for task 3.

Task 4. Closing the bag.

The work environment was simulated, the machine that closes the bag is at the end of the table where the bags are placed, the scene is shown in Figure 10. The result of the method is indicated in Figure 11. The final score is 7, according to Table 2, the level is 4: an urgent change in the task is required.

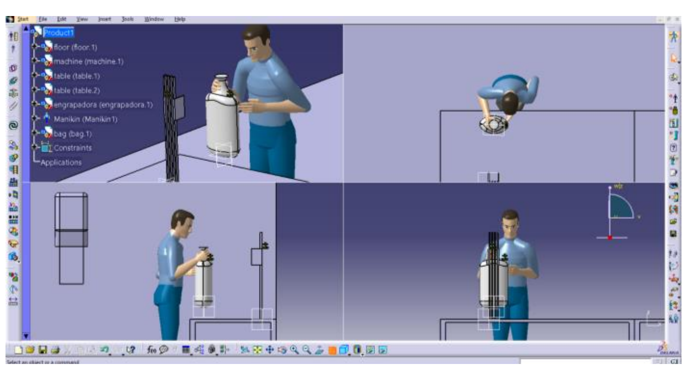

Figure 10. Simulation of the closure of the bag.

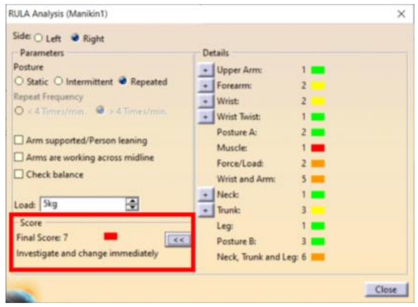

Figure 11. Results of the application of the RULA method for task 4.

Task 5. Place the bag.

Figure 12 shows the work environment, the operator places the closed bag on the mobile platform. Subsequently, the platform is taken to the cold zone.

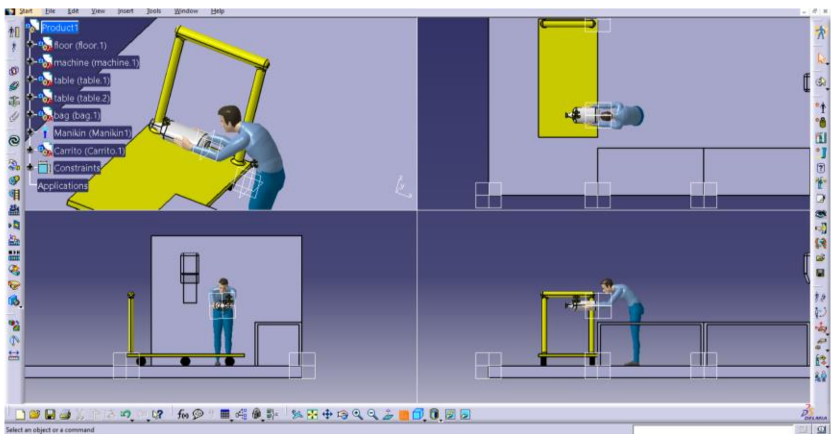

Figure 12. Simulation of the placement of the closed bag on the mobile platform.

The result of the method is indicated in Figure 13. The final score is 7, according to Table 2, the level is 4: an urgent change in the task is required.

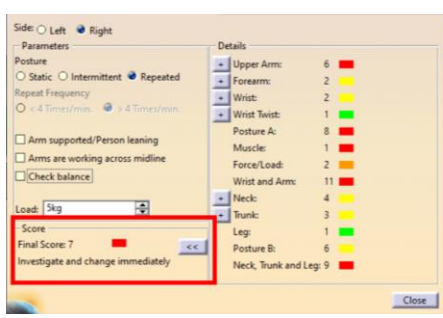

Figure 13. Results of the application of the RULA method for task 5.

The results obtained in the application of the RULA method, with manual calculation and with software, are shown in Table 4. The application of the RULA ergonomic evaluation method was implemented correctly, this is observed when comparing the results of manual calculation with the results obtained in the software, in task 4 there was a minimal difference, however, this was due to the greater precision of the software; the analysis of the data reflects that the 4 critical task must have an immediate change so that no injury occurs to the operators due to the poor design of this workstation.

Table 4. Results of the critical tasks obtained with manual calculation and with software.

Task	Description	Final score, manual calculation	Final score software	Observations
2	Filling the bag.	7	7	
3	Placement of the bag in its closing area.	7	7	
4	Closing the bag.	6	7	The difference is minimal and is due to higher precision of the software.
5	Placement of the bag	7	7	

4.2 Stage 2. Conceptual design.

To determine the most important variables to redesign the job, the QFD (Quality function deployment) design methodology was applied. In this methodology, the operator describes his demands, which are transformed into a quality design, (Izar, 2017). An operator who works in the ice cube bagging area comments on the reasons why he believes that there is always a loss of product when bagging.

"The ice bags are very heavy, so I get tired after a while, and besides, there are many hours of work in the same place with little rest between downloads and with the cold they end up numbing my hands, besides that the machine cannot be controlled the speed and there is not a place to put the weight of the bag".

From what the user comments, 8 causes that are affecting his work were identified and listed: 1 The bagged product is heavy. 2 The task is repetitive. 3 Static position. 4 Insufficient breaks. 5 Numbness of the hands. 6 long days. 7 The speed of ice discharges. 8 Work without support points.

These 8 causes that were identified must be improved so that the operator works in a comfortable way that does not cause any muscular discomfort. The information obtained with the application of the design methodology allowed to propose several sketches to improve the workplace.

The results of the QFD methodology provide the following requirements: A product must be designed that includes a base to support the weight of the bag; the product must have a suitable height so as not to cause bad posture; that is mobile to move the bags, in addition to having adequate protection for the environment in which the operator works.

4.2.1. Design proposals.

To develop the conceptual design, the criteria to avoid forced postures, overloads and repetitive movements were applied, the ideas were drawn in 4 designs (Melon, 2010). Figure 14 shows the evolution of the designs.

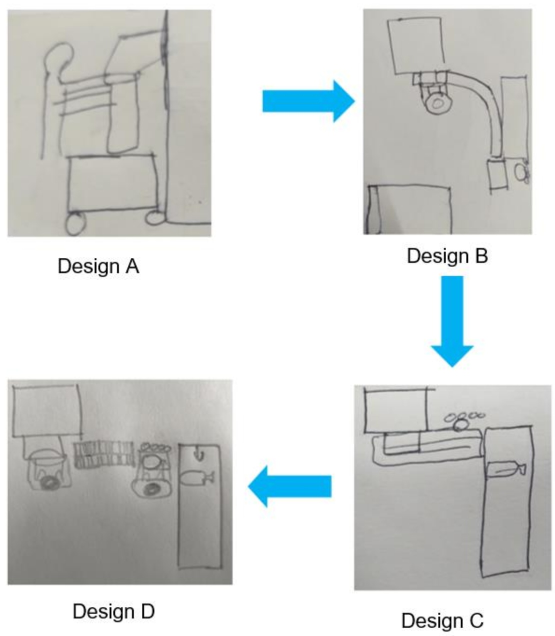

Figure 14. Design changes.

Design A. This was the initial design with which it was proposed to improve the operator's posture, without involving other aspects of the process, and as a result, the height of the machine was adjusted so that the operator did not have to lean over.

Design B. In this design, criteria of the RULA method were considered, in which load transportation problems were observed, a device that is easy to move and that would be displaced, for which there will be a support that moves on a rail, as can be seen, also, that the rail had a radio to get to the next task.

Design C. In this proposal, the design criteria were considered where a tool was needed to help the worker avoid having to transport himself, for which the idea of improvement that was implemented in designs A and B was to add a conveyor belt, however, the idea of the rail is modified at this point by making a change in the work area since, as can be seen, the rail would only go straight to place the bag on the automatic band.

Design D. All the criteria of designs A, B and C were considered, it began with a support that stopped the weight and was height adjustable, thus adjusting to the measurements of any operator. For design B, the rail was discarded and replaced by a roller support on which the product bag was placed.

It was proposed that the support be inclined, since the bag would be placed before being closed and thus avoid the product was spilled, in addition it was also proposed that the support be height-adjustable, later it reaches another support that is equally height-adjustable, where the bag will be closed and later placed on the conveyor belt for the final product to be taken to the cold room. It is important to mention that movement reduction criteria were handled and the operators and devices to be implemented are redistributed.

In addition, in this proposal unnecessary distances were shortened to reduce efforts during transport, and that it is in line avoids turning in the workers' body which could also generate some type of injury. The areas and devices were also changed, the process to reduce repetitive movements was also considered, for which this proposal also included a different work plan, the details are shown in the redesign of the workstation with the support of the software.

4.3 Stage 3. Redesign of the workstation.

4.3.1 Description and simulation of the tasks proposals.

Proposal for task 1: Placement of the bag.

In this task there was no change, there is no risk factor, it is considered an efficient and effective process.

Proposal for task 2. Filling the bag.

In this task, the design of the hopper that was very high (1.30m) was considered since for people with heights between 1.60 and 1.90 meters it would be a task in which they would have to place their arms raised assuming a forced posture, so which was proposed to place an adjustable work platform in which the workers carried out their work without raising their arms more than 90 degrees, in addition to this, a support bench for the ice bag that is height adjustable was considered. Figure 15 illustrates these changes.

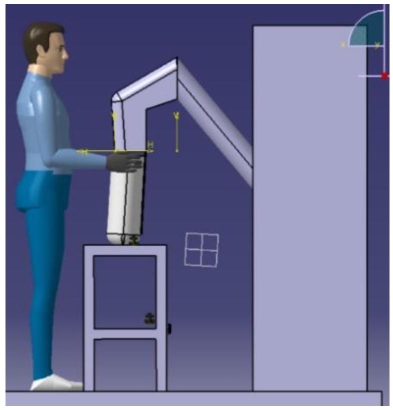

Figure 15. Proposal for task 2.

As for the times, a total of 8 bags per minute will be filled, for which each operator will carry out a total of 4 products in each task in a period of 30 seconds and to help with the times, an alarm will be implemented that emits a signal from the start every 7.5 seconds announcing that the next product must be worked. Proposal for task 3. Placement of the bag in its closing area.

It was proposed to avoid large transfers by placing the bags on a bench, to which bags will be placed and the rollers will help move the bags previously placed, as shown in Figure 16.

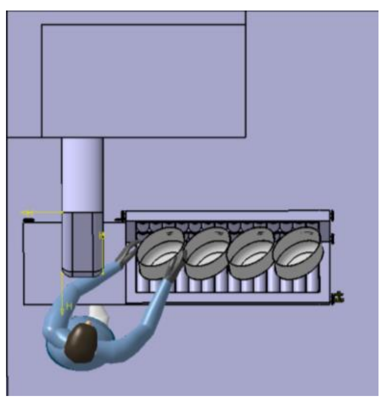

Figure 16. Top view of the movement of the bags on the roller bench.

It is important to mention that the inclination of the roller bank helps to keep the product inside the bag as shown in Figure 17.

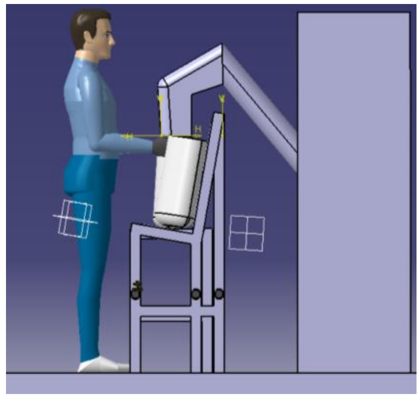

Figure 17. Side view showing the inclination.

Proposal for task 4. Closing the bag.

Figure 18 shows the activity where the operator is placed in the closing area, he holds the bags that he himself placed on the roller bench and proceeds to close them.

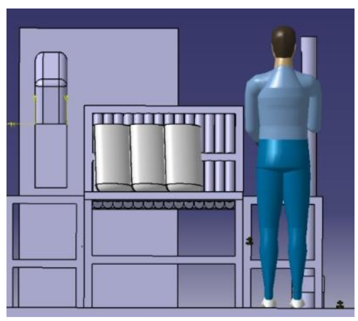

Figure 18. Closing the bag.

In this task, the improvement that was proposed consisted of modifying the support of the banding machine to make it variable in height, and in the same way as in task 2, there was a bench with adjustable height in such a way that the operator could fully support his weight on the bench, while the bag is closed with the ringing machine. Figure 19 describes this process.

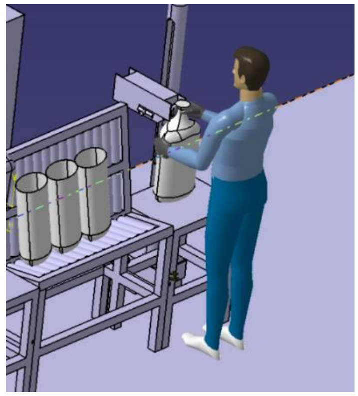

Figure 19. Isometric of the bag closure.

Figure 20 shows that operator 1 starts the bagging cycle so that the bags move towards the banding machine and operator 2 closes them.

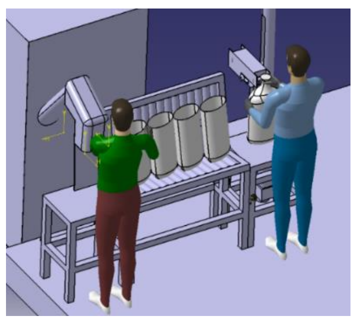

Figure 20. Movement of bags towards the banding machine.

Proposal for task 5. Placement of the bag.

For this task, the transfer distances are shortened, a conveyor belt is proposed so that it can take the bags to the cold room, and this is placed on one side of the closing area in such a way that the operator must turn and place the product on the belt without having to move as shown in Figure 21.

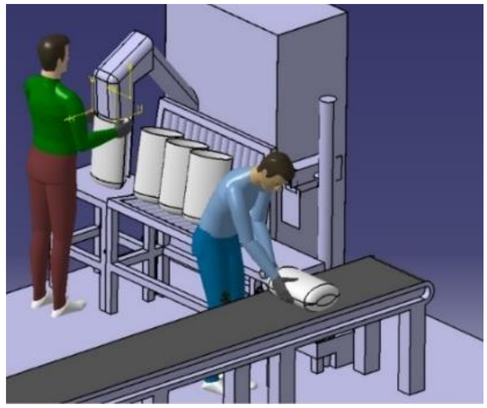

Figure 21. Placement of the bag on the conveyor belt.

Finally, operator 2, after placing the 4 bags that correspond to him on the conveyor belt, will go back to the beginning of the cycle, while operator 1 will have to go to the bag closing area and perform task 4 again.

4.3.2. Ergonomic evaluation of proposals.

Ergonomic evaluation was performed using software.

Proposal for task 1: Placement of the bag.

Task 1 changed, but it does not have a risk level, so its analysis is discarded.

Proposal for task 2. Filling the bag.

Figure 22 shows the results for the task 2 proposal. A final score of 2 was obtained, according to Table 2, this result corresponds to a level 1, acceptable risk. It is considered as an acceptable position.

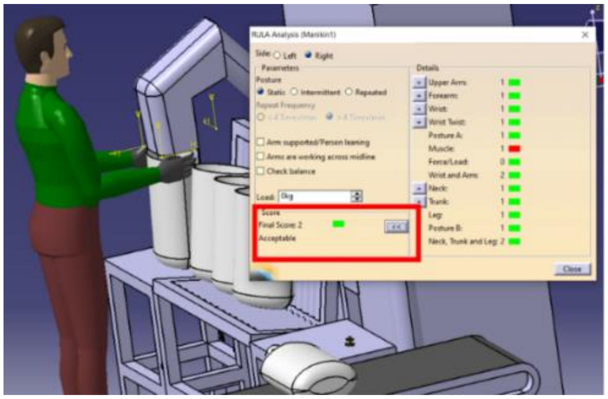

Figure 22. Result of the proposal for task 2.

Proposal for task 3. Placement of the bag in its closing area.

As can be seen in Figure 23, this proposal obtained a final score of 3, according to Table 2, level 2 corresponds to it; It is concluded that some changes may be required, but to have a more exact result it is recommended to deepen the study for this task.

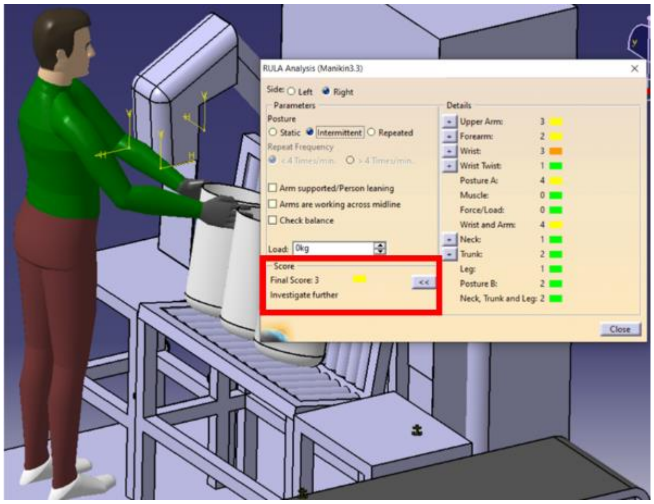

Figure 23. Result of the proposal for task 3.

Proposal for task 4. Closing the bag.

Figure 24 shows that, like task 3, task 4 obtains a final score of 3, according to Table 2, it corresponds to level 2, for which some changes may be required, but to have a more accurate result It is also recommended to deepen the study for this task.

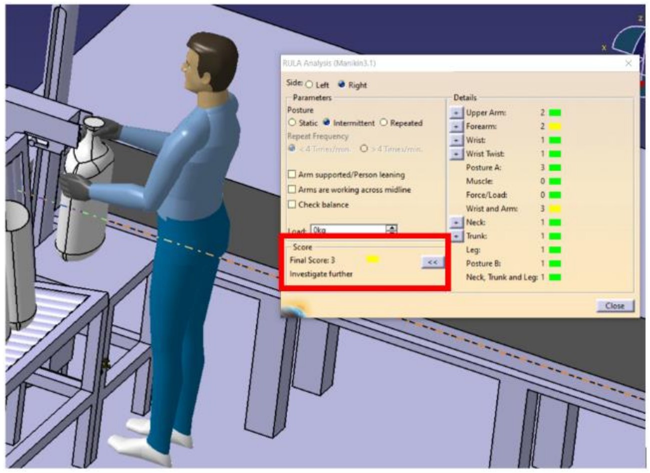

Figure 24. Result of the proposal for task 4.

Proposal for task 5. Placement of the bag.

Figure 25 shows that task 5 obtains a final score of 4, according to Table 2, level 2 corresponds to it; despite the changes that were introduced in this task, it was not possible to eliminate the extra effort of having to load the product. This activity may require some changes, but it is necessary to deepen the study to have a more accurate result.

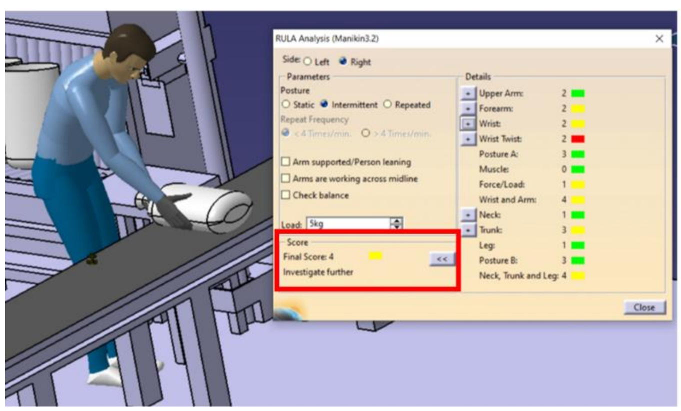

Figure 24. Result of the proposal for task 5.

Table 5 presents an analysis of the improvement that was obtained when applying the proposals, for this the score that was obtained at the beginning of the analysis is observed and compared with the score obtained after applying the design and ergonomic criteria, a percentage is obtained for each task and in general. This means that the workstation improved approximately 57%.

Table 5. Percentages of improvement with the redesign of the workstation.

Task	Description	Original workstation score	Score after applying improvement criteria.	Percentage of improvement
2	Filling the bag	7	2	71.4
3	Placement of the bag in its closing area	7	3	57.14
4	Closing the bag	7	3	57.14
5	Placement of the bag.	7	4	42.86
		Total		57.14

5. CONCLUSIONS

Analyzing each task separately, it is concluded that task 2 had a good improvement, however, it is necessary to consider other aspects so that tasks 3, 4 and 5 have the same results, with the software it was observed that this proposal still has areas of chance. In the new proposals, the worker continues to rotate the body, it is believed that this would be the biggest problem during the task; in addition to this, task 5 should be improved, where the weight of the bag is loaded to place it on the conveyor belt.

A significant improvement was observed in the workplace, however, it is still possible to lower the levels of ergonomic risk, for this a more detailed analysis will have to be carried out with methodologies such as MAC (Manual Handling Assessment Charts) to determine the correct way to load the product based on its weight and repeatability. In this investigation, the temperature of the environment, the consequences of physical activity and the increase in body temperature were not studied. Regarding the proposals of the tasks, an improvement is observed because no result required an immediate change of the task and previously all the tasks obtained a score of 7. It is important to mention that for this proposal to have better results, the company was recommended to train its staff in proper load handling, to provide equipment to be able to lift weights, such as belts, and for the hands, the use of gloves with non-slip, plus this will help maintain the temperature; It is not omitted to mention that these types of tasks must be rolled out, that is, that the operators do not focus solely on this activity.

The application of design methodologies contributed to present various proposals to select the most appropriate. Computer programs allowed to streamline the way of working and invest less time. It was concluded that a significant improvement of the analyzed job was achieved. This research demonstrates the importance of having ergonomically designed workstation, therefore, it is possible to reduce accidents and illnesses of operators.

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DESCRIPTIVE STUDY OF THE CRITICAL SUCCESS FACTORS OF ERGONOMICS PROGRAMS AND ITS BENEFITS FROM THE WORKER'S PERSPECTIVE IN THE MANUFACTURING INDUSTRY IN MEXICO

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Resumen: La Ergonomía es la disciplina científica relacionada con el conocimiento de la interacción entre el ser humano y otros elementos de un sistema (SOCIEDAD DE ERGONOMISTAS DE MEXICO, 2023). Es por ello que las empresas manufactureras buscan su implementación para obtener sus beneficios. La finalidad de esta investigación es desarrollar un estudio descriptivo para determinar los factores críticos de éxito en la implementación de programas de Ergonomía desde la perspectiva del trabajador dentro de la industria manufacturera automotriz en México.

Utilizando un cuestionario para la determinación de factores críticos de éxito compuesto por las siguientes dimensiones: las obligaciones de la empresa, las obligaciones del trabajador y los beneficios de la implementación de los programas de Ergonomía.

La metodología consta de cuatro etapas en las que se recolecta información durante el trabajo de campo, se crea y limpia la base de datos, se obtienen medidas de tendencia central y dispersión, se caracteriza gráficamente la muestra y se interpretan los resultados obtenidos.

De acuerdo con los resultados encontrados del análisis descriptivo, dentro de las industrias manufactureras desde la perspectiva del trabajador, los trabajadores aplican frecuentemente las medidas de prevención y procedimientos de seguridad dentro de las empresas y mantener su lugar de trabajo ordenado. Además, los trabajadores acceden con frecuencia a realizarse los exámenes médicos que determine la empresa, a participar en las capacitaciones que brinda la empresa y, en general, a cumplir con sus obligaciones.

En lo que respecta a los beneficios que se obtienen de un programa de Ergonomía, los trabajadores perciben con frecuencia la reducción de accidentes, lesiones y accidentes laborales y enfermedades. Del mismo modo, la reducción del estrés físico y mental. Además, los trabajadores coinciden en un mayor confort en cuanto a las condiciones ambientales dentro del área de trabajo, como temperatura, iluminación y calidad del aire.

Palabras clave: Factores críticos de éxito, Programas de Ergonomía, Estudio descriptivo.

Relevancia para la ergonomía: Este estudio contribuye a dar a conocer aquellos factores críticos de éxito en la implementación de programas de Ergonomía desde la perspectiva del trabajador dentro de la industria manufacturera en México. Esta investigación facilita la comprensión de la perspectiva del trabajador en la implementación de los programas. De esta manera, las organizaciones conseguirán dedicar los recursos económicos necesarios a aquellos factores más frecuentemente y significativos entre los trabajadores para tener una mayor probabilidad de éxito.

Abstract: Ergonomics is the scientific discipline related to the knowledge of the interaction between human beings and other elements of a system (SOCIEDAD DE ERGONOMISTAS DE MEXICO, 2023). That is why manufacturing companies seek its implementation to obtain its benefits. The purpose of this research is to develop a descriptive study to determine the critical success factors in the implementation of ergonomic programs from the worker's perspective within the automotive manufacturing industry in Mexico. Using a questionnaire for the determination of critical success factors composed of the following dimensions: the obligations of the company, the obligations of the worker, and the benefits of the implementation of ergonomic programs. The methodology consists of four steps: information is collected during field work, the database is created and cleaned, measures of central tendency and dispersion are obtained, the sample is graphically characterized, and the results obtained are interpreted.

According to the results found from the descriptive analysis, within the manufacturing industries, from the worker's perspective, workers frequently apply preventive measures and safety procedures within the companies and keep their workplace tidy. In addition, workers frequently agree to take the medical exams

determined by the company, to participate in the training provided by the company, and, in general, to comply with their obligations.

Regarding the benefits obtained from an ergonomics program, workers frequently perceive a reduction in accidents, injuries, and occupational accidents and illnesses. Similarly, the reduction of physical and mental stress. In addition, workers agree on greater comfort in terms of environmental conditions within the work area, such as temperature, lighting, and air quality.

Keywords. Critical success factors, ergonomic programs, descriptive study.

Relevance to Ergonomics: This study contributes to the understanding of those critical success factors in the implementation of Ergonomics programs from the worker's perspective within the manufacturing industry in Mexico. This research facilitates the understanding of the worker's perspective in the implementation of the programs. In this way, organizations will be able to dedicate the necessary economic resources to those factors most frequently and significantly affecting workers, with a higher probability of success.

1. INTRODUCTION

According to the International Ergonomics Association (IEA), Ergonomics is a scientific discipline within the understanding of the interactions between humans and other elements in a system (International Ergonomics Association, 2000). Ergonomics applied in the manufacturing industry seeks to preserve the physical and health integrity of the worker and identifies, eliminates, or minimizes exposure to different risks (Tirado, 2016). For this reason, organizations develop Ergonomics programs, involving all stakeholders involved in the change through preparation, evaluation, and implementation (Rodríguez & Pérez, 2016)

Several studies mention the importance of Ergonomics programs within companies. Ergonomics is important since it brings benefits to the quality of life at work, economics, and health and safety due to the timely prevention of accidents and occupational diseases (Abinaya & Rajkumar, 2021; Heidarimoghadam et al., 2022; Palma et al., 2017; Rostami et al., 2021).

This research presents a descriptive study of the critical success factors in the implementation of ergonomics programs, as well as their health and safety benefits from the worker's perspective within the automotive manufacturing industry in Mexico. The questionnaire for the determination of critical success factors used is composed of 69 items, together with the dimensions of the company's obligations, the worker's obligations, and benefits. The workers in manufacturing companies were asked to respond on a Likert-type scale from 1 to 5, where 1 means never and 5 means always, to evaluate the level of effectiveness of the Ergonomics programs and their perception of the benefits.

2. OBJECTIVES

The objective of this research is to develop a descriptive study to determine the critical success factors in the implementation of Ergonomics programs from the worker's perspective within the automotive manufacturing industry in Mexico.

3. DELIMITATIONS

As a delimitation, this research obtained a convenience sample of workers from two companies. Workers were directly involved in the automotive manufacturing areas of the automotive industry about brake pads and electronic components in Ciudad Juárez, Chihuahua, Mexico. Regarding the descriptive analysis, the factor related to the worker's obligations was delimited and the results of the health and safety benefits are shown.

4. METHODOLOGY

The methodology consists of four stages in which information is collected during fieldwork, the database is created and cleaned, measures of central tendency and dispersion are obtained, the sample is graphically characterized, and the results obtained are interpreted. **Figure 1** shows the methodology used for the descriptive analysis.

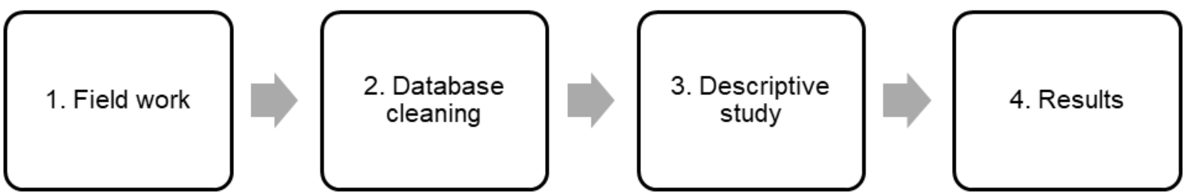

Figure 1. Methodology used for the descriptive analysis.

Stage 1. Field work. It consisted of the application of the questionnaire; permission was requested from the companies for its application, and the participants signed the letter of informed consent. In accordance with the research protocol, it was approved by the Research Ethics Committee of the Universidad Autónoma de Ciudad Juárez. The nature of the study was informed, and the participants' rights to confidentiality and anonymity were respected by using the data only for academic purposes. The departments involved in this process were Human Resources, Operations, and finally the Health and Safety Department.

Step 2. Database cleaning. For the creation of the database, the information was captured in a worksheet in the IBM® SPSS® program in version 26. For the cleaning of the database, the following steps were conducted:

1. Treatment of out-of-range values

These values are derived from human errors of capture or otherwise under the specifications of the range indicated in the questionnaire according to the Likert scale used. Using descriptive statistics and the use of maximums and minimums, these values can be checked.

2. Treatment of missing data

Regarding missing data, there are different methods to treat and analyze these values, such as substituting the mean and median for the mean. In this case, the method used was data imputation, which consists of replacing missing values with values obtained from a statistical analysis through the median for ordinal data and the mean for scalar data (Kwak & Kim, 2017).

3. Outlier data.

For outlier data, the box or whisker plot was used in IBM® SPSS® software version 26. In this box plot, any data outside the top or bottom lines is considered an outlier and should be left out of the analysis (Kwak & Kim, 2017).

Stage 3. Descriptive study. For the descriptive study, measures of central tendency such as the median were obtained, as were measures of dispersion with interquartile ranges. For the latter, the 25th and 75th quartiles were determined together with the interquartile ranges, which is the difference between the third quartile and the first quartile.

Phase 4. Representation and interpretation of the results. The results are used to characterize the sample by sex, age, and length of service. In addition, the results obtained are interpreted from the values of the interquartile range and the median to observe the behavior of the answers given to the questionnaires.

5. RESULTS

The results of this study have been organized by stage according to the methodology.

1. Field work. There were 180 participants working directly in manufacturing areas in the automotive industry in Ciudad Juárez, Chihuahua, Mexico. As shown in **Figure 2**, within the characterization of the sample, the female gender predominates (56%).

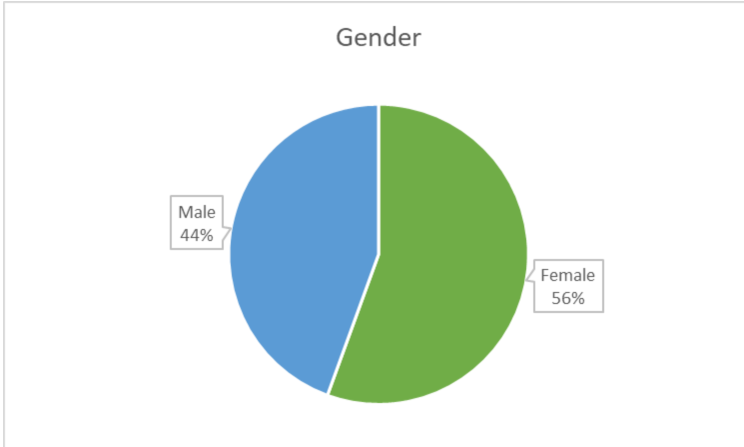

Figure 2. Gender of participants.

Figure 3 shows the age range of the participants, where the majority is between 18 and 28 years old (35%), and the minority is over 51 years old (17%).

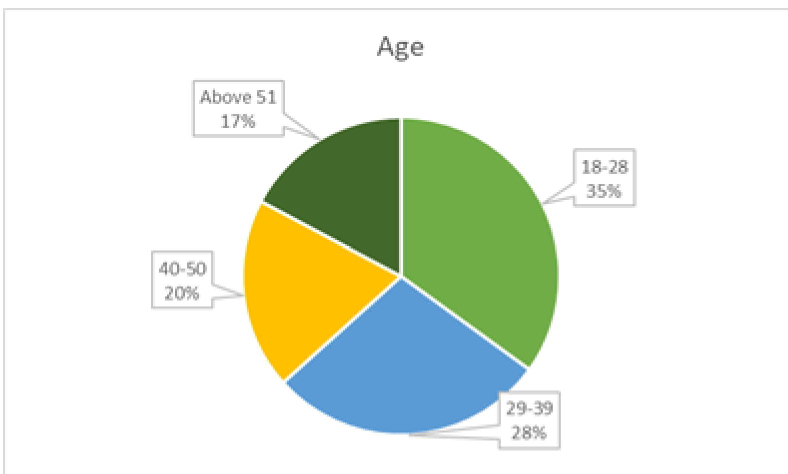

Figure 3. Age range of participants.

In relation to the length of service in the company. **Figure 4** shows the percentage of those workers who have been working in the organization for 2 years or less (53%). Followed by 21% of those who have been working for between 2 and 5 years, 17% for more than 10 years, and, to a lesser extent, 9% of those employees who have been working for between 6 and 10 years.

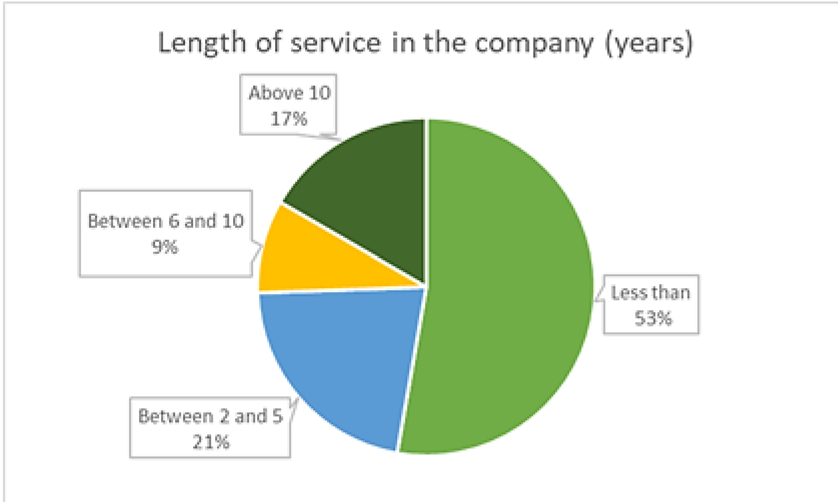

Figure 4. Length of service in the companies of the participants.

Regarding the field work and the characterization of the sample, it is possible to observe the age range of the respondents, most of whom are under 30 years of age, with a predominance of women. In addition, in relation to the length of service in the company, most of the respondents have spent 2 years or less working in the company, leaving in smaller numbers those with more than 10 years of seniority. We were able to highlight the high rate of personnel turnover in the companies, which can be attributed to the wide range of manufacturing industries in the city. As well as the competition among them to attract talent. However, regulations regarding industrial safety and ergonomics are mandatory for all workplaces that have more than 50 workers. Ensuring, in general, the perception of workers regarding Ergonomics programs.

2. **Database cleaning.** In this step, the IBM® SPSS® statistical analysis software version 26 was used; no out-of-range values or atypical data were detected. However, 26 missing data points pertaining to the ordinal Likert-type scale were found in the questions asked by the workers. These values were replaced using the median method by close points.

3. **Descriptive study.** The descriptive analysis was conducted by dimension. The dimension analyzed in this research is called conditions associated with the worker's obligations. **Table 1** shows the 11 activities that make up the dimension. It also shows the median value, the 25th quartile, and the 75th quartile.

Table 1. Quartiles and medians of the dimensions of the conditions associated with the worker's obligations.

Dimension	Acronym	Median	Quartiles		IR
			25.00	75.00	
Conditions associated with my obligations					
1. Related to safe practices:	**PS1**				
I apply prevention measures and security procedures.	PS1.1	4.66	4.12		
I use the measures and safe work practices established by the company.	PS1.2	4.74**	4.16		
I perform the work safely to avoid risks.	PS1.3	4.74**	4.22		
I immediately report unsafe conditions in my work environment.	PS1.4	4.67	4.12		
2. About my workspace:	**ET2**				
I keep my workplace tidy.	ET2.1	4.78**	4.29		
I keep my workplace clean.	ET2.2	4.69	4.17		
I keep my workplace free of obstacles.	ET2.3	4.73	4.20		
3. Related to my health:	**RS3**				
I inform the company about the conditions to my health or possible limitations for carrying out my activities in my workplace.	RS3.1	4.71	3.97		
I do the medical exams determined by the company.	RS3.2	4.84**	4.51		
4. Regarding training:	**RC4**				
I participate in training, training or information events provided by the company	RC4.1	4.55*	3.44		
In general, I comply with my aforementioned obligations	GLO1.2	4.77**	4.26		

Note: The item with the lowest median value is indicated with an asterisk, (*) and the item with the highest median value per dimension is indicated with a double asterisk (**).

Regarding the benefits dimension, the dimension analyzed corresponds to health and safety benefits. This dimension is called benefits from the implementation of Ergonomics. **Table 2** lists eight benefits of the implementation of Ergonomics programs in this dimension. It also shows the median value, the 25th and 75th quartiles, as well as the interquartile range.

Table 2. Quartiles and interquartile ranges of the benefits of Ergonomics implementation.

Dimension	Acronym	Median	Quartiles		IR
			25.00	75.00	
Health and safety benefits					
The implementation of Ergonomics:					
Reduces accidents, injuries or illnesses at work.	IME1	4.4**	3.61		
The fatigue in my work decreases.	IME2	4.08	3.07	4.85	1.78
Improves hygiene at work (excess noise, dust, toxicity, etc.)	IME3	4.06	3.01	4.85	1.84
Reduces/eliminates physical/mental stress from my job.	IME4	3.73*	2.66	4.67	2.01
Increases the comfort level of environmental conditions (temperature, lighting, air quality, humidity, etc.)	IME5	4.12	3.13	4.85	1.72
Reduces soil/water/atmosphere pollution.	IME6	4.0	3.06	4.78	1.72
Reduces the probability of environmental incidents.	IME7	4.17	3.14	4.92	1.78
Reduce the number of environmental complaints.	IME8	4.2	3.15	4.90	1.75

Note: The item with the lowest median value is indicated with an asterisk, (*) and the item with the highest median value per dimension is indicated with a double asterisk (**).

4. Results interpretation. According to the results of Table 1 and the highest median values with responses according to the Likert scale used, it can be determined that, for the success of an Ergonomics program within the manufacturing industries from the worker's perspective, workers frequently apply the prevention measures and safety procedures within the companies and keep their workplace tidy. In addition, workers frequently agree to take the medical exams determined by the company, to participate in the training provided by the company, and, in general, to comply with their obligations.

It should be noted that all activities show a high median value according to the scale used. This indicates a consensus among the respondents' answers, and we can confirm the importance of the activities for the workers.

Based on the results of Table 2 and the highest median values with responses according to the Likert scale used, it can be determined that, within the benefits obtained from an Ergonomics program, workers frequently perceive the reduction of accidents, injuries, and work-related illnesses. Similarly, the reduction of physical and mental stress. Furthermore, workers agree on increased comfort regarding environmental conditions within the work area, such as temperature, lighting, and air quality.

Within this dimension, there are several benefits with a low interquartile range, indicating a consensus among the respondents' answers and the importance of the benefits perceived by the workers. It is worth highlighting that all benefits with the highest median value show a low interquartile range value, corroborating the benefit among respondents.

6. CONCLUSIONS

Through the descriptive analysis established, it was possible to define those critical success factors in the implementation of Ergonomics programs from the worker's perspective. Respondents agree on several factors, which we managed to highlight, including compliance with prevention measures and safety procedures within the companies and keeping the workplace tidy. In addition, workers agree that the completion of medical examinations determined by the company and participation in training provided by the company are key factors for the ergonomic program to have a higher probability of success.

Recall the importance of involving workers to empower them with authority, responsibility, and accountability in decisions (Vinodkumar & Bhasi, 2010).

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APPLICATION OF NOM-036-1-STPS-2018 IN THE EMPTYING PROCESS IN PRODUCTION EQUIPMENT IN THE FOOD WORKSHOP

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Resumen: El diseño de un recipiente ergonómico en el área de vaciado en equipos de producción del taller de alimentos del ITCC, es un aspecto importante para mejorar la seguridad y eficiencia de las operaciones. Una estructura bien diseñada ayuda a reducir el riesgo de lesiones musculoesqueléticas y mejorar la comodidad y productividad de los estudiantes. Existen algunas consideraciones básicas para el diseño de dicho recipiente, como el tamaño y capacidad adecuada para ajustar la cantidad de material que se va a vaciar y manipular, ya que un tamaño adecuado evitará la sobrecarga y facilitará el manejo.
Palabras Claves: Análisis ergonómico, industrias alimentarias, seguridad, ebullición.
Relevancia para la ergonomía: Las actividades realizadas dentro del Taller de Alimentos, contribuye a realizar un análisis ergonómico sobre la carga, transporte y maniobra de recipientes de gran volumen, lo cual se ha observado que puede causar un trastorno en el sistema musculoesquelético por las malas posturas que se efectúan para la maniobra de dichos recipientes , así como lesiones en el

personal y los estudiantes, lo anterior en busca del objetivo principal de la ergonomía que es el bienestar físico y mental del trabajador

Abstract: The design of an ergonomic container in the emptying area in production equipment of the ITCC food workshop is an important aspect to improve the safety and efficiency of operations. A well-designed structure helps reduce the risk of musculoskeletal injuries and improve student comfort and productivity. There are some basic considerations for the design of such a container, such as the proper size and ability to adjust the amount of material to be emptied and handled, since a proper size will avoid overloading and facilitate handling.

Keywords: Ergonomic analysis, food industries, safety, boiling process.

Relevance to Ergonomics: The activities carried out within the Food Workshop, contributes to carry out an ergonomic analysis on the loading, transport and maneuvering of large volume containers, which has been observed that can cause a disorder in the musculoskeletal system due to the bad postures that are made for the maneuver of such containers, as well as injuries to staff and students, the above in search of the main objective of ergonomics which is the worker physical and mental well-being.

1. INTRODUCTION

The main objective of ergonomics is to design or modify people's work activities so that they can develop them within their capabilities, without any risk of injuries or accidents. In the case of the process done in the food workshop, there are risks due to handling heavy objects, so that forced postures and repetitive movements can be assumed, as well as being exposed to fractures or injuries, which can be controlled through a process of prevention and control of risks. This research was carried out to design a prototype that helps to improve the process of gripping and maneuvering containers of different sizes and weights, identifying ergonomic risk factors when manually handling the container.

2. OBJETIVE

Design a prototype that meets the ergonomic and safety conditions during the process of clamping, lifting, gripping, emptying and transport of different containers, in the Food Workshop, where academic practices of the Educational Program of Engineering in Food Industries, of the TECNM, Campus Cuauhtémoc City are carried out.

3. DELIMITATION

With the realization of this project, the current conditions are observed, analyzed and evaluated, carrying out improvements in the Food Workshop of the Engineering in Food Industries Educational Program from the TECNM, Campus Cuauhtémoc City.

4. METHODOLOGY

Based on the suggested specifications of the Mexican standard NOM-036-1-STPS-2018, this methodology consists of the following steps to determine the level of risk of the practices:

a) The work process is observed during the practice carried out by the student, detecting the risks and inadequate conditions in the handling of containers of different sizes and weights.
b) The identification of activities that involve ergonomic risk factors due to manual handling of loads, which involves lifting, lowering, transporting, pushing, pulling and / or stowage materials, in accordance with numeral 7.2 of the Standard.
c) A preliminary analysis of the activities is carried out to determine the ergonomic analysis tools to be used.
d) A report is prepared with all the findings that include recommendations based on ergonomic guidelines.

4.1 Procedure for loading, moving, and emptying:

4.1.1 The student loads the container with the contents at high temperature, from the stove to move it and position it (Figure 1).

Figure 1. Container first handling (Authors).

2.- The container is placed on a stainless steel table measuring 8 x 3 x 2.5 feet, for the product to cool (Figure 2)

Figure 2. Step two in the process (Authors).

3.- The container with an approximate weight of 65 pounds is moved between two people, holding it by the ends for handling and cooling. as shown in figure 3.

Figure 3. Step three in the process (Authors).

4.- The content is emptied, maintaining the balance in arms

Figure 4. Fruit emptied (Authors).

5.- Panoramic view of the Food Workshop of the ITCC

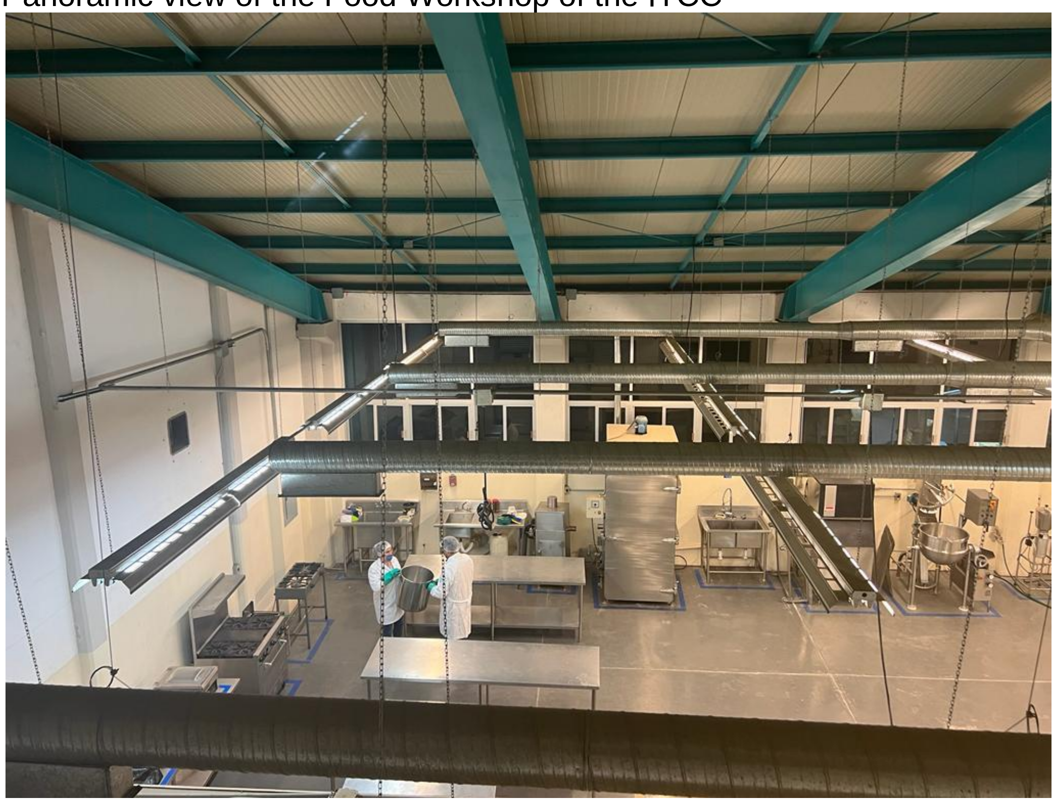

Figure 5. Panoramic view (Authors).

Following table 1 shows the different activities involves in the investigation.

Table 1. Activities schedule

ACTIVITIES	WEEKS							
	1	2	3	4	5	6	7	8
1. DRAW THE PARTS OF THE STRUCTURE								

Following table 1 shows the different activities involves in the investigation.

Table 1. Activities schedule

2. DESIGN THE ERGONOMIC STRUCTURE								
3. ANALYZE THE POSSIBLE MATERIALS TO BE USED								
4. WEIGHTING OF PHYSICAL PROPERTIES (WEIGHT AND FINAL DIMENSIONS)								
5. ASSEMBLY OF THE PROTOTYPE								
6. PERFORM PHYSICAL TESTS								
7. RESULTS								

5. RESULTS

Based on the methodology applied, favorable results were obtained, minimizing the level of risk in the handling of containers of different sizes and weights, by users.

The standard NOM-036-1-STPS-2018 was taken into account, to know the level of work risk carried out by the students in the practices; Table 2 considers the maximum mass in kilograms, depending on age and gender, it is established that for men it is 25 kg and for women it is 20 kg with an age range of 18 to 45 years, of which the weight of the container and the contents have an approximate weight of 100 kg, so it is concluded that it is not within the standards and a metal structure is necessary for the transport of the pot, following ergonomics guidelines.

Table 2 Maximum mass depending on age and gender (STPS, 2018)

Maximum mass (kgs)	**Gender**	**Age (in years)**
7	Female	Under 18
	Male	
15	Female	Mayores de 45*
20	Female	Entre 18 y 45
	Male	Mayores de 45*
25	Male	Entre 18 a 45

The estimation of the ergonomic risk due to the manual lifting and transport of loads to evaluate the conditions in which these tasks are done and following Standard 036 guidelines were made according to the following method:
Before starting to apply the method, the following should be considered:

a) Use as much time as necessary to observe the activity. Ensure that what is observed is representative of normal work procedure.
b) Involve students, professors, or workshop managers in the work during the evaluation process.
c) Identify the activity type, whether it is lifting/descending by students, team lifting/descent, or carrying loads. If the process involves a combination of these activities, consider all.
d) Follow the assessment guide to determine the level of risk for each identified risk factor.
e) Classify the level of risk according to Table 3

Table 3. Risk Level (STPS, 2018)

Low - Acceptable: No corrective actions are required. The risk is zero or although it is low, it is considered acceptable.
Medium - Possible: Short-term corrective actions are required. Although there is no high-risk situation, activities should be examined in more detail.
High - Significant: Corrective actions are required soon. A significant proportion of workers may be exposed to the risk of an occupational musculoskeletal disorder.
Too high or unacceptable: Corrective action is required immediately. Such operations can pose a serious risk of injury, should be thoroughly examined and improved.

To estimate the risk level, the color and value factors obtained for each activity should record the type, the results of the foundry workshop are shown in table 4.
Table 4. Results

RISK LEVEL ESTIMATION						
RISK FACTORS	**Lift**		**Transport**		**Equipment**	
	Color	**Value**	**Color**	**Value**	**Color**	**Value**
Weight and load lift/transport frequency		0		0		0
Horizontal distance between hands from lower back		6		6		6

Vertical lift region		0		0		0
Torso Torsion and lateral flexion; Asymmetrical load on the torso (transport)		1		1		1
Postural restrictions (awkward, forced, or restricted postures)		1		1		1
Hand-load coupling (fasteners)		1		1		1
Work surface		0		0		0
Other environmental factors		0		0		0
Transport distance		0		0		0
Obstacles on the route (transport only)		0		0		0
Communication, coordination and control (only manual handling of loads in equipment)		0		0		0
Value	**9**		**9**		**9**	
Risk Level	**MEDIUM**		**MEDIUM**		**MEDIUM**	

Determine the level of risk according to Table 5.

Table 5. Risk Levels determination.

RISK LEVEL	PRIORITY	TOTAL SCORE
Low - Acceptable	No corrective actions required	0 to 4
Medium - Possible	Short-term corrective actions required	5 to 12
High - Significant	Corrective actions are required soon	13 to 20
Very High - Unacceptable	Corrective actions required immediately	21 to 32

Define the actions, according to the level of risk, following table 6.

Table 6. Actions corresponding to each risk level.

RISK LEVEL	ACTIONS
Low - Acceptable	It is only necessary to follow up on the most vulnerable groups, such as pregnant women or underage workers.
Medium - Possible	Tasks should be examined in greater detail, through the application of a specific assessment, or control measures should be implemented through an Ergonomics Program for manual handling of loads.
High - Significant	Rapid action is required, so control measures must be established through an Ergonomics Program for manual handling of loads.
Very High - Unacceptable	Activities must be stopped, and control measures implemented through an Ergonomics Program for manual handling of loads.

After this process of analysis and application of the different tools described in NOM-036-1-STPS-2018, the need to design, build and use the metal prototype is defined, to ensure the physical integrity of users. The following figures show the results of the design process.

Figura 6. Complete design (Authors)

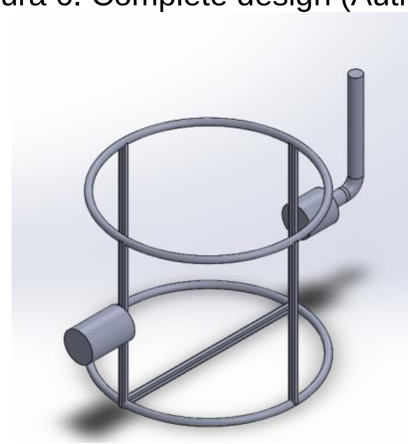

Figura 7. Structure for carrying container.

5. CONCLUSIONS

Based on the results obtained, it can be concluded[i1] that the research project carried out is of great benefit, since the level of risk in the execution of the practices in the food and biochemistry workshops would be reduced, applying the NOM-036-1-STPS-2018 in this improvement project.

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Level of Psychosocial Risk derived from the Organization of Working Time in Higher Level Teachers

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1. INTRODUCTION

While it is true, before 2019 countries of the European Union and the United States, already developed a variety of jobs virtually or blended; the COVID-19 pandemic represented a drastic change in lifestyle. This change involved the sudden and forced migration of workers and students of all educational levels to telework. Therefore, several organizations worldwide study this modality to know its advantages, disadvantages, and the impact on their work, academic or organizational performance indicators. Thus, Eurofound in conjunction with the International Labour Organization (ILO), affirm that teleworking arises when information and communication technologies are used to work outside the employer's premises (Eurofound & International Labour Organization, 2019; International Labour Organization, 2020). This research is interested in the effects of teleworking on work-family balance in higher education teachers during the health contingency in a sample of teachers in the state of Chihuahua.

In this state during 2021 there was the enrollment of 132,718 students at the higher level served by 11,518 teachers (*Statistical Yearbooks of Higher Education - ANUIES*, 2021). Of which, 350 were attached to the Tecnológico Nacional de México Ciudad Juárez campus (D. Renteria, personal communication, 2021). During the pandemic, when it comes to education, teachers as students and administrators faced various obstacles to teleworking. Among the main ones was that for that year only 63.7% of the homes referred to internet access -whose quality was not the most adequate-, and only 45.3% had a computer at home (Government of Mexico, 2021). Likewise, neither teachers nor students had the opportunity to be previously trained (Brito-Cruz et al., 2021). As a result, an increase in the time and efforts required to online teaching development was observed; generating new occupational risks, both physical and mental (Selvaraj et al., 2021), reducing the time dedicated to care and interaction between family members, generating an imbalance in the organization of work-family time as psychosocial risk factors in teleworking (Alvites-Huamaní, 2019).

In addition, the ILO reports that women are more likely to present psychosocial risks and stress (International Labour Organization, 2012) while Domínguez refers those other important aspects that influence is the teachers' academic degree, as well as the type of job indenture and seniority as a teacher (Dominguez Gomez, 2009). Therefore, various individual and work aspects can affect and influence the risk levels of psychosocial risk factors in telework and this research presents a descriptive analysis of the level of psychosocial risk derived from the organization of work during the COVID-19 pandemic in higher education teachers, distinguishing gender, seniority, appointment.

Keywords: Teleworking, Organization of working time, Teachers in higher education

Work area (according to call): Ergonomics and Gender/ Interdisciplinary work/ Work evaluation

Objectives: *To develop a descriptive study in a sample of teachers of the TecNM/IT Ciudad Juárez regarding the level of psychosocial risk derived from the organization of work.*

Delimitation: Although the study was conducted at the national level, only the professors of the TecNM Ciudad Juárez campus during the January-June 2021 semester are presented.

2. METHODOLOGY

It is a cross-sectional, non-experimental study. The sample consists of 202 teachers, who voluntarily participated in the study. The methodology consists of three stages.

1. Reference Guide III proposed by Nom-035-STPS-2018 was used for data collection; specifically, the items corresponding to the category Organization of Working Time (Official Mexican Standard NOM-035-STPS-2018, Psychosocial risk factors at work-Identification, analysis, and prevention., 2019).
2. Debugging of the database for the analysis of the level of risk derived from the organization, analysis of the median and interquartile ranges.
3. A descriptive study of the sections of interest was conducted using frequency diagrams, and comparative tables according to gender, academic degree, type of appointment.

3. RESULTS

It is observed that, of the sample of 202 teachers, 50.5% were men and 49.5% women. Of which 78.7% are between 30 and 59 years old. In addition, 65.8% have married marital status. In addition, it was found that 62.4% of the sample observed high level for psychosocial risk. For this sample, the highest risk levels are more frequent among women, teachers without a permanent job contract job and also teach classes for fees, and whose educational level is master’s degree.

Conclusions: The descriptive study determines the prevalence of risk factors faced by higher education teachers when performing their work through telework. It helps to better understanding the psychosocial risk factors and the aspects and the study provides data that contribute to the analysis of the working hours in regular basis during telework and the conditions in which it develops. This is so that it is contemplated when establishing the working days with their minimum requirements. It can be seen that a percentage of teachers are exposed to high levels of psychosocial risk. In addition to this, it is important to consider the factors that indirectly aggravate the situation ranging from gender, age, and academic degree to the type of appointment and the demands contemplated by the teaching work.

Contribution to Ergonomics: This research contributes to the analysis of the psychosocial risk factor derived from the organization of working time to which teachers were exposed during teleworking.

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PILOT TEST OF MENTAL WORKLOAD ASSESSMENT USING HEART RATE VARIABILITY.

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Resumen. Este trabajo se centra en la evaluación de la carga mental mediante técnicas subjetivas y fisiológicas. La carga mental viene determinada principalmente por la cantidad de información que hay que procesar, el tiempo disponible y la importancia de la decisión. La metodología implica la selección de tareas basada en variables de la técnica subjetiva NASA-TLX y la fisiológica, variabilidad del ritmo cardiaco. La selección de participantes se realizó mediante un muestreo de conveniencia y un procedimiento experimental que comprende la ejecución de tareas, en cuatro repeticiones, y la recogida de datos. El análisis de datos emplea Kubios© para el análisis de la variabilidad cardiaca haciendo uso del índice de estrés por parte de los participantes. Los resultados muestran picos en las evaluaciones de ambas técnicas durante el tercer ensayo, pero Kubios© detecta mejor los cambios sutiles. La dimensión de frustración contribuye de forma significativa según los resultados de NASA-TLX. En conclusión, Kubios© ofrece ventajas en la evaluación de la carga mental en tiempo real en comparación con NASA-TLX. El estudio subraya el potencial de técnicas fisiológicas como la VFC para monitorizar la carga de trabajo mental durante la ejecución de tareas.

Palabras clave: Ergonomía cognitiva, Carga mental, Variabilidad cardiaca, NASA-TLX.

Relevancia para la ergonomía: Por medio de este trabajo se investiga el uso de una técnica de evaluación de la carga mental de trabajo con efecto fisiológico en el individuo, el cual tiene la ventaja de no depender de la opinión del participante el cual puede presentar algún sesgo o condicionamiento mental.

Abstract. This paper focuses on the assessment of mental workload using subjective and physiological techniques. Mental workload is mainly determined by the amount of information to be processed, the time available and the importance of the decision. The methodology involves the selection of tasks based on variables of the subjective NASA-TLX technique and the physiological, heart rate variability. Participant selection was performed by convenience sampling and an experimental procedure involving task execution, in four trials, and data collection. Data analysis employs Kubios© for the analysis of the heart rate variability using the stress index by the participants. The results show peaks in the assessments of both techniques during the third trial, but Kubios© better detects subtle changes. The frustration dimension contributes significantly according to NASA-TLX results. In conclusion, Kubios© offers advantages in real-time mental workload assessment compared to NASA-TLX. The study highlights the potential of physiological techniques such as HRV to monitor mental workload during task execution.

Keywords. Cognitive ergonomics, Mental workload, Cardiac variability, NASA-TLX.

Relevance to Ergonomics: This work investigates the use of a technique for the evaluation of mental workload with physiological effect on the individual, which has the advantage of not depending on the opinion of the participant who may present some bias or mental conditioning.

1. INTRODUCTION

Mental workload is primarily determined by the amount of information to be processed, the available time, and the significance of decisions (Álvarez, 2014) when engaging in cognitive tasks. Evaluation of mental workload is divided into two main techniques: subjective and physiological (Ryu & Myung, 2005).

Subjective techniques are designed to seize the operator's perception of mental load. These techniques encompass the Cooper-Harper Scale (MCH), Subjective Workload Dominance (SWORD) and Pro-SWORD, Subjective Workload Assessment Technique (SWAT) and Pro-SWAT, as well as the NASA-Task Load Index (NASA-TLX), among othersv(Stanton et al., 2013).

A widely used tool for measuring and assessing mental workload is the NASA Task Load Index (NASA-TLX). Developed by the National Aeronautics and Space Administration (NASA) in collaboration with the University of Texas, NASA-TLX provides a structured methodology to comprehend and analyze the underlying components of mental workload in various tasks and work situations (Widiasih & Nuha, 2019), It has solidified itself as a reliable and validated instrument for evaluating mental workload. Through its multidimensional approach, NASA-TLX breaks down mental workload into several core components, including mental demand, physical demand, perceived effort, frustration, performance level, and time required to complete a specific task. Each of these components contributes to the overall perception of mental workload experienced by an individual during a given task (Hart & Staveland, 1988; Morales et al., 2020). The description of each of the above dimensions is as follows (Hart & Staveland, 1988):

- Mental demand: The amount of mental demand and perceptual activity required when performing the task.
- Physical demand: The level of physical activity required to complete the task.

- Temporal demand: The perceived time pressure resulting from the speed or pace at which tasks or task elements are executed.
- Effort: The perceived level of effort (both physical and mental) required to achieve the desired performance level.
- Performance: The perception of how successful one was in executing the tasks and meeting the task goals set by the analyst (or oneself).
- Frustration level: The feelings of insecurity, discouragement, irritation, stress, and annoyance versus confidence, satisfaction, contentment, relaxation, and complacency experienced during the task.

As per Ryu and Myung (2005), physiological techniques for assessing mental workload are based on the notion that this general activity or its manifestations can be quantified. In this context, all mentals' tasks and activities draw from a common pool of resources. Consequently, when task demands escalate, the central nervous system heightens the allocation of resources.

Heart rate, acquired through an electrocardiogram (ECG), stands as one of the most extensively employed physiological techniques with a prolonged history in mental workload assessment (Fallahi et al., 2016). As indicated by Luque-Casado, Perales, Cardenas, and Sanabria (2016), heart rate variability (HRV) varies based on task demands and is notably responsive to overall attentional requirements. The utilization of HRVs has evolved from intricate and costly ECGs to lightweight, portable, and cost-effective devices (Dias et al., 2018). A prominent tool for processing such data is Kubios© (Tarvainen et al., 2014), software that facilitates swift and straightforward analysis of data stemming from an ECG, EEG, or any other device measuring heart rhythm.

Controlled sampling is grounded in the intentional selection of experimental and control groups to compare effects under controlled conditions. It enables establishing causal relationships more accurately (Marcotte et al., 2022) as seen in this article that utilized a controlled sample. Pilot tests are crucial to assess the viability and effectiveness of research, projects, or interventions before full implementation, helping identify potential issues and refining methodologies (Zheng et al., 2020), ensuring more robust and successful outcomes. In this case, they supported mental workload assessment through heart rate variability.

1.1 Objective

This work aims to provide an introductory analysis of using cardiac variability to determine mental workload. Additionally, the results obtained from NASA-TLX will be used as a point of comparison.

1.2 Delimitation

For this work, heart rate variability will be evaluated using an RS800CX Fitness Watch by Polar. Participants will be selected from individuals with good health, without cardiac conditions, and not using any medications.

2. METHODOLOGY

In the development of this work, the methodology was divided into four sections, which are illustrated in Figure 1.

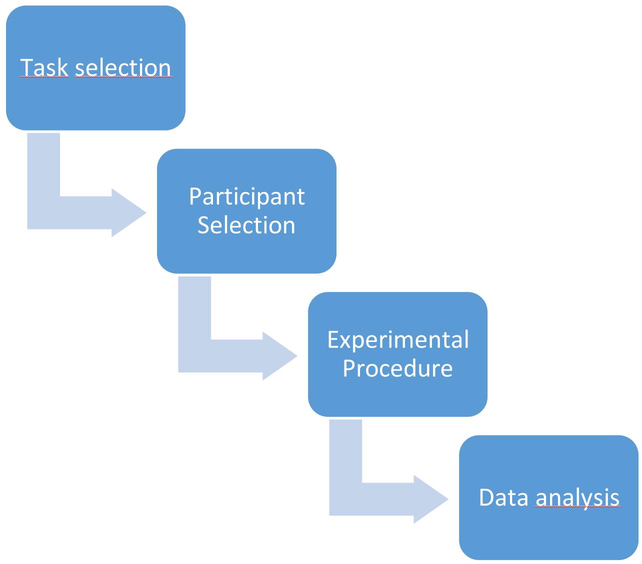

Figure 1. Methodology used in this work.

Task Selection: The methodology employed in this study adhered to a rigorous scientific approach. The task selection was grounded in factors evaluated by the NASA Task Load Index (NASA-TLX) and the optimal conditions for measuring heart rate variability. In this case, the task involved activating a series of switches on a board within a specified time frame. The board comprised electronic components like potentiometers and two-pole double-throw switches, managed and recorded using an Arduino Uno and a computer program. Figure 2 shows the board and Figure 3 show the computer program.

Participant Selection: Participants were selected using a convenience sampling approach. Male individuals aged between 23 and 28 years were chosen, ensuring they had no cardiac issues and had refrained from alcohol or substance consumption for 48 hours.

Experimental Procedure: Each participant underwent a consistent series of steps in every session:

1. Participants were informed about the experimental procedures and were required to provide consent by signing the provided form.
2. Participants were given a chance to familiarize themselves with the experimental setup by engaging in a practice run before data collection.

3. Participants were fitted with heart rate monitoring equipment, and instructions were provided on how to complete the NASA-TLX questionnaire through a virtual form.
4. Participants were instructed to perform the task repeatedly for 5 minutes and at the end of the time they had to answer the NASA-TLX questions.
5. The preceding step was repeated four times, with participants offered short breaks if needed.

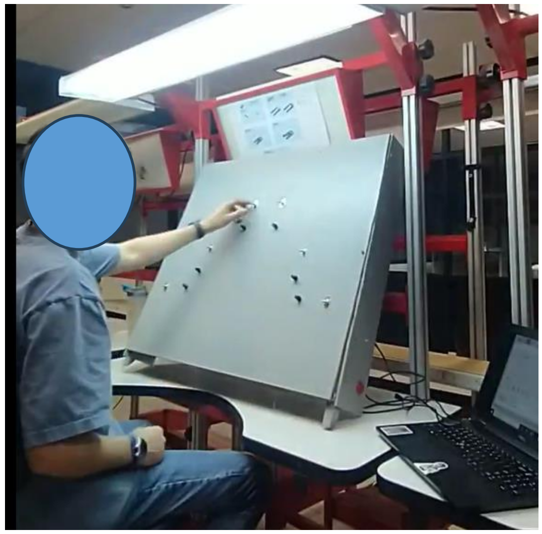

Figure 2. Participant in the board

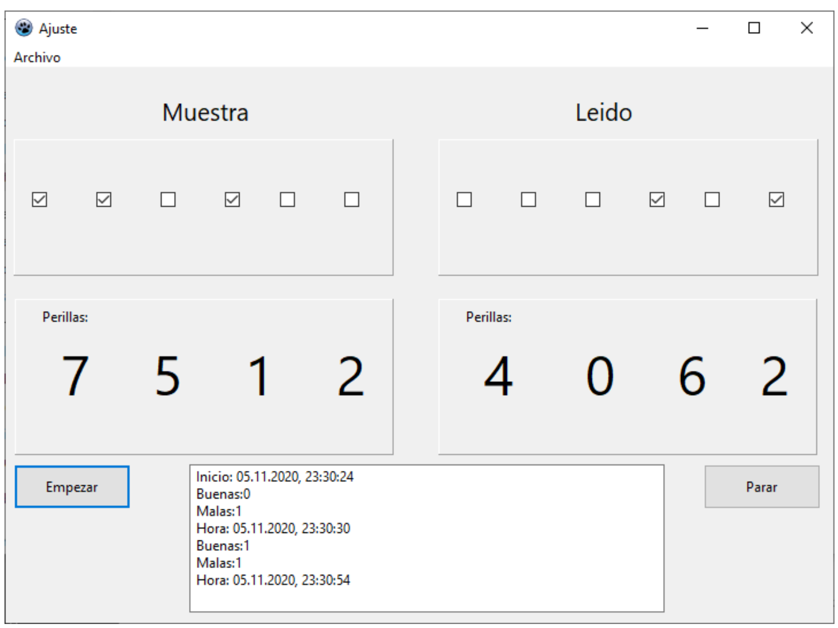

Figure 3. Computer program used in this work.

Data analysis: Using Kubios software and retrieving data from the heart rate variability recording device RS800 CX POLAR, stress indices were recorded. Likewise, the time required by each participant to complete the sequence requested by the board was timed, generating a summary for each participant for subsequent analysis. Regarding NASA-TLX results, they were obtained following the standard procedure of this technique. Due to the distinct scales employed by the two techniques in this study, the utilization of statistical techniques for their comparison is not advisable.

3. RESULTS

The sample for this study consisted of 11 participants, with six being male and five being female. Among them, nine participants were aged between 21 and 25, one fell between 16 and 20, and another between 31 and 35. Out of the total, eight were students, and three were employed in the private sector.

Figure 4 shows the average times (in seconds) in which the participants executed the task in the four repetitions and where a constant decrease can be observed.

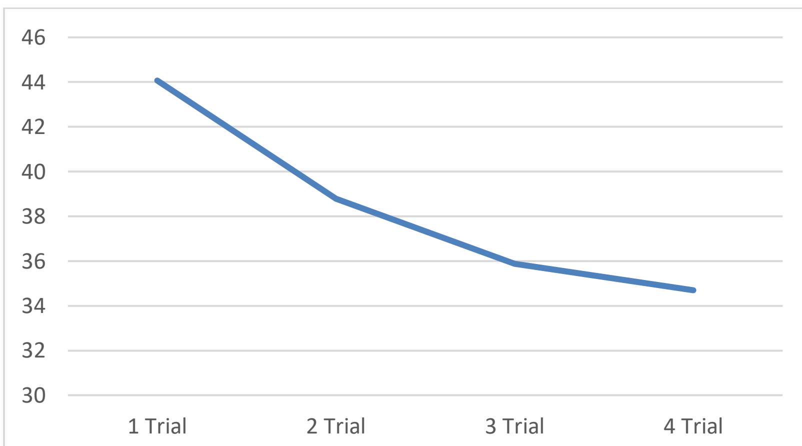

Figure 4. average task execution times (seconds)

In this study, the results obtained from Kubios were utilized, specifically focusing on the stress index calculated using Baevsky's formula. The average results from the four tests are illustrated in Figure 5, revealing an increase in the stress index until reaching a peak during the third test. Figure 6 displays a window depicting the results obtained from a single participant.

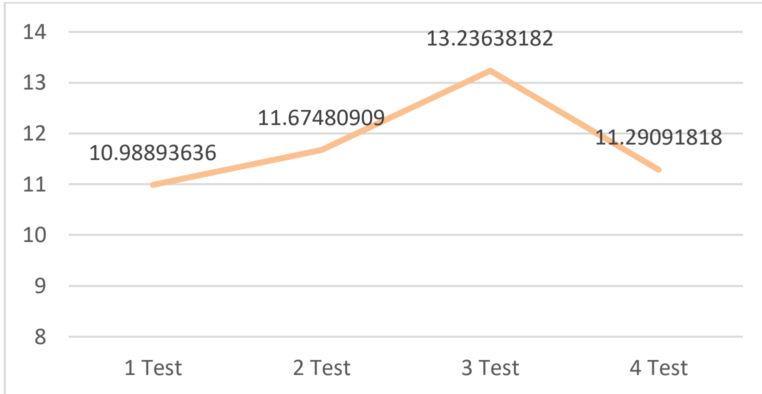

Figure 5. Stress index obtained by Kubios.

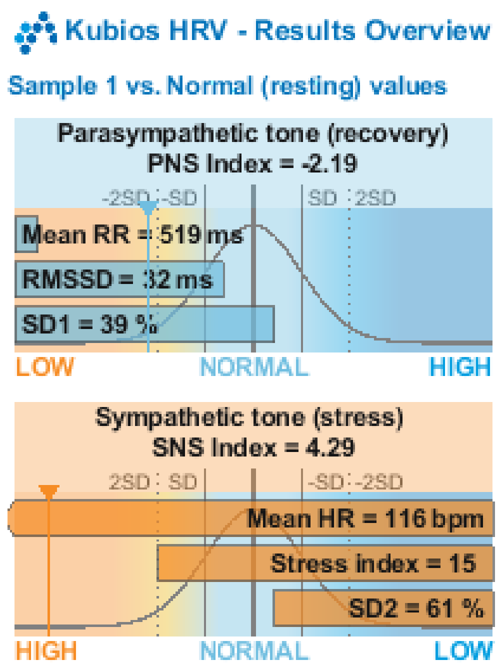

Figure 6. Example of results obtained by Kubios.

In relation to the average results obtained through NASA-TLX, as depicted in Figure 7, a peak can also be noticed after the third trial. When considering the results for each dimension of NASA-TLX, it becomes evident that frustration serves as the primary contributor, as illustrated in Figure 8.

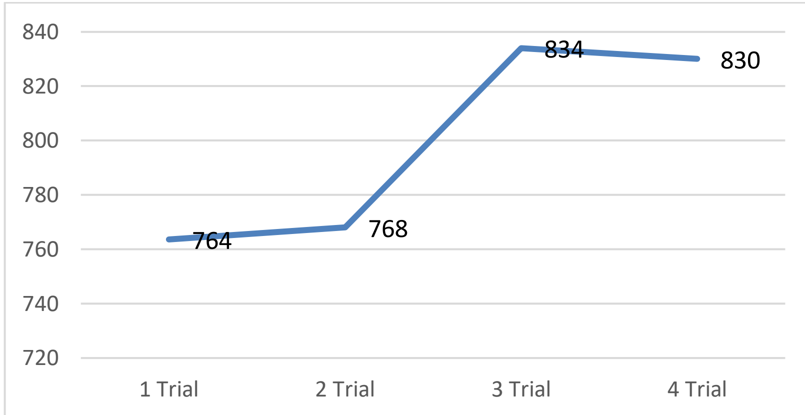

Figure 7. NASA-TLX scores.

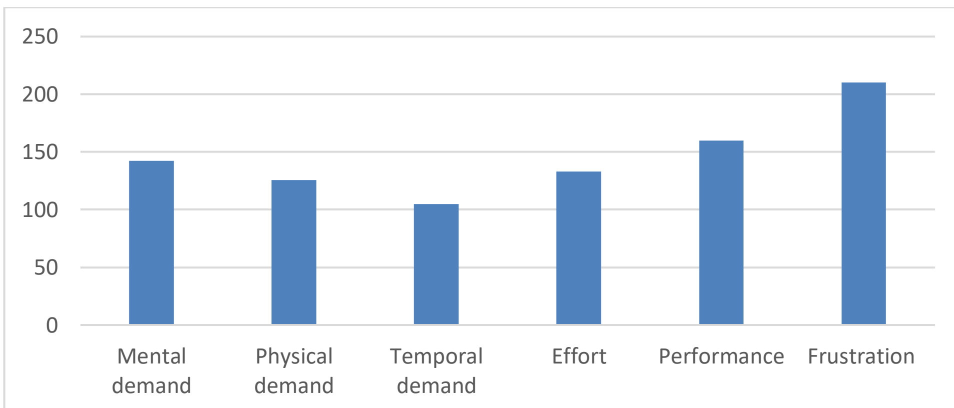

Figure 8. NASA-TLX Dimension Contribution

4. CONCLUSIONS

Returning to the results obtained by both techniques, it is evident that in both cases, there is a peak during the third trial. Concerning the results acquired via Kubios, a consistent rise is noticeable until the peak is reached. Subsequently, in the fourth trial, a decrease is observed, bringing the level nearly to that of the second trial. In the context of results obtained from NASA-TLX, a peak is also observed in the third trial. However, the increase is primarily concentrated between the second and third trial. Following the attainment of the third trial, a minor decrease is noted in the fourth trial. This distinction is since physiological techniques, unlike subjective methods, lack the sensitivity to detect subtle alterations in the level of mental load (Barajas-Bustillos et al., 2023).

Regarding the maximum value during the third repetition and considering the results for each dimension of NASA-TLX, it can be inferred that the main contributors were frustration, followed by performance. This maximum can be elucidated by the fact that participants were able to continuously observe the errors they were making in each execution. Consequently, upon noticing their mistakes, both their frustration and performance escalated. Despite the increase in frustration and effort, the average time to complete the task decreased with each trial.

Building upon the aforementioned information, it can be asserted that utilizing the stress level derived from Kubios for assessing mental workload offers certain advantages over NASA-TLX. Consequently, if the intention is to continuously monitor the level of mental workload during task execution, the employment of Kubios would be more suitable. This represents a significant edge over NASA-TLX, which can only furnish outcomes once the task is completed, thereby lacking the capability to evaluate mental workload during the task itself.

It is worth mentioning that since this was a pilot test, the results cannot be considered absolute, so they should be considered as an introduction to the evaluation of mental workload by physiological means.

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UNIVERSITY BURNOUT. ANALYSIS AND IMPLICATIONS FOR NEW STUDENTS AT THE TECNM PUERTO PEÑASCO CAMPUS.

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Resumen: Este proyecto de investigación pretende detectar factores relacionados al burnout en estudiantes de los cuatro programas de licenciatura ofertados en Tecnológico Nacional de México Campus Puerto Peñasco. Como primera fase, se selecciona el grupo de interés que, en este caso, serán los estudiantes de nuevo ingreso a los programas educativos en el ciclo 2022-2023. En la segunda de las fases, se aplica el instrumento el cual consiste en una adaptación del Maslach Burnout Inventory, adaptación que pretende no solo descubrir de forma inmediata casos graves o casos que requieran una pronta intervención del departamento de psicología institucional, sino además brindar información sobre el estado emocional y físico de los encuestados. En la tercera etapa, con apoyo del software SPSS, la información es interpretada y analizada para su uso. Se obtienen estadísticas descriptivas básicas pero útiles para medir el grado en que algunos factores que promueven el burnout están presentes en los estudiantes, factores como la tristeza, dificultad para concentrarse, trastornos del sueño, irritabilidad, consumo de drogas o pensamientos suicidas, etc.

En la última parte, se generan conclusiones y se emiten algunas sugerencias con la finalidad de mejorar este tipo de estudios en instituciones educativas en general.

Palabras clave: Burnout, nuevo ingreso, rendimiento escolar, educación superior, trastornos.

Relevancia para la ergonomía: Promover la identificación y manejo de los síntomas relacionados al burnout presentes en estudiantes de nuevo ingreso a la educación superior y con ello, recomendar acciones que permitan crear estrategias que favorezcan la estadía en su trayectoria universitaria contribuyendo a su bienestar psicoemocional y físico, logrando con ello individuos capaces de realizar sus metas personales y profesionales, aportando en su formación integral, además consiguiendo la disminución de indicadores de rezago y abandono escolar.

Promover también la concientización del desgaste físico y emocional, denominado burnout, ya que solo se le ha dado la importancia en el ámbito laboral y no en el escolar. El estudiante puede considerarse que realiza un trabajo desde el punto de vista psicológico ya que participa en una estructura organizativa con actividades obligatorias. En nuestro país han entrado en vigor leyes y normas que regulan la salud mental de los trabajadores, pero no se han realizado las gestiones pertinentes en el ámbito educativo.

Abstract: This research project aims to detect factors related to burnout in students of the four undergraduate programs offered at Tecnológico Nacional de México Campus Puerto Peñasco. As a first phase, the group of interest is selected which, in this case, will be the new students entering the educational programs in the 2022-2023 cycle. In the second phase, the instrument is applied, which consists of an adaptation of the Maslach Burnout Inventory, an adaptation that aims not only to immediately discover serious cases or cases that merit prompt intervention by the institutional psychology department, but also to provide information on the emotional and physical state of the respondents. In the third stage, with the support of SPSS software, the information is interpreted and analyzed for use. Basic but useful descriptive statistics are obtained to measure the degree to which some factors that promote burnout are present in the students, factors such as sadness, difficulty concentrating, sleep disorders, irritability, drug use or suicidal thoughts, etc.
In the last part, some conclusions are generated, and some suggestions are issued with the purpose of improving this type of studies in educational institutions in general.

Keywords: Burnout, new entry, school performance, higher education, disorders.

Relevance for ergonomics: To promote the identification and management of the symptoms related to burnout present in new students entering higher education and with this, to recommend actions that allow the creation of strategies that favor the stay in their university career contributing to their psychoemotional and physical well-being, thus forming individuals capable of accomplishing their personal and professional goals, contributing to their comprehensive training, also achieving the reduction of indicators of school lag and dropout.

Promote awareness of physical and emotional exhaustion, called burnout, since it has only been given importance in the workplace and not in school. The student can be considered as performing a job from the psychological point of view, since he/she participates in an organizational structure with obligatory activities. In Mexico, laws and norms that regulate the mental health of workers have entered into force, but the pertinent steps have not been taken in the educational field.

1. INTRODUCTION

When talking about burnout, reference is made to a work-related disease, which the WHO defines as: "A syndrome conceptualized as a result of chronic work stress that has not been satisfactorily managed", in recent times in this sense, the same symptomatology is identified in students of different educational levels, it is a syndrome in which the pressure for student life in conjunction with social, emotional, economic factors, it is a syndrome in which the pressure of student life in conjunction with social, emotional, economic, physical and other factors, generate negative responses in which symptoms such as exhaustion develop, not only physical but also mental, which translates into anxiety, disappointment, frustration, rejection, emotions of sadness, anger, fear, among others, considerably lowering the performance of students, who completely lose the desire to continue and the desire to excel. A key aspect of burnout syndrome is the increase in the feeling of emotional exhaustion (Maslach, 1981). In recent times, these factors have intensified, greatly worrying teachers, tutors, managers and other actors related to education.

Aiming to analyze the symptomatology presented in the entry profile of the students of the Tecnológico Nacional de México campus Puerto Peñasco, it has been decided to carry out this study in which factors that promote or influence the burnout levels presented by new students in the Institution's undergraduate programs will be investigated, in order to propose alternatives that allow providing orientation and channeling to the different areas or dependencies, as well as administrative decision making. This project consists of applying an instrument that provides reliable, easy-to-interpret and direct information, which allows obtaining a complete scenario on the level of stress and frustration of the participants. The instrument consisted of a survey of 18 questions related to their emotions, feelings, habits, addictions, among other issues that determine the level of stress they are dealing with. This research concludes that the presence of burnout syndrome in incoming students at the Tecnológico Nacional de México campus Puerto Peñasco allows for the detection of symptomatic levels and constitutes an indicator of possible future difficulties in the educational and professional environment. (Castro Bastidas, 2011).

1.1 Objectives

To identify factors that affect the academic burnout syndrome in the new student community of the Tecnológico Nacional de México campus Puerto Peñasco, through scientific research, for the exploratory analysis of the data and the understanding of the physical and emotional panorama of the generation.

1.2 Delimitation

Academic burnout is a term that encompasses the prolonged disorder of students, thus affecting their ability and motivation to study (Peña, 2020). The present research is focused on exploring factors that could affect some degree of this syndrome and the possible academic repercussions in incoming students 2022, of the four educational programs offered by the Tecnológico Nacional de México Campus Puerto Peñasco.

2. METHODOLOGY

The stages into which the project was divided are shown below:

2.1 Sector identification to be analyzed.

Several studies indicate that the highest percentage of dropouts at the higher education level, regardless of the area of study or specialization, occurs during the first year (Kuz, 2023). It is for this reason that the young new entrants to the different programs were selected as the object of study, thus covering the first stage of the project.

2.2 Measuring instrument selection

The purpose is to observe all those characteristics connected to burnout that may trigger early or medium-term desertion. To carry out the second stage, an instrument consisting of 18 questions was applied to a total of 157 new students out of a universe of 183, that is, 85.8% of this population was covered. The survey was previously applied at the Tecnológico Nacional de México campus Cananea, also belonging to the TecNM network, obtaining valuable results for that institution, hence the decision to apply it to the Tecnológico Nacional de México campus Puerto Peñasco. The results obtained on both occasions were used for the early detection of serious cases in students, channeling and follow-up by the institutional psychology departments.

The instrument used is based on the Maslach Burnout Inventory (Maslach, 1981), which, in its original form, is made up of three areas: emotional exhaustion, indifference and personal efficacy, distributed in items or questions with Likert-type responses. Table 1 includes the questions in the adapted instrument applied.

PREGUNTA		Nada	Poco	Regular	Mucho
1	Me siento triste o afligido (a).				
2	Tengo ganas de llorar constantemente.				
3	Tengo dificultad para concentrarme.				
4	Me siento con falta de confianza en mí mismo.				
5	Tengo dificultad para comprender las cosas.				
6	Me encuentro nervioso (a).				
7	Tengo dificultad para dormir o duermo mucho.				
8	Me irrito fácilmente.				

9	Contengo frecuentemente mis emociones.				
10	Tengo la confianza de platicar de mis problemáticas con personas cercanas				
11	Tengo problemas constantes con miembros de mi familia				
12	Acostumbro a dejar para el último la preparación de los trabajos.				
13	El sueño o el cansancio me impiden estudiar eficazmente en muchas ocasiones.				
14	Con frecuencia pienso que no vale la pena el tiempo y el esfuerzo que son necesarios para lograr una educación del nivel superior.				
15	Me siento habitualmente incapaz de concentrarme en los estudios debido a que estoy inquieto (a), aburrido (a) o de mal humor.				
16	Siento frecuentes deseos de abandonar la escuela y conseguir un trabajo.				
17	He pensado en quitarme la vida.				
18	He consumido drogas o alcohol hasta perder control de mi persona o de manera constante.				

2.3 Measuring instrument application

Stage 3, application of the instrument, was in charge of the Psychology Department. This task was preceded by an induction talk with the objective of sensitizing the students and thus guaranteeing the reliability of the data obtained. The time taken for the induction talk and the application of the instrument did not exceed 1 hour in each of the groups surveyed.

One objective pursued from the beginning was the detection of serious cases. For this reason, the psychology department had access to the name and registration number of each of the persons surveyed, personal data that were omitted once the information passed to the analysis phase.

3. RESULTS ANALYSIS

After the application of the adapted instrument and the analysis in the SPSS package, a Cronbach's alpha of 0.868 was found, which guarantees the consistency or reliability of the questionnaire. The reliability test performed on the instrument was after its application, i.e., no pilot test was performed for validation.

The KMO (Kaiser-Meyer-Olkin) measure was also calculated, obtaining a value of 0.880, which indicates that the instrument, even when modified, is suitable for the detection of internal structures or factors. As a complement to this measure, a Bartlett's test of sphericity was performed, which proved to be significant.

Of the 18 questions included in the survey instrument applied to the 157 incoming students from the different educational programs, 10 were selected for this study. It was considered that they best reflected the exhaustion or burnout that could be present in the students, which could affect academic performance in the short and medium term.

For the first question I feel sad or distressed, Figure 1 shows the findings.

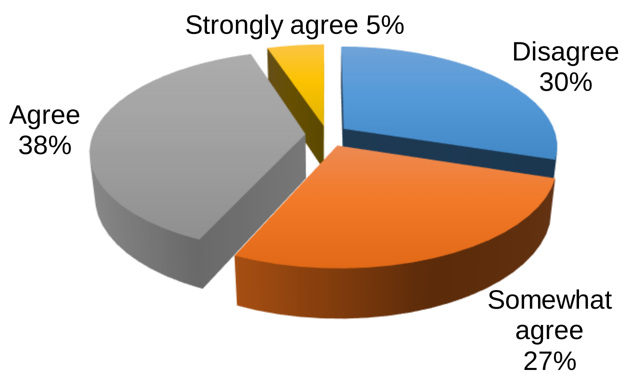

Figure 1. I feel sad or distressed

The above graph shows that 70% of those surveyed declare some degree of sadness or distress. according to the National Survey on Access and Permanence in Education 2021, of the National Institute of Statistics and Geography, in the indicator that sought to measure the emotional situation of the Mexican student population, 8.5% of higher-level students indicated feeling sad or depressed. (INEGI, 2022). If these data are placed in comparative, the difference between the local and national indicator expresses a great relevance and makes evident the importance of deepening on the causes of such level of sadness in the students of the Tecnológico Nacional de México, Puerto Peñasco campus, in subsequent studies.

The next question analyzed is I have trouble concentrating, which shows the following.

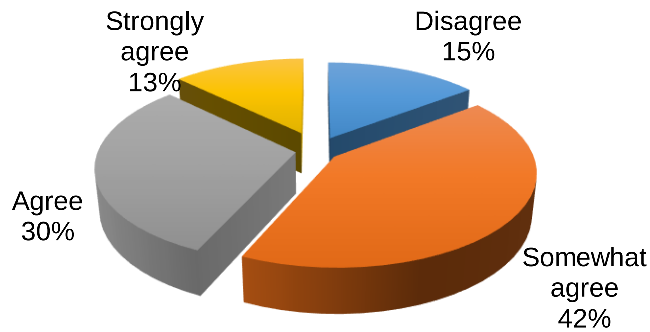

Figure 2. I have trouble concentrating.

Within information processing, that is, the encoding and analysis of stimuli, attention operates in a particular way compared to the rest of the basic cognitive processes (memory, perception), possessing its own characteristics, one of which is concentration, defined as the amount of attention resources devoted to an activity (Londoño, 2009). Knowing that cognitive processes are indispensable for learning, at the university level a greater development of these processes is expected; therefore, it is important to focus the analysis on the 85% of students who express having felt some degree of difficulty in concentrating, in addition to the fact that only 15% mentioned never having felt this difficulty.

Following on with the analysis, when asked the question I find myself nervous, the graph shows that 31% of the respondents are not nervous, as opposed to the high percentage that admit to being nervous due to a particular situation. Figure 3 shows this clearly.

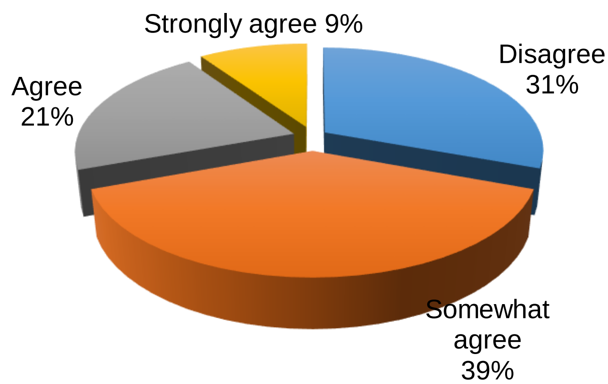

Figure 3. I find myself nervous

The National Health and Nutrition Survey (ENSANUT) in our country revealed a deterioration in the mental health of adolescents and young people (with a higher prevalence in women), an alarming increase in suicide attempts and in the number of people living with depression.

On the other hand, 83% of students reported experiencing some anomaly in their sleep cycle, which directly affects the performance of each of their daily activities, including academic ones. There are approximately 80 sleep disorders, being insomnia the most common, in Mexico 17% percent of the population suffers from it according to Forbes Mexico (2022). The above is important to dimension the results to the question I have difficulty sleeping or I sleep a lot, as shown in the Figure 4.

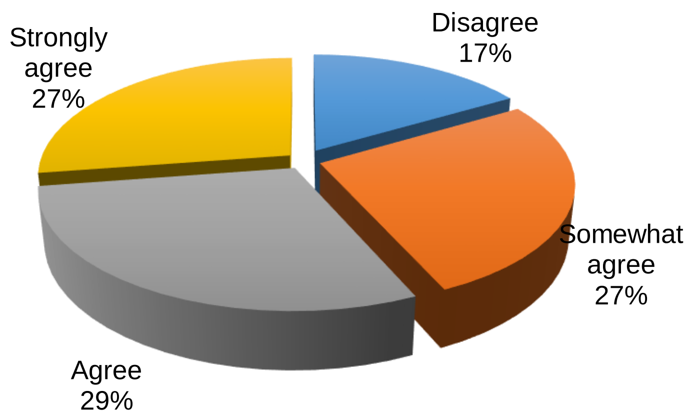

Figure 4. I have difficulty sleeping or I sleep a lot.

Irritability is defined as a low threshold for experiencing anger in response to frustration and is one of the most common symptoms in children and adolescents (Morales y Gutiérrez 2019). The figures obtained in this study about the questioning I get irritated easily, captured in Figure 5, show that at least 71% of the population studied affirms that, to a greater or lesser extent, they present anger reactions due to academic pressures and poor management of these. This indicates that special attention should be paid to mental health care and the correct management of emotions.

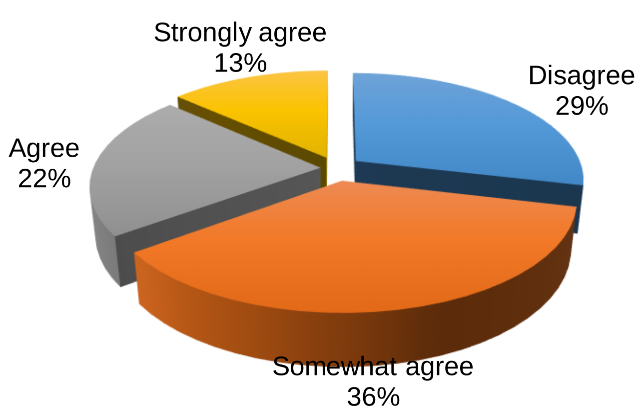

Figure 5. I get irritated easily.

Although the ideal university student is one who satisfactorily meets all the demands of the higher education environment, this is not an absolute reality, since there is a high percentage of students who are not able to succeed academically, because they present, among other phenomena, procrastinating behavior. (Ramos, Jadán, Paredes, Bolaños y Gómez, 2017).

This research determined that 82% of students procrastinate in their academic work to a greater or lesser extent, repeatedly failing to comply with the corresponding responsibilities, perhaps generating low grades in their evaluations and thus losing interest or worse still, acquiring a feeling of inability or inadequacy because they do not perceive themselves as capable of achieving the proposed objectives. The previous is summarized in Figure 6.

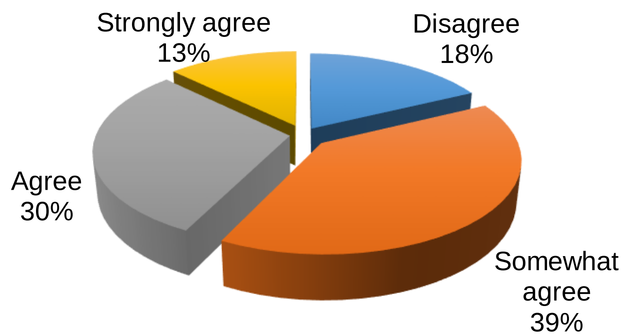

Figure 6. I usually leave the preparation of assignments to the last minute.

One of the most notable characteristics of burnout is that of physical decay or fatigue, which, progressively or immediately, causes the failure to fulfill responsibilities, in this case, low or null academic performance due to failure in the delivery of projects, assignments or exams.

An altered sleep cycle and physical fatigue play a preponderant role in what should be an optimal student performance at any level. Insomnia can generate behavioral problems such as irritability, anxiety, hyperactivity, impulsivity or aggression, in addition to being a risk factor for the development of long-term depression, all these factors are strongly associated with burnout. (Carrillo, Barajas, Sánchez y Rangel, 2018). Figure 7 shows the results obtained in relation to this problem.

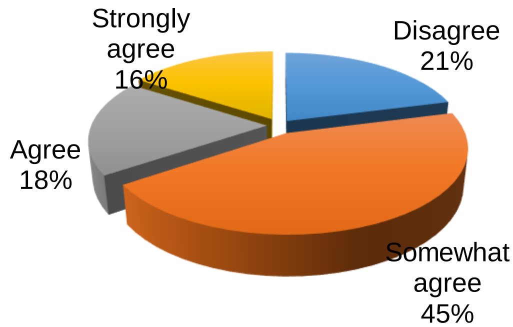

Figure 7. Sleepiness or tiredness prevents me from studying effectively.

Motivation and the determination of personal goals are fundamental factors in achieving a higher education. In this case, about 50% of the students, when asked the question I often feel that it is not worth the time and effort it takes to get a college education mentioned not feeling that the effort and time invested in school are worth it. This low motivation may be the consequence of depression or mental exhaustion. Figure 8 presents the findings in relation to this question.

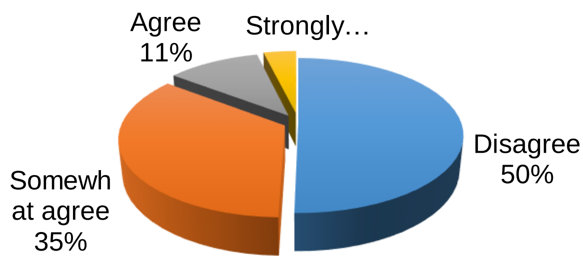

Figure 8. I often feel that it is not worth the time and effort it takes to get a college education.

Continuing with the analysis of the questions, a fundamental indicator in this work is the one related to suicidal thoughts or intentions in students, which was presented as I have thought about taking my own life. Quick action in the presence of this problem is of vital importance. It is for this reason that this item triggered the rapid mobilization by the department of institutional psychology in the presence of responses in the degrees of Somewhat agree, Agree or Strongly agree of the instrument. Due to the seriousness of the case, the analysis was further deepened in comparison with the other questions of the survey, and it was also analyzed whether the answers were directly linked to a particular educational program. As a result of the above, it was found that the Industrial Engineering program did not present any response at levels other than Nothing, a situation that is very interesting.

Official statistics (INEGI, 2022) show that the suicide rate in Mexico in 2021 was 6.5 deaths per 100 inhabitants and the age range where this phenomenon mostly occurs is between 15 and 29 years old, the age range in which the surveyed students are found. The response percentages for the question I have thought about taking my own life are presented in Figure 9.

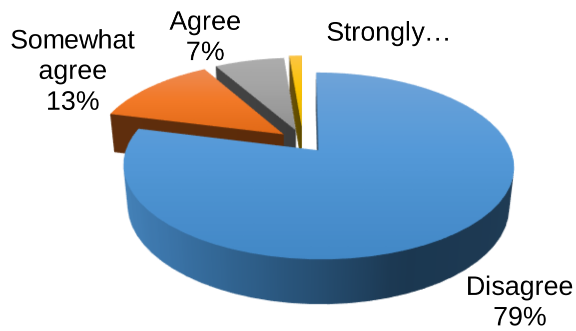

Figure 9. I have thought about taking my life.

Excessive alcohol consumption is a global public health problem due to its social and health burden on the population (Rivera, Séris, Reynales, Villalobos, Jaen y Natera 2021). It has been found that the cause of the consumption of psychoactive substances is associated with the search for identity, autonomy and freedom, new emotions and sensations, escape mechanisms and curiosity (Salcedo, Palacios y Espinosa 2011). It is for this reason that the consumption of drugs or alcohol represents an obvious risk factor for triggering physical and/or mental exhaustion.

The last question analyzed for this study is I have consumed drugs or alcohol until I have consumed drugs or alcohol until I lost control of my person or on a constant basis. It is observed in Figure 10, that 25% of the students recognize having consumed some type of drug (not specified) or alcohol until losing control over myself or on a regular basis.

Two important considerations should be made on this issue, the first is that it is not clear whether the student consumes alcohol or some other type of drug, i.e., he/she only acknowledges consumption, but does not specify which one. The second consideration is that the question mentions consumption until losing control or constant consumption and not only occasional consumption. With this 25% of the responses already speak of a worrying level of consumption among young people.

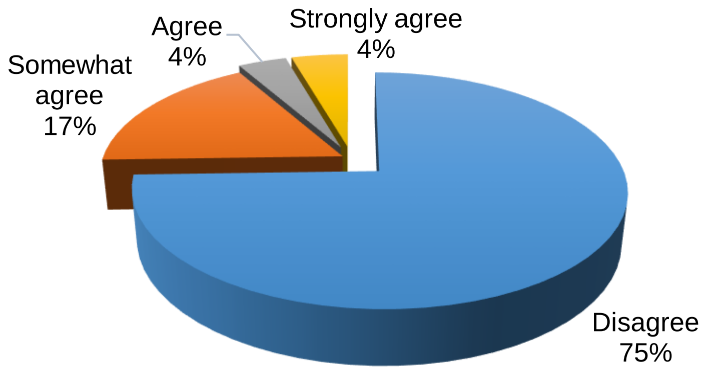

Figure 10. I have consumed drugs or alcohol until I lost control of my person or on a constant basis.

4.CONCLUSIONS AND RECOMMENDATIONS

The problems generated by the burnout syndrome include physical and mental exhaustion, lack of motivation in academic activities and even in common activities, leading to little or no participation of students in their learning process.
Studies on this subject show that this syndrome is the result of the overload of activities, academic pressure, economic situation, lack of support, lack of concentration, competition and social pressure, among others.
Based on the results found and presented in this research, some factors that trigger burnout are present and at a high level in new university students at the TecNM campus Puerto Peñasco. Factors such as sadness, sleep disorders, irritability, concentration problems, consumption of drugs or alcohol, etc.

Strategies focused on individual and institutional well-being should be created. At the individual level, strategies for self-care, mental health and emotional well-being should be promoted. Collectively, the institution must manage the necessary resources to have personnel trained in these areas, recognize burnout as a real problem in the educational environment, and increase the number of activities that promote the well-being of everyone, with actions that produce a healthy academic and work environment.

This research shows once again that burnout syndrome is a complex and multifactorial problem that requires special attention from different areas to prevent and deal with it.

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State of the Art of the application of the Nordic Kuorinka Questionnaire in the Construction Industry in Sonora, Mexico.

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Resumen La investigación descrita atiende a la Ergonomía como herramienta de gestión en la industria de la construcción para la identificación y búsqueda de la disminución de trastornos musculoesqueléticos en microempresas del ramo de la construcción del Estado de Sonora.
Una de las herramientas utilizadas para la identificación de posibles trastornos musculoesqueléticos y áreas del cuerpo afectadas por la exposición al trabajo propio de la construcción, fue el cuestionario Nórdico de Kuorinka. El diseño del estudio fue transversal y correlacional/causal, donde las variables fueron las posibilidades de lesiones por la exposición de los trabajadores a un potencial trauma acumulativo o un trastorno musculoesquelético en un período de tiempo por el desarrollo de sus actividades en la construcción.
El articulo aquí presentado corresponde únicamente a las evidencias encontradas en la bibliografía correspondiente al tema y aquellos estudios que se han desarrollado en el tiempo, los cuales aportan y contribuyen al trabajo en cuestión.

Palabras clave: Cuestionario Nórdico de Kuorinka, Industria de la Construcción, TME.

Relevancia para la ergonomía: Datos solidos de los TME presentes en la industria de la construcción en el Estado de Sonora.

Abstract: The research described deals with Ergonomics as a management tool in the construction industry for the identification and search for reduction of musculoskeletal disorders in micro-enterprises in the construction industry of the State of Sonora.

One of the tools used to identify possible musculoskeletal disorders and areas of the body affected by exposure to construction work was the Nordic Kuorinka questionnaire. The study design was cross-sectional and correlational/causal. The variables were the chances of injury from worker exposure to a potential cumulative trauma or musculoskeletal disorder over a period of time as a result of their construction activities.

The article presented corresponds just with the evidence found in the bibliography corresponding to the subject and those studies that have been developed over time, which contribute to the work in question..

Keywords. Nordic Kuorinka Questionnaire, Construction Industry, TME.

Relevance to Ergonomics: Solid data on TME present in the construction industry in the State of Sonora.

STUDY AND ANALYSIS OF CONDITIONS OF THE WORK ENVIRONMENT IN A FOOD COMPANY IN THE CITY OF GUASAVE, SINALOA

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Resumen Analizar los ambientes laborales en los que los trabajadores están expuestos durante su jornada de trabajo es sumamente importante debido a que eso depende del rendimiento del mismo. La salud ocupacional es la parte que se enfoca en estudiar detalladamente cualquier tipo de riesgo o fuente de peligro que pueda generarle un daño al trabajador, la elaboración del presente documento tuvo como foco central la situación actual en la que se encuentra una empresa alimentaria de la ciudad de Guasave. En los últimos años la empresa ha trabajado de acuerdo con un marco normativo, pero no cuenta con un sistema de seguridad y salud ocupacional completo que se adecúe a las necesidades de la planta una vez que ésta sea rediseñada. Es de vital importancia analizar las necesidades que hay en la empresa, así como también el hacer revisiones constantes para asegurarse que se están controlando y previniendo los riesgos existentes en este tipo de compañía. Se busca un mejoramiento continuo, que permita predecir y minimizar los riesgos y errores presentes.

Es por eso qué este trabajo está enfocado a trabajar con un marco legal aplicable, haciendo propuestas e implementando acciones correctivas para que se cuente formalmente con un programa interno de respuesta ante emergencias; con este se logrará disminuir el número de incidentes en la planta, y realizar un análisis anticipado de las cuotas de seguro y multas, pues habrá requisitos legales para avalar su autenticidad.

Palabras clave: Salud ocupacional, integridad, productividad, requisitos, seguridad.

Relevancia para la ergonomía: Debido que este estudio está enfocado a la salud ocupacional estudiando y analizando factores que puedan poner en riesgo la integridad del trabajador dentro de sus condiciones laborales, tiene una relación estrecha con la ergonomía ya que este estudio busca mejorar las condiciones de la empresa para tener una mejora dentro del área de trabajo y así obtener una mayor eficiencia, eficacia y rendimiento en el trabajador, esto hará que se tenga una mayor productividad de calidad para la empresa.

Abstract: Analyzing the work environments in which workers are exposed during their workday is extremely important because it depends on their performance. Occupational health is the part that focuses on studying in detail any type of risk or source of danger that may cause harm to the worker, the preparation of this document had as its central focus the current situation in which a food company of the Guasave city. In recent years, the company has worked in accordance with a regulatory framework, but it does not have a complete occupational health and safety system that meets the needs of the plant once it is redesigned. It is of vital importance to analyze the needs that exist in the company, as well as to make constant reviews to ensure that the risks existing in this type of company are being controlled and prevented. A continuous improvement is sought, which allows predicting and minimizing the risks and errors present.

That is why this work is focused on working with an applicable legal framework, making proposals and implementing corrective actions so that an internal emergency response program can be formally established; With this, it will be possible to reduce the number of incidents in the plant, and carry out an anticipated analysis of insurance fees and fines, since there will be legal requirements to guarantee its authenticity.

Keywords. Occupational health, integrity, productivity, requirements, safety.

Relevance to Ergonomics: Because this study is focused on occupational health, studying and analyzing factors that may jeopardize the integrity of the worker within their working conditions, it is closely related to ergonomics since this study seeks to improve the conditions of the company to have a improvement within the work area and thus obtain greater efficiency, effectiveness and performance in the worker, this will lead to a higher quality productivity for the company.

1. INTRODUCTION

Legal requirements within industries play an important role since they help to have due compliance with all applicable regulations, to contribute to a better working environment. According to the SEGOB (2021), the NOMs institute measures to ensure the quality, health, and harmonization of the products and services obtained by consumers in Mexico. In addition, it mentions that they are a way of verifying compliance and the authorities or empowered persons who will do so.

There is a great variety of standards, these are divided according to the focused area for their application. Taking care of the integrity of workers is essential for companies since this influences the productivity of workers and therefore that of the company.

Occupational health is used as a way to maintain both the mental, social and physical health of workers within the company and also takes care of the healthy aspects, that is, everything that entails the well-being of the employee. (DeHury & Kumar, 2019)

In this research, an analysis and study of occupational health and safety was carried out, using methodological strategies on legal requirements to improve working conditions in the NO TIF area of a food company.

The manuals have rules and operations which are used by the organization to logically carry out each of the operations and inspect the work activities and avoid repetitions. The activities that make up the processes are complemented by flow charts, forms, and reports that are used in each of the procedures that are carried out in the institution. (Molina, 2016)

To carry out this investigation, a sequence of actions was carried out, which began with: a tour and knowledge of the plant, the analysis of the applicable legal framework, design of the checklists, implementation of the checklists, design and implementation of the risk matrix, report of the corrective action proposal and finally design of the risk map.

The results were positive since it was possible to identify risk areas and areas of opportunity. In which some corrections on compliance with legal aspects were displayed.

2. OBJECTIVES

2.1 General objective

Analyze and study the safety and hygiene working conditions to achieve an improvement in the NO TIF area of a food company in the city of Guasave, by documenting the applicable legal requirements.

2.2 Specific objectives

- Analyze the work environment to detect risk areas for workers.
- Identify legal standards and requirements applicable to the area
- Give proposals for corrective actions to the problems detected.

3. METHODOLOGY

In order to study the NO TIF area of a food company in the city of Guasave, it was necessary to follow a series of steps in order to cover all the important aspects to be dealt with.

Tour and knowledge of the plant

It began with the tour and knowledge of the plant, focused on identifying all the areas of the company, so that they had a clear idea of the situation with which they were working. Subsequently, an analysis was carried out on each of them, as well as data collection.

Analysis of the applicable legal framework

With the previously acquired knowledge, it was possible to investigate the applicable legal framework for its procedures and products, ranging from laws, decrees, regulations and standards that apply to the business and business name of the company.

Applicable legal framework Plant No TIF

Table 1Non-TIF plant legal framework

Political Constitution of the United Mexican States: articles 1, 5 and 123	They protect and guarantee human rights, the exercise and practice of a profession or employment, as well as dignified or decent work.
Federal Labor Law	Rules the right to work, governs labor relations.
Planning Law	Establishes basic norms and principles regarding National Development Planning.
Organic Law of the Federal Public Administration	Establishes organizational bases of the Federal Public Administration.
General law of health	Regulates the right to health with respect to Article 4 of the Constitution.
STPS Internal Regulations	Establishes the scope of competence and organization of the Ministry of Labor and Social Welfare.
Federal Regulation of Safety and Health at Work	Prevents work risks and guarantees safe environments for workers in accordance with the LFT.
General Regulation of Labor Inspection and Applications and Sanctions	Oversees compliance with labor legislation and the application of sanctions for violations thereof in workplaces.
Safety, Hygiene and Environment Regulations at Work in the Federal Public Sector	Establishes mandatory measures in Agencies and Entities of the Federal Public Administration. It prevents illnesses, accidents and improves safety and industrial hygiene conditions.
SECURITY	
NOM-001-STPS-2008	Buildings, premises and facilities
NOM-002-STPS-2010	Prevention and protection against fire
NOM-004-STPS-1999	Safety systems and devices in machinery

NOM-006-STPS-2014	Material handling and storage
NOM-020-STPS-2011	Pressure vessels and boilers
NOM-029-STPS-2011	Maintenance of electrical installations
NOM-034-STPS-2016	Access and development of activities for workers with disabilities
HEALTH	
NOM-011-STPS-2001	Noise
NOM-015-STPS-2001	Elevated or depressed thermal conditions
NOM-024-STPS-20013	Vibrations
NOM-025-STPS-2008	Lightning
NOM-035-STPS-2018	Psychosocial Risk Factors
NOM-036-STPS-2018	Ergonomic risk factors. Part 1: Manual handling of loads
ORGANIZATION	
NOM-017-STPS-2008	Personal protection equipment
NOM-019-STPS-2011	Safety and hygiene commissions
NOM-026-STPS-2008	Colors and safety signs
NOM-030-STPS-2009	Preventive and occupational health and safety services
SPECIFIC RULES	
NOM-003-STPS-1999	pesticides and fertilizers
FOOD/PRODUCT STANDARDS	
NOM-213-SSA1-2002	Products and services. Processed meat products and establishments dedicated to their processing. Provisions and sanitary specifications. test methods

Design of checklists

To design the checklists, the applicable standards mentioned above were taken into account. This checklist format consists of the requirement of the standard and its description, a section where it is marked whether or not this requirement applies to the plant. Finally, there are the observations and corrective or preventive actions for said requirement.

Implementation of checklists

REQUIREMENT	MEETS		OBSERVATIONS	CORRECTIVE ACTIONS
	YES	NO		

Figure 1. Checklist format

It began by filling out the form and ticking to find out which requirements applied and which did not, in the same way corrective actions were established for each one of them.

With the help of this format, it will be possible to analyze the risks and proposals for change for any incorrect situation.

To visualize how the checklists were implemented, a table showing how the form was filled out is shown below.

Table 2Non-TIF plant checklist

REQUIREMENT		MEETS		OBSERVATIONS	CORRECTIVE ACTIONS
		YES	NO		
	OBLIGATIONS OF THE EMPLOYER				
5.1	Show the labor authority, when requested, the documents that this Standard obliges you to prepare.	X		You have official documents to show to the authorities	N/A
5.2	Prepare a study to analyze the potential risk generated by machinery and equipment in which an inventory of all the dangerous factors and		X	There is no document that collects all the information regarding the potential risks of the machinery	Investigate the information required from each piece of equipment in the plant to carry out the risk study

	conditions that affect the worker's health must be made.				

Design and implementation of the risk matrix

In this section, all those factors of environmental conditions that can be an element of annoyance for workers were analyzed, so that in this way they avoid exposing them to situations or sudden changes within the work area. The factors that were taken into account were:

- Ventilation
- Temperature
- Electrical installations
- Lightning
- Noise

Analysis of risk agents

Table 3Analysis of risk agents

RISKS	WHAT IS IT?	GUYS	CONDITIONS	PREVENTION
Physical	All those environmental factors that depend on the physical properties of bodies.	Physical load, noise, lighting, ionizing radiation, high temperature and vibration	Ruptured eardrum, temporary/permanent deafness, increased heart rate. Aggression, anxiety, decreased attention, memory loss	Periodically inspect and verify the correct functioning of the PPE.
Chemical	Environmental agents present in the air, which enter the body through the respiratory, skin or digestive tract.	Dusts, gases, vapors, sprays, mists and metal fumes. Concentrated acids and alkalis, phosphorus	Inhalation of dusts, gases, vapors and fumes	Issue substance handling authorization only to trained individuals.

Biological	Presence of an organism or substance derived from an organism, which poses a threat to human health	Viruses, bacteria, fungi, animal proteins or vegetable substances	Hepatitis B, tuberculosis, anthrax, brucellosis, tetanus, chlamydia psittaci and salmonella	Do not unknowingly expose workers to waste that may contain bacteria or viruses.
Ergonomic	Those related to overexertion, produce musculoskeletal disorders or injuries (MSD) in workers	Improper work postures or lifting procedures, awkward postures, repetitive movements	Inflammatory or degenerative pain and injuries in the back and upper extremities	Designate as much space as possible for workstations, in addition to training them to perform the appropriate movements for their activities.
Mechanic	Factors that can cause injuries due to the mechanical action of machine elements, tools, work pieces or projected materials	Tools, equipment and machinery	Falls from a height, falls at the same level, falling objects, blows or collisions with or by objects, cuts with or by objects	Train employees to handle machinery and create information boards.

Safety at work

The table contains the risks found in the NO TIF plant, as well as a corrective and preventive action for each of them.

Table 4Risks identified in the non-TIF plant

AREA	RISK	SOURCE OF DANGER	ACT OR CONDITION	CORRECTIVE ACTION	PREVENTIVE ACTION	DECREASE OR ELIMINATE	APPLICABLE STANDARD
	Drop	Constantly wet kitchen floor	combination of both	Install floor drainage systems	Take precautions to dry the floor from time to time	decreases	NOM-001-STPS-2008

	Electric shock	Exposed and bad wires	Condition	Cover cables by creating a specific space so they are not exposed	Do not leave cables lying on the floor or outside their designated place	delete	NOM-029-STPS-2011
	Health implications	Paint residue falling on food	Condition	Repaint with the right paint	Improve humidity and heat conditions in the room	delete	NOM-001-STPS-2008
	damage to health	Lack of adequate equipment and machinery in the kitchen	Condition	Place extractors that contribute to ventilation in the kitchen	Do not overload the capacity of the room with odors and smoke	decreases	NOM-004-STPS-1999
	unsanitary conditions	Kitchen	Act	Designate a single space for kitchen cleaning products	Do not leave cleaning products in the same room where food is prepared	delete	NOM-030-STPS-2009
	incidents	Very narrow corridors in all areas	Condition	Design a better arrangement for the objects and equipment that are positioned in the corridors	Do not hog all the available space between aisles	decreases	NOM-001-STPS-2008
	poorly treated diseases	Lack of medical attention and knowledge in employees	Condition	Get help from a professional for emergency situations	Train employees to know how to respond to emergency situations	decreases	NOM-030-STPS-2009

	Spill Hazard	Pots in poor condition in fritangas	Combination of both	Use new cookware to reduce the risk of spillage	Prevent them from falling on the floor and getting dents and change them periodically	decreases	NOM-004-STPS-1999
	accidents	Unstable and inadequate structure in frying pans	Combination of both	Install the appropriate equipment to withstand the high temperatures of the cooking pots	Take care of the installed equipment from splashes or spills of the content in the cooking pot	delete	NOM-004-STPS-1999
	Risk of electric shock	Court	Condition	Properly cover the wiring and plugs. And, fix the cover of the load center	Keep the load center closed and the wiring positioned correctly	delete	NOM-029-STPS-2011
	slips	Spilled water on the floor of the cutting area	Act	Adequate a better place for the water supply	Keep the water tap closed after use	delete	NOM-001-STPS-2008
	setbacks	Obstruction in the ground cut	Combination of both	Install a hose storage attachment	Put the hose in its respective place after being used	delete	NOM-001-STPS-2008
	Hits	Spill of substances that cause	Act	Place non-slip material floor and	Perform daily cleaning	decreases	NOM-006-STPS-2014

		the floor to be slippery		slippery floor markings	of the apartment		NOM-026-STPS-2008
	accidents	Shelves at the top of their capacity and boxes poorly positioned in the warehouse	Act	Design a better distributio n for the shelves and reinforce them	Do not load shelves beyond their capacity	delete	NOM-006-STPS-2014

Analysis and evaluation of risks

Table 5Analysis and evaluation of non-TIF plant risks

RISK IDENTIFICATION						ANALYSIS		ASSESSMENT
No.	P/SP/A/T	DESCRIPTION	ADVERSE EVENT	CAUSES	CONSEQUENCES	PROBABILITY	IMPACT	
1	Production process Plant No TIF	Use of the kitchen to carry out productive activities	Drop	The floor is constantly wet due to the activities carried out in the kitchen	Medical Expenses – Loss of Products Made	2	3	6
2		Use of load center to turn lights on or off in kitchen	Electric shock	Cables without protection or insulation	Medical expenses	2	3	6
3		Preparation of food in kitchen	Health implications	Deteriorating and peeling ceiling paint	Loss of products – Damage to the health of consumers	1	3	3
4		Traffic through the corridors of the plant	incidents	The corridors are very narrow, leaving very little space to move safely	Medical expenses – Loss of product and equipment	4	3	12
5		Use of the packinghouse	Hits	Some of the substances that are stored in that room contain liquids that result in a slippery floor.	Medical expenses – Loss of products	4	4	16
6		Use of finished products warehouse	accidents	Poorly positioned shelves and at maximum capacity	Product Loss – Medical Expenses	3	4	12

Risk Matrix

Table 6. Non-TIF plant risk matrix

ID		ANALYSIS		ASSES SMENT	TREATMENT		
No.	ADVERSE EVENT	P	Yo		DECISION	ACTIONS	INDICATORS
R1	Drop	2	3	6	Decrease	Install floor drainage systems	decreases
R2	Electric shock	2	3	6	Eliminate	Keep the power source devices in the correct conditions	decreases
R3	Health implications	1	3	3	Eliminate	Using the right paint for the ceiling	delete
R4	incidents	4	3	12	Decrease	Walk carefully through the corridors and take care that the space is not cluttered with elements that are not essential	decreases
R5	Hits	4	4	16	Decrease	Be careful with liquid substances and place signs that the floor is slippery	decreases
R6	accidents	3	4	12	Eliminate	Make a better arrangement and stowage of the products in the warehouse	delete

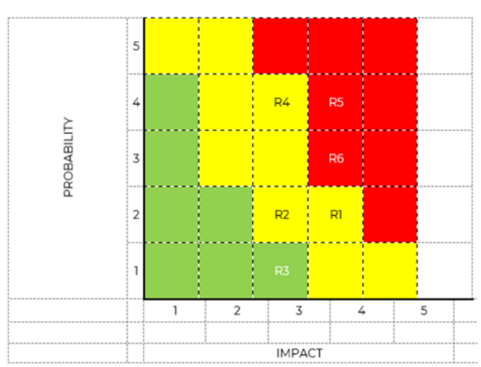

Figure 2Visual representation of the NO TIF plant risk matrix

Color	Risk level	Description
	Low risk	The consequences of these risks do not generate very large damage to facilities or personnel.
	moderate risk	The consequences of these risks can cause losses to the company, but they are remediable.
	High risk	The consequences of these risks generate large losses, it is recommended to develop a contingency plan to prevent their results.

Figure 3Symbology risk matrix plant NO TIF

Corrective Actions Proposal Report

The following proposals for corrective actions to improve the company are presented.

Corrective actions

- Install floor drainage systems
- Cover exposed wiring
- Repaint ceilings and walls
- Install extractor fans in kitchen
- Implement cleaning stations for each production process
- Invest in adequate kitchen utensils (fritangas)
- Renew Fry Cases
- Improve slippery floor conditions
- Reorganize the distribution in the finished product warehouse
- Conservation and repair of real estate
- Maintenance and repair of machinery and work equipment
- First aid kit
- Fire extinguishers
- signs

Design of the risk map

Figure 4Non-TIF plant risk map

3. RESULTS

As a result, some alternatives for corrective actions were obtained for a better optimization of the company within the NO TIF plant, at the end of the investigation the proposals for the risk areas found were made known, all of this so that better conditions are achieved. and thus, avoid and prevent incidents and/or accidents that put the physical integrity of workers at risk.

14 risks were detected to which a corrective action proposal for worker safety was attributed. All this for the benefit of the NO TIF plant seeking to have an improvement within it.

Table 7. Non-TIF plant risk matrix

ID		ANALYSIS		ASSES SMENT	TREATMENT		
No.	ADVERSE EVENT	P	Yo		DECISION	ACTIONS	INDICATORS
R1	Drop	2	3	6	Decrease	Install floor drainage systems	decreases
R2	Electric shock	2	3	6	Eliminate	Keep the power source devices in the correct conditions	decreases
R3	Health implications	1	3	3	Eliminate	Using the right paint for the ceiling	delete

R4	incidents	4	3	12	Decrease	Walk carefully through the corridors and take care that the space is not cluttered with elements that are not essential	decreases
R5	Hits	4	4	16	Decrease	Be careful with liquid substances and place signs that the floor is slippery	decreases
R6	accidents	3	4	12	Eliminate	Make a better arrangement and stowage of the products in the warehouse	delete

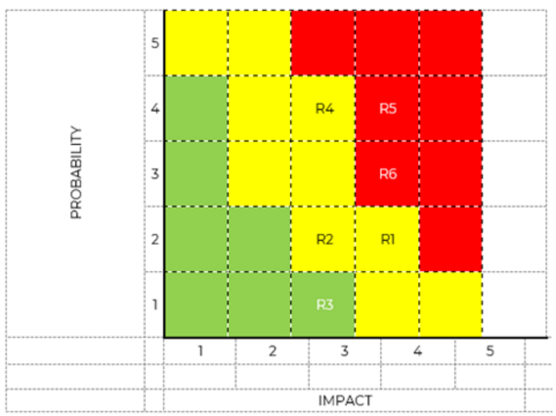

Figure 5Visual representation of the NO TIF plant risk matrix

Color	Risk level	Description
	Low risk	The consequences of these risks do not generate very large damage to facilities or personnel.
	moderate risk	The consequences of these risks can cause losses to the company, but they are remediable.
	High risk	The consequences of these risks generate large losses, it is recommended to develop a contingency plan to prevent their results.

Figure 6Symbology risk matrix plant NO TIF

Figure 7Non-TIF plant risk map

4. DISCUSSION/CONCLUSIONS

The study gave us positive results since the main objective of the investigation was met, which consisted of identifying risk areas for workers within the work environment, also the activities to be carried out within the facilities were established, these activities will help the company in a positive way, obtaining an improvement in benefit to the performance and safety of the workers and the productivity of the company.

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ERGONOMIC EVALUATION OF AN ACCOUNTING OFFICE THROUGH THE ROSA METHOD

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Resumen En el presente artículo se realizó una evaluación ergonómica en un puesto de oficina mediante el método ROSA existente en un despacho contable. El objetivo del estudio es evaluar los riesgos ergonómicos en trabajadores de oficina, a través del método ROSA. Se determinaron molestias musculoesqueléticas con el mapa del cuerpo de Corlett & Bishop, se analizó el trabajo y se aplicó antropometría para finalmente aplicar el método ROSA (Rapid Office Strain Assesment). Como resultados, 4 partes del cuerpo se encuentran en la zona de mayor disconformidad y 5 zonas presentan una ligera molestia; es muy probable que requieran tratamiento siendo las más afectadas la zona de glúteos, espalda baja y cuello. Las puntuaciones del método ROSA para el asiento, pantalla y ratón indican riesgo con un valor global de entre 6 y 7 puntos por lo que se requiere actuación inmediata por lo que se presenta una propuesta de cambios en la distribución de la zona de trabajo y alcances de tal forma que el nuevo diseño pueda resultar mejora para el puesto de trabajo y para la salud de los trabajadores apegándonos a lo que es correcto ergonómicamente hablando.

Palabras claves: Postura, riesgo ergonómico, lesiones, carga estática, método ROSA.

Aportacion a la Ergonomia: Generacion de evidencia de la eficacia en la aplicación del metodo ROSA en el trabajo de oficina (area: fatifga y salud ocupacional)

Summary: In the present article an ergonomic evaluation is performed in an accounting office through the existing ROSA method. The main objective is to evaluate the ergonomic risks of office workers through the following method. Musculoskeletal discomfort was determined though the body map of Corlett & Bishop, so anthropometry was applied once work was analyzed so that the ROSA method (Rapid Office Strain Assessment) could finally be applied. As a result, 4 parts of the body were found in a major discomfort zone. Also, another 5 zones show a slight discomfort; It is likely they receive treatment due to the zones that are being the most affected such as the glute zone, back and neck area. The score obtained by the ROSA method indicates that the chair, screen and mouse show a global value of 6 and 7 which means immediate action needs to be taken. A proposition is made

about changes in the distribution of the workspace and accessibility of tools, this brings a new design that could result in an upgradable workspace and for the wellbeing of the workers while staying close to what is ergonomically correct.

Keywords: Posture, ergonomic risks, injuries, static charge, ROSA method

Contribution to Ergonomics: To generate evidence of the efficiency of the ROSA method when applied in an office workspace (area: fatigue and occupational health).

1. INTRODUCTION

In compliance to the ROSA method, labor of the accounting office was examnied to see if their workspace is ergonomically correct for the amount of hours in which they spend their time performing daily duties. The accountant has an 8 hour shift in which apporximately 7 hours the individual is found in their workspace.

This group of individuals was chosen with the objective of conducting studies due to them showing body discomfort and was also selected to prove if these problems are consecuences of a bad ergonomic codition in the work area.

Figure 1 ilustrates the way in which the officeworker adapts their body so that they can continue with their activites due to the long time they are sitting down infront of the screen while conducting its duites. As observed, the ergonomic design of the desk, screen, and a lack of adjustment of the chair results in a measured value of risk, and an estimated need of taking action to reduce the level of risk.

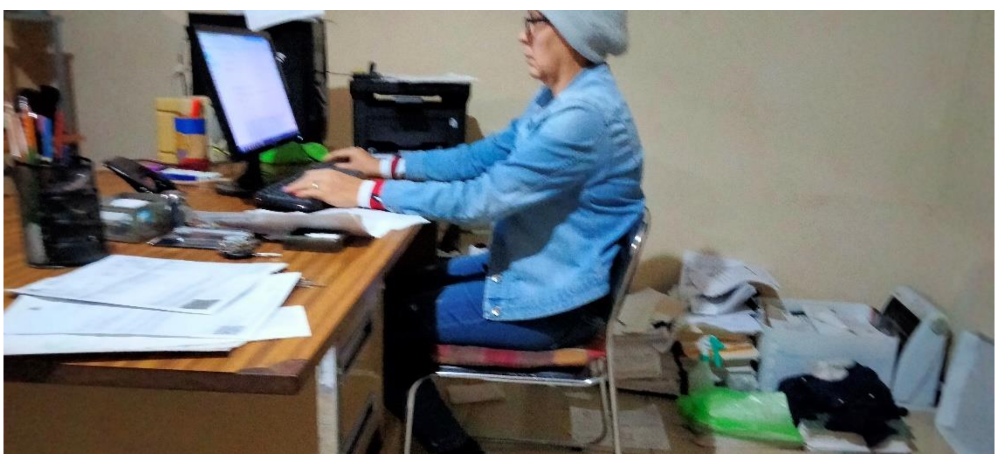

Figure 1: Posture of office workers

2. OBJECTIVES

General Objective: Evaluate the ergonomic risks of office workers through the ROSA method.

Specific Objectives:

1. Identify musculoskeletal risks of the worker
2. Indetifying muscle discomfort through the Corlett & Bishop diagram
3. Apply anthropometry
4. Propose an upgrade

3. METHOLOGY

Office workers were observed in both of their work shiftts for 2 days. On the first day, the morning shift consist of 4 hours and the second shift in the afternoon is a 4 hour period as well.

Before the office worker arrived to their work space , measurements of their station and tools were taken.

Before our individuals arrive to their work area measurements of their body are taken in relation to their work space and parameters that we talk about in the method that is being implemented so an analisys can be conducted.

Once measuremts are finally taken, an observation is done on how the office worker moves while they do their daily tasks, also the ROSA method points out that body and facial reactions are a response to the effort and static weight while conducting their work. When taking notes and grading every area the ROSA method covers while at the same time indentifying the points in which most discomfort is shown according to Corlett and Bishop.

3.1 Determination of Musculoskeletical risks

Basing ourselfs on the Corlett & Bishop map we determined the zones that are most affected by the excesive amount of time in which the office worker conducts its daily activities in what is dictated as an incorrect ergonomic workspace. Figure 2 is a simbolic representation on discomfort shown by the test subject.

As shown in figure 2, zones with the most discomfort are marked as red such as the neck. To be more specific the the nape area; the lumbar region and lower back, this is due to the static charge generated when supporting the weight of the body in a prolonged lapse of time. Also some discomfort is shown in the thighs due to the height of the chair not being the correct 90° its supposed to be if we were to take the knees as the vertices.

The yelllow zones represent a slight discomfort which are more bearable, but at the same time they could cause problems in their shoulders due to the desk and chair not being the necessary height and also not having the correct proportions. In addition an inflamation of the legs due to bad blood circulation which is provoked by its bad positioning. And finally the white zones are those that are not affected by any type discomfort.

A total of 37.5% of the body is in a daily discomfort. Although there is a musculoskeletal discomfort, tierdness of the eyes, headaches, stress and emotional exhaustion are also sypmtoms due to bad ergonomic conditions.

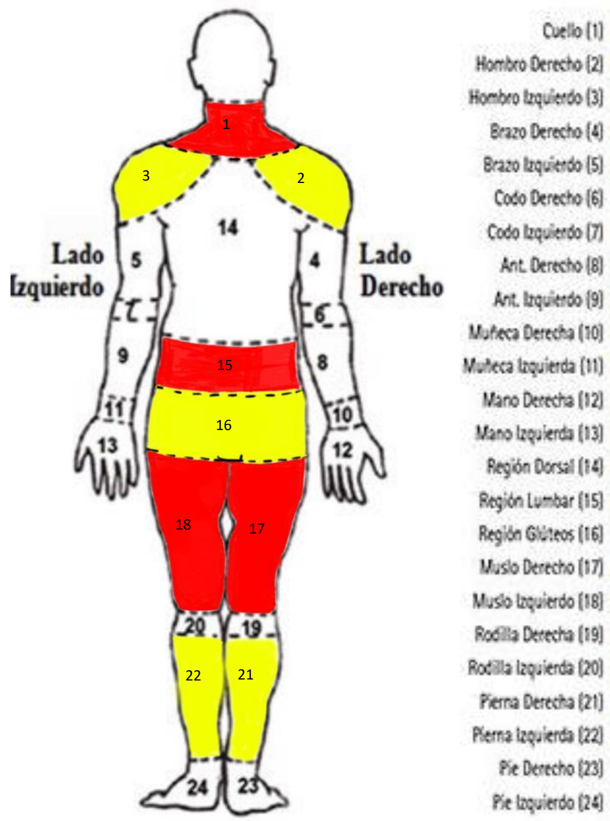

Figure 2: Musculoeskeletical discomfort map

3.2 Measurements of the Workstation

Figure 3 we can see the measurements of once of the work stations in which we notice that the height of the desk is 75.8 cm, height of the chair being 43 cm, 85 cm wide and a longitude of 183 cm.

3.3 ROSA Method

The ROSA method calculates the existent deviation bewteen the characteristics of the evaluated position and the ideal characteristics of an office. For it applying score diagrams that assign a score to each of the elements of the job position: chair, keyboard, mouse and phone.

With the obtained necessary data ponits will be given to each element of the job when applying the diagrams that will be presented later. These diagrams are designed to give a score of 1 if one of the elements in the workstation is ideal. If the workstaion diverts from the ideal score, it gives a higher linear score up to 3. In the other hand certain specific situations conserning each of the elements raise the score obtained by the element (+1). For example if the armrest position is not adjustable it increases by one point. In addition the amount of time the worker uses each of the elements during the shift works to increase or dercrease the points. Once the all five elements of the workspace has been graded according to the ROSA method, partial points and final points of ROSA through consultation of the following tables that will be presented later.

In

Figure 3: Workstation masurements

The value of ROSA points can oscillate between 1 and 10, the higher the number depending on the level of risk. Score values between 2 and 4 indicate a low level of risk, but only if its still upgradable. Points equal or superior to 5 indicates that the level of risk is high. Therefore 5 levels of action are proposed when the final score is determined by ROSA.

The Level of Action establishes that if necessary some kind of action in the work station depending on its urgency and could oscillate between level 0, which idicates that no necessary action is needed until level 4. Four prioritized actions can be established once partial points are obtained for each element of the workstation.

Figure 4: Chair

Figure 5: Posture of the operator (sitting down)

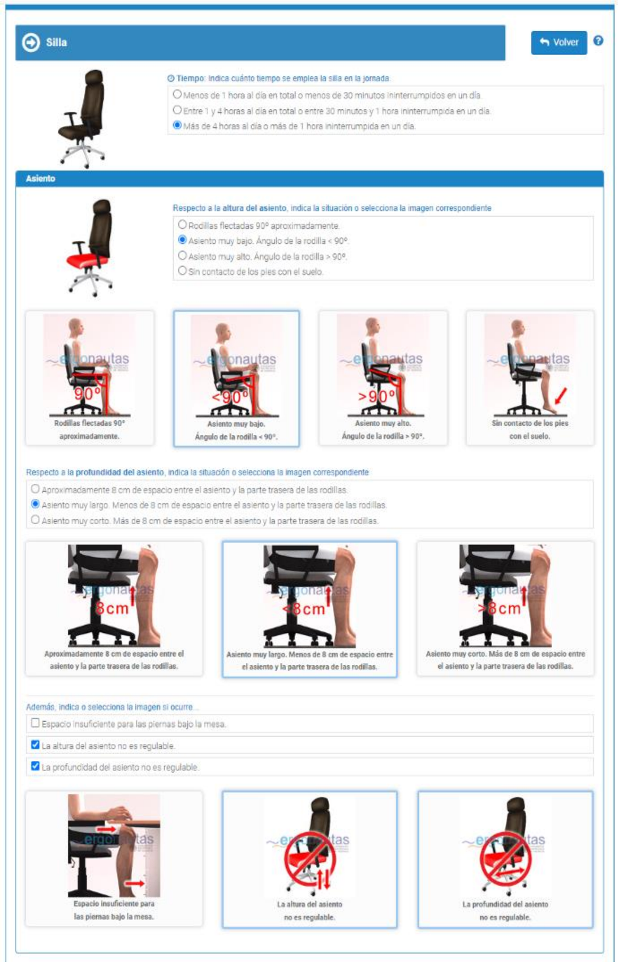

Figure 6: Evaluation of the chair (seat)

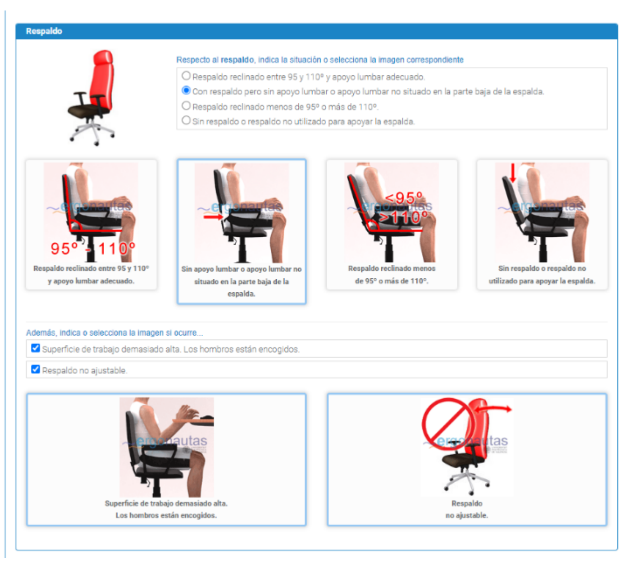

Figure 7: Evaluation of the chair (backrest)

Figure 8: Evaluation of the chair (armrests)

Figure 9: Tool evaluation (screen)

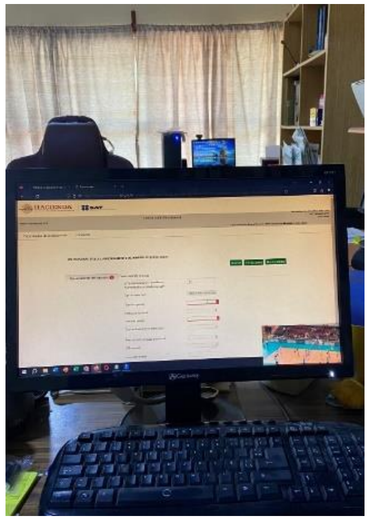

Figure 10: Operator view of the screen

Figure 11: Tool evaluation (phone)

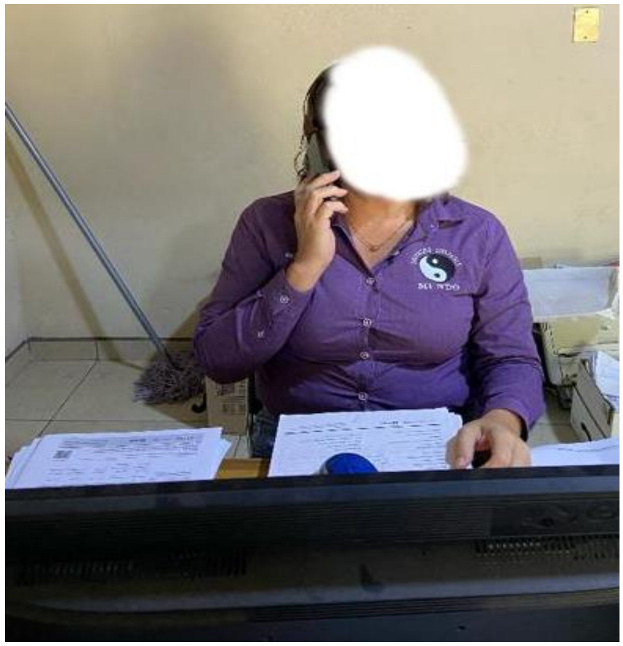

Figure 12: Use of the Phone

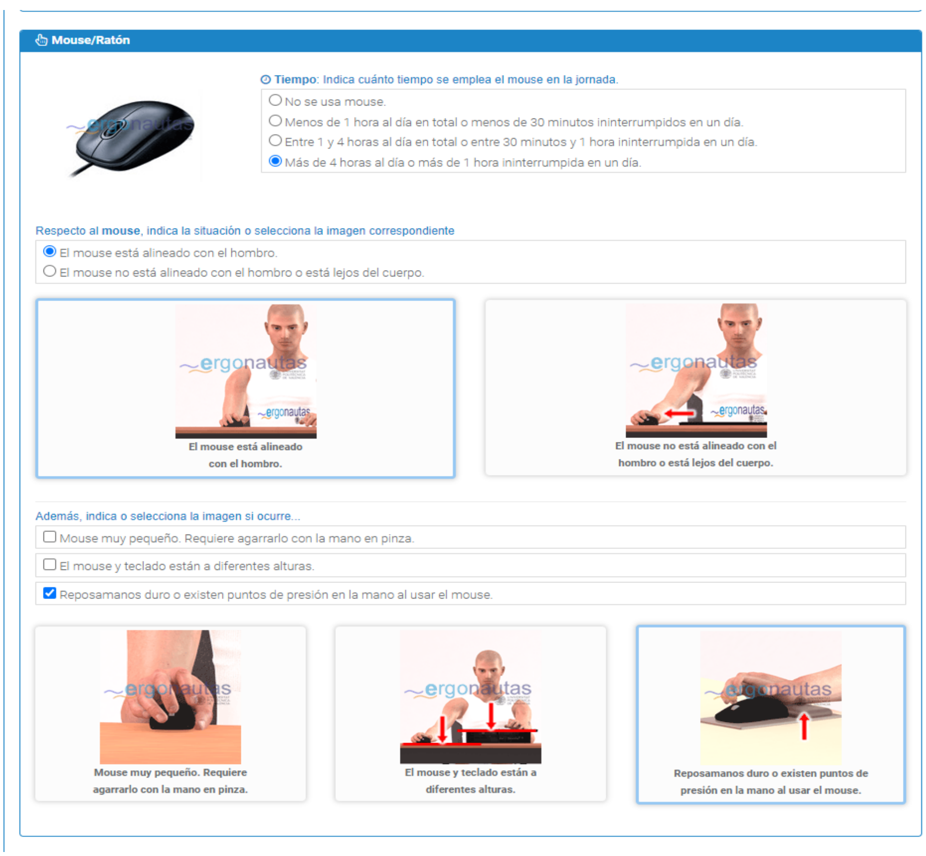

Figure 13: Evaluation of tools (mouse)

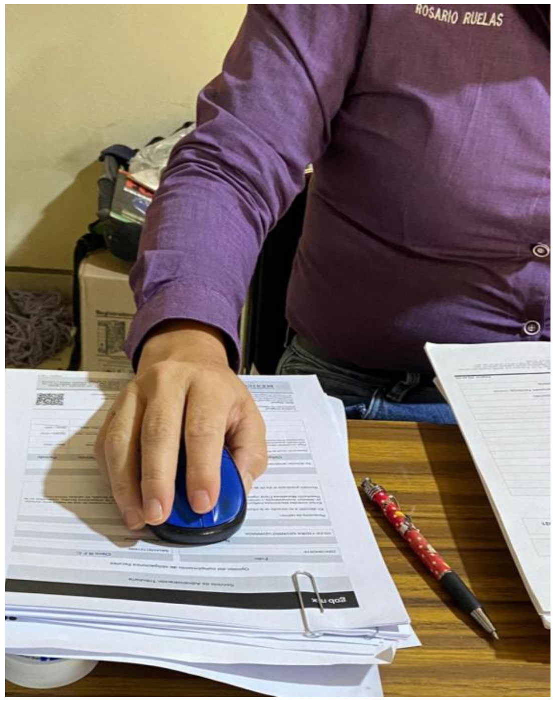

Figure 14: Mouse grip

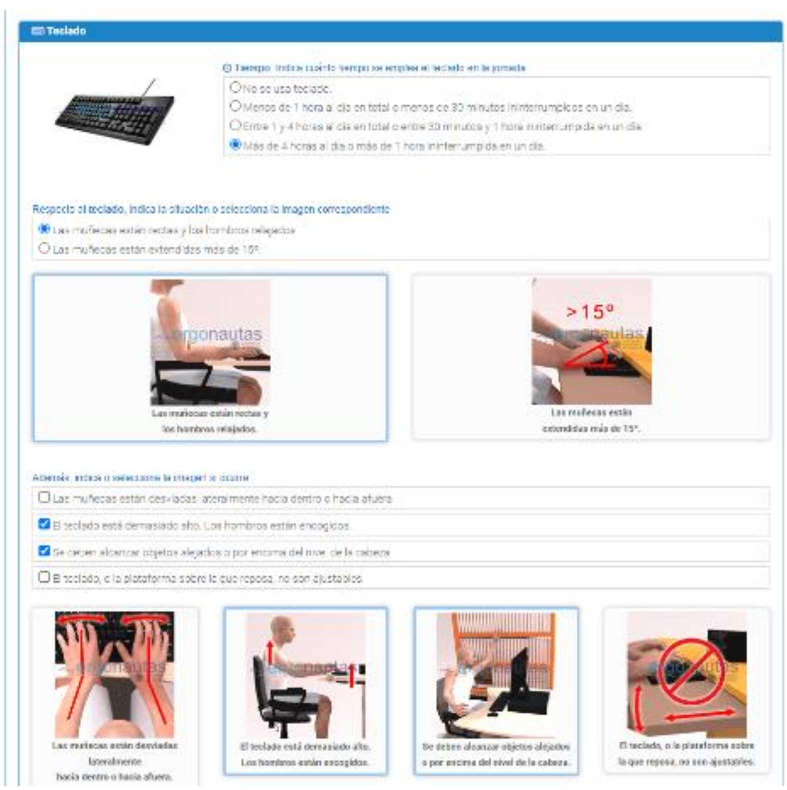

Figure 15: Evaluation of Tools (keyboard)

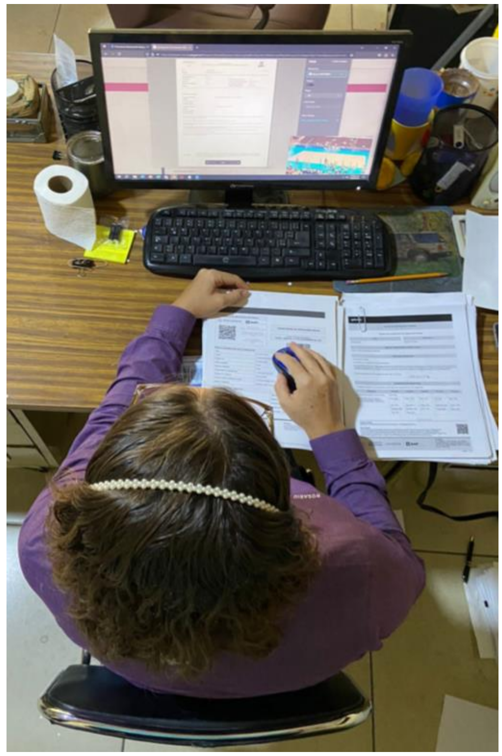

Figure 16: Top view of the operator

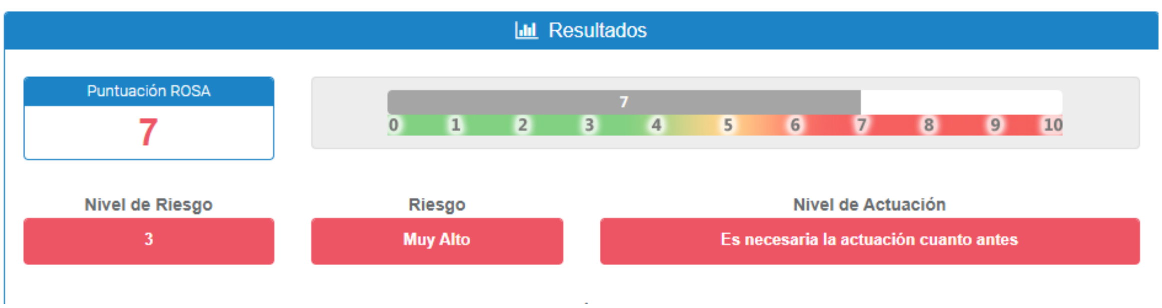

Figure 17: Test results

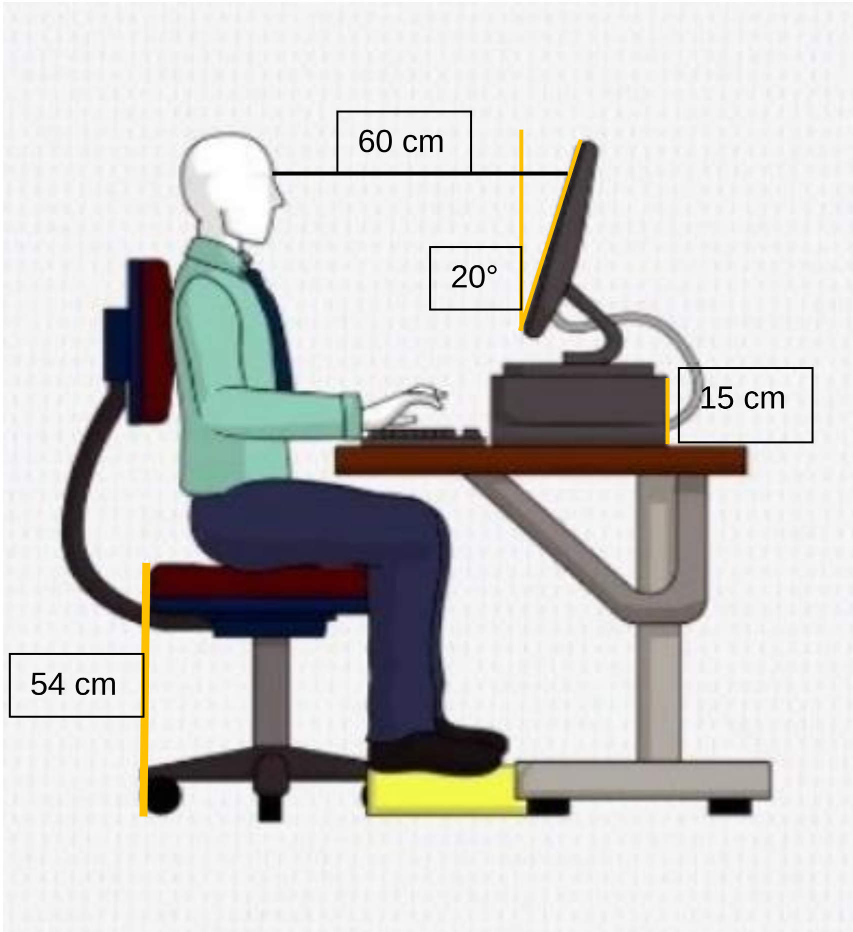

Figure 18: Theoretical improvement

3.4 Upgrade proposal

With this redesign the purpose is to reduce the level of risk and musculoesketical discomfort now that the individual can adjust the height of the chair, so this way they can adjust to a 90° angle with the desirable inclination of their legs, arms, and backrest. Also, keeping the height of the screen up to the subject's eyes at an angle so that their view is not uncomfortable.

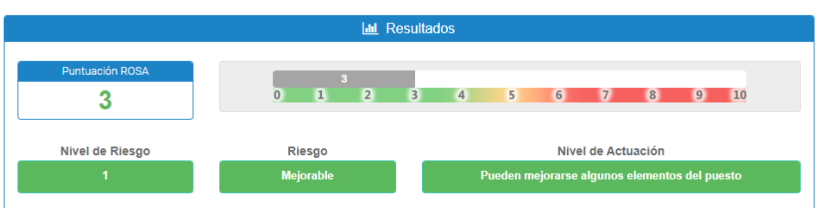

Figure 19: Theoretical results of the redesign

The ROSA method score obtained by the new design of the workspace is a 3 on a scale of 1 to 10. This new score results on a level 1 ergonomic risk which indicates although there is no existent level of important ergonomic risk, its still upgradable and in some respects, they could be optimized so that the circumstances are satisfying for the worker.

3.5 Conclusion

The ROSA method is a valuable tool in ergonomics of an office. Its focus is to rapidly simplify and identify effectively the ergonomic risks on a workspace in a company. Although it's important to remember that the ROSA method is an important tool, it does not replace a better ergonomic evaluation that can be more detailed or complete. This method can be complemented by preventive measures and training programs adequate to guarantee the well-being and health at a prolonged lapse of time for the office workers in a working environment.

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ANALYSIS OF THE MULTIFACTORIAL COMPONENTS IN THE BIOMECHANICAL DECOMPRESSION OF INTERVERTEBRAL DISCS.

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Resumen: Mantener niveles de competitividad que exigen los modernos mercados globales hace que la actividad industrial deba mantener un conjunto de tareas multifuncionales, necesarias en el cumplimiento de los estándares de producción y calidad. Para lograr mantener este estándar de trabajo productivo, se hace necesario establecer una dinámica secuencial operativa en el sistema de operaciones de la industria, donde se contemplan jornada de trabajo extendidas, estaciones de trabajo múltiples, manejo manual de cargas, trabajos repetitivos, secuenciación dependiente. Todo ello, en conjunto y aglutinando el tiempo de exposición al trabajo, generan la posibilidad de que los trabajadores desarrollen en un periodo de tiempo corto lo denominado Trastornos Musculoesqueléticos.

Los Trastornos Musculoesqueléticos de origen laboral referenciados a la columna vertebral son los de mayor incidencia en la actualidad. Siendo la zona lumbar la que presenta la frecuencia más alta en los trabajos donde se hace necesario el manejo manual de materiales. Esta problemática no se ha visto mejorada con los planes y programas de protección lumbar, rotación de puestos de trabajo, soportes lumbares. Por lo que, establecer un plan de prevención que minimice el impacto del trabajo en la columna vertebral, es necesario y urgente. Para ello, se ha diseñado un mecanismo para la descompresión de los discos intervertebrales y la alineación de la estructura ósea – muscular de la columna vertebral. Dicho mecanismo alinea de forma horizontal los acromiones en función a su acción pragmática, a través de la descompresión de los discos intervertebrales, estableciendo con ello una medida preventiva en la operabilidad diaria del trabajador.

El funcionamiento del mecanismo contempla una gran cantidad de variables que intervienen en el proceso de descompresión y aportan un valor significativo en el cálculo del desnivel horizontal de los acromiones. Variables como la altura del operador, sexo, peso, condición ósea, tipo de labor que desempeña, nivel de hidratación, presión arterial, ritmo cardiaco, están en interrelación con el nivel de compresión de los discos intervertebrales.

La estadística multivariante en su técnica denominada componentes principales estructura un mecanismo matemático que valora el impacto del conjunto de variables dependientes sobre una variable independiente, permitiendo al analista

establecer el nivel jerárquico de cada variable dependiente sobre la independiente y la toma de decisiones en cuanto a cuáles variables participarán en el desarrollo del experimento con los niveles de confianza y significancia estadística requeridos por el investigador.

La presente investigación desarrolla un modelo de estadística multivariante para valorar la contribución que mantiene cada variable sobre la nivelación horizontal de los acromiones y llegar a una ecuación matemática que logre pronosticar dicha alineación en función al conjunto de componentes principales que defina el modelo, minimizando con ello el esfuerzo de cálculo, mejorando la precisión del pronóstico y reduciendo la complejidad del mecanismo de descompresión del disco intervertebral. Es importante mencionar que el trabajo investigativo contempla tres partes, primera definida con el modelo multivariante presentado, segunda desarrolla la aplicación el proceso de descompresión sobre una población extensa dedicada a las labores industriales, tercera validación predictiva del procedimiento de descompresión de los discos intervertebrales.

Palabras clave: Descompresión, disco intervertebral, análisis multivariante.

Relevancia para la ergonomía: El presente trabajo investigativo muestra como los análisis estadísticos multivariantes logran reducir el número de variables que intervienen en la descompresión de los discos intervertebrales, en función a la contribución que pueden representar en la variable y establece un modelo matemático para la predicción del nivel de descompresión en el personal objeto de estudio. Con ello, la ergonomía logra establecer la importancia de las mencionadas variables en los procesos de descompresión de los discos intervertebrales.

Abstract (Spanish/English, this order): In order to maintain the competitiveness levels required by modern global markets, industrial activity must maintain a set of multifunctional tasks, necessary to comply with production and quality standards. In order to maintain this productive work standard, it is necessary to establish an operative sequential dynamic in the industrial operations system, where extended working hours, multiple workstations, manual handling of loads, repetitive work, and dependent sequencing are contemplated. All this, together and agglutinating the time of exposure to work, generate the possibility that workers develop in a short period of time what is called Musculoskeletal Disorders.

Musculoskeletal Disorders of occupational origin related to the spine are the ones with the highest incidence at present. Being the lumbar area the one that presents the highest frequency in jobs where manual handling of materials is necessary. This problem has not been improved with the plans and programs of lumbar protection, job rotation, lumbar supports. Therefore, it is necessary and urgent to establish a prevention plan that minimizes the impact of work on the spine. To this end, a mechanism has been designed for the decompression of the intervertebral discs and the alignment of the bony-muscular structure of the spine. This mechanism horizontally aligns the acromion’s according to its pragmatic action, through the decompression of the intervertebral discs, thus establishing a preventive measure in the daily operability of the worker.

The operation of the mechanism contemplates a large number of variables that intervene in the decompression process and contribute a significant value in the calculation of the horizontal unevenness of the acromion’s. Variables such as the operator's height, sex, weight, bone condition, type of work performed, level of hydration, blood pressure, heart rate, are interrelated with the level of compression of the intervertebral discs. Multivariate statistics in its technique called principal components structures a mathematical mechanism that assesses the impact of the set of dependent variables on an independent variable, allowing the analyst to establish the hierarchical level of each dependent variable on the independent one and to make decisions as to which variables will participate in the development of the experiment with the levels of confidence and statistical significance required by the researcher.

The present research develops a multivariate statistical model to assess the contribution of each variable on the horizontal leveling of the acromion’s and to arrive at a mathematical equation that can predict such alignment according to the set of principal components defined by the model, thus minimizing the calculation effort, improving the accuracy of the prognosis and reducing the complexity of the mechanism of decompression of the intervertebral disc. It is important to mention that the research work contemplates three parts, the first one defined with the multivariate model presented, the second one develops the application of the decompression process on an extensive population dedicated to industrial work, the third one is the predictive validation of the decompression procedure of the intervertebral discs.

Keywords. Decompression, intervertebral disc, multivariate analysis.

Relevance to Ergonomics: The present investigative work shows how multivariate statistical analyzes manage to reduce the number of variables involved in the decompression of intervertebral discs, based on the contribution that they can represent in the variable and establishes a mathematical model for the prediction of the level of decompression in the personnel under study. With this, ergonomics manages to establish the importance of the aforementioned variables in the decompression processes of intervertebral discs.

1. INTRODUCTION

The continuous interactivity between the scientific-technological development and the highly competitive requirements of the market, generate a strongly demanding effect of productivity and efficiency in the current productive processes, which in the last link of the productive chain impacts the synergic relationship of the man-machine system and increases the probability of generating complications in the musculoskeletal system of the operator and with it the so-called Musculoskeletal Disorders (Kuorinka, 1998).

Musculoskeletal Disorders are defined as health problems related to a wide range of conditions such as: manual handling of loads, highly repetitive work, working in a bipedal position, extreme temperature conditions(Craig et al., 2013). All these together affect the locomotor system of the human body and lead to inflammatory or degenerative injuries of muscles, tendons, joints, ligaments, nerves and bones. Mostly frequent in shoulders, elbows, wrists, hands and in the spine mainly in the cervical and lumbosacral area(Skals et al., 2021).

Musculoskeletal Disorders of occupational origin specifically referenced in the spine, represent one of the problems with the greatest negative impact on the health and quality of life of workers. In the case of the maquiladora and manufacturing industry located in the Northeast of the State of Sonora, this type of problems represents 62% of the complaints and ailments of the operators. Now then, the Mexican Institute of Social Security in its statistics 2021, shows a high growth of pathologies related to the spine, being its last report of 18.3% of the total of Musculoskeletal Disorders.

The situation described above has not been improved with the application of preventive and corrective measures, ergonomic procedures for manual handling of loads, the use of lumbar supports and calculations of the maximum permissible weight(Li et al., 2017). Therefore, it is necessary to complement these strategies with a procedure that reduces the negative impact of the work on the worker(Kucera et al., 2009).

For the above, a non-invasive alignment procedure was designed to reduce the biomechanical impact of repetitive work and manual handling of loads. The research was directed towards the development of an ergonomic machine for the decompression of the intervertebral disc. The designed procedure concentrates in its first instance, on measuring the deviations of the worker's spine on its central axis of rotation (Skals et al., 2021). These measurements make sense from the application of static dimensional anthropometry, by establishing the orthogonality of the first cervical and its alignment with the coccyx, and the alignment of the acromion’s, this being understood as the difference between the height from the floor to the left acromion and the height from the floor to the right acromion (Howarth et al., 2013). For this purpose, it was necessary to design a posturogram to measure the deviations of the spine.

In its second point, the pragmatic action of the machine is carried out, and the measurement of the deviation of the spine about its central axis of rotation is again contemplated, comparing through statistical procedures the discrepancies between the first and second measurement. In this way, the effect of the pragmatic action of the machine is taken into account.

Having considered the above, it is necessary to contemplate an analysis of the impact of each of the components that are affecting the application of the designed procedure. At the same time, the interaction of a multifactorial set that intervenes in the decompression is observed.

To achieve the above, a multifactorial analysis of each of the components involved in the biomechanical decompression of the intervertebral discs is proposed and the effective contribution of each component in the alignment and decompression of the spine is observed (Abdullah et al., 2023).

2. OBJECTIVES

2.1 General objective:

Assess the multifactorial impact of the main variables involved in the biomechanical decompression of intervertebral discs.

2.2 Specific objectives:

1. Establish the theoretical and methodological foundations through a multifactorial study of the components involved in the intervertebral disc decompression procedure.
2. Structure the functionality of the decompression procedure.
3. Establish the multifactorial model of the main components and their effect on decompression.

2.3 Project boundaries:

The research work focuses on operators involved in manual handling of loads within intermittent production lines with assembly line flows in the export-oriented maquiladora and manufacturing industry in the northeast of Sonora.

3. PROJECT METHODOLOGY

The methodology used in this project is based on a descriptive cross-sectional observational study with a quantitative approach. It consists of three stages:

1. In the first stage, data collection is conducted, focusing on the variables of interest: Difference between the acromions before the pragmatic action of the intervertebral disc decompression machine, age, gender, weight, hydration, and height.
2. The second part of the methodology involves performing a multivariate statistical analysis. This includes applying tools such as multivariate linear regression and multivariate factorial analysis.
3. The third step involves developing a mathematical model to predict the dependent variable based on the independent variables identified as the key factors in the factorial analysis.

4. RESULTS

The observational studies established a cardinality of 60 people who participated in the study, to each of the participants were taken the measurements corresponding to: age, full height, weight, sex, hydration, difference between the height of the acromion's.

These measurements were taken before the pragmatic action of the intervertebral disc decompression machine and once the action was exercised, the process of measuring the difference between the height of the acromion's was carried out again. The second measurement referring to the difference in the height of the acromion's after the action of the decompression machine is considered as a dependent variable of those initially taken. Figure 1 shows the diagram by means of which the data collection was carried out in the observational studies.

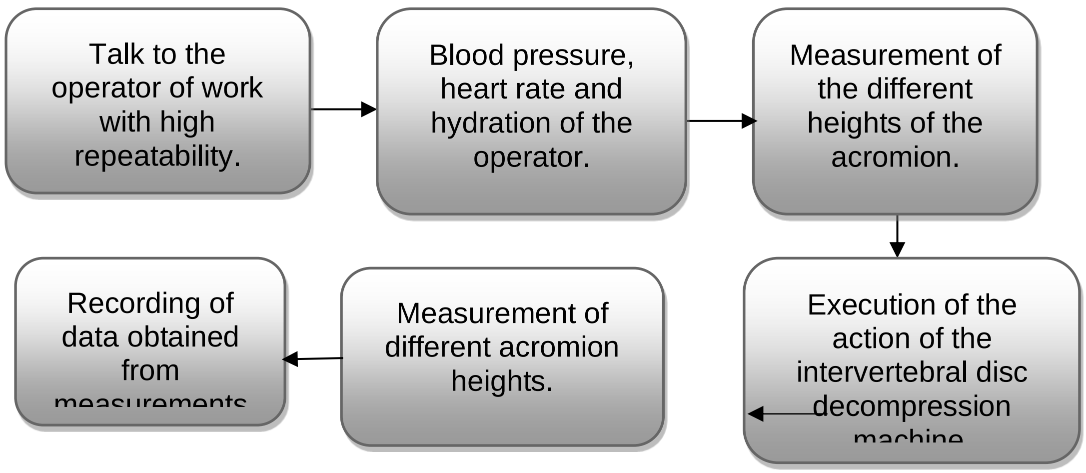

Figure 1: Flow of action of the application of the decompression procedure.

In order to carry out the measurement process, a mechanism was designed to measure the deviation of the spine from its axis of rotation. This mechanism is based on the scientific principles of posturological evaluation.(Vázquez, 2016). Figure 2 shows the measuring procedure.

Figure 2: Measurement template and procedure for measuring spinal column deviation.

Once the measurement processes have been developed, the pragmatics of the decompression machine is carried out, according to the variables obtained for each operator.

As a first multivariate study, a multivariate linear regression is carried out, where the possibility of the data set to comply with the generalized linearity is analyzed, thus being able to generate projections on the effect of the pragmatic action of the decompression machine, according to the independent variables(García et al., 2008).

It is of utmost importance to establish that the variables sex and hydration are dichotomous variables and therefore are not considered in the regression model. Figure 3 shows the results obtained for the multivariate linear function and the anti-image matrix of the factor analysis (Berlanga et al., n.d.).

Resumen del modelo[b]

Modelo	R	R cuadrado	R cuadrado ajustado	Error estándar de la estimación
1	,638[a]	,406	,363	,24313

a. Predictores: (Constante), Diferencia antes , Peso , Edad, Estatura

b. Variable dependiente: Diferencia despúes

Matrices anti-imagen

		Diferencia antes	Edad	Estatura	Peso
Covarianza anti-imagen	Diferencia antes	,904	-,190	,163	,001
	Edad	-,190	,871	,053	-,222
	Estatura	,163	,053	,714	-,346
	Peso	,001	-,222	-,346	,690
Correlación anti-imagen	Diferencia antes	,523[a]	-,214	,203	,001
	Edad	-,214	,475[a]	,067	-,286
	Estatura	,203	,067	,505[a]	-,494
	Peso	,001	-,286	-,494	,498[a]

a. Medidas de adecuación de muestreo (MSA)

Figure 3: Multiple linear correlation coefficient and Anti - image matrix.

As can be seen in Figure 2, the correlation coefficient R is .638, which shows a medium correlation. For this, a factorial analysis is performed with the objective of verifying the impact of each variable and with this, establish a decrease of the variables that entail a possible contribution to the dependent variable(Escalona, 2020).

In this case, it is observed in the anti-image matrix of Figure 3 that the variables age and weight are the variables that contribute the least to the dependent variable and therefore can be eliminated from the multivariate model.

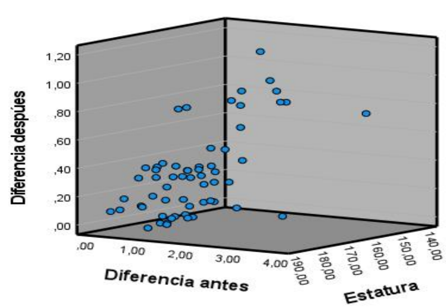

Figure 4: Three-dimensional graph of the variables: Height, Acromion difference before and after the pragmatic action of the decompression machine.

The three-dimensional plots of all the possible combinations of the variables: Difference of acromion's before action, height and weight, establish that the best combination is: Difference of acromion's before action and height.

Figure 4 shows the three-dimensional graph of the variables with the greatest impact on the dependent variable, acromion difference after the pragmatic action of the decompression machine.

It is important to identify that the action of the machine maintains as a central objective that the differences in the heights of the acromion are equal or as close to zero as possible, thus implying that the action improved the alignment of the spine. Based on the above, the linear regression model is set out in Figure 5.

Coeficientes[a]

Modelo		Coeficientes no estandarizados		Coeficientes estandarizados			Correlaciones			Estadísticas de colinealidad	
		B	Desv. Error	Beta	t	Sig.	Orden cero	Parcial	Parte	Tolerancia	VIF
1	(Constante)	,885	,561		1,579	,120					
	Estatura	-,005	,003	-,156	-1,476	,146	-,283	-,192	-,152	,951	1,051
	Diferencia antes	,248	,046	,572	5,400	<,001	,607	,582	,558	,951	1,051

a. Variable dependiente: Diferencia despúes

Figure 5: Multivariate linear regression model.

For this, the mathematical model of multivariate prediction would be as follows:

$$\boldsymbol{Difference\ after} = \mathbf{0.885} - \mathbf{0.005}\ \boldsymbol{height} + \mathbf{0.248}\ \boldsymbol{difference\ before}\ (\mathbf{1})$$

The equation allows us to predict the horizontal alignment of the acromion's according to the anthropometric characteristics of the worker to whom the intervertebral disc decompression procedure is applied. With this we can perform a predictive validation of the designed procedure.

5. CONCLUSIONS

The analysis of the specialized literature does not provide evidence of formal studies defining the advantages of intervertebral disc decompression for workers who carry out their activities in manual material handling.

The processes of decompression of the intervertebral discs are a preventive strategy that reduces the possibility of a worker developing a Musculoskeletal Disorder, as a result of the effort made in their daily activity.

The application of multivariate statistical tools developed in this research has allowed establishing the mathematical model for the prediction of the effect generated by the pragmatic action of the intervertebral disc decompression machine.

This allows framing the studies of intervertebral disc decompression in the variables: difference of acromion's before the action of the machine and stature. Given that these two variables are the ones that reflect the greatest contribution to the dependent variable. The data and equations obtained in the present investigation provide an effective platform for a subsequent predictive validation analysis of the procedure and thus be able to predict the levels of horizontal alignment that an operator can achieve according to his activity and anthropometric dimensions.

The decompression of the intervertebral discs is a preventive mechanism of the degeneration of the intervertebral discs produced by the work activity, mostly defined in the manual handling of materials, so that the establishment of a plan of decompression of the intervertebral discs reduces the possibility of generating a Musculoskeletal Disorder and with them the quality of life of the operator is improved.

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CONFLICT ROLE, OVERLOAD ROLE AND JOB SATISFACTION IN A MANUFACTURING INDUSTRY

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Resumen: Los factores humanos y la ergonomía son una disciplina que se ocupa de la comprensión de las interacciones entre los seres humanos y otros elementos de un sistema que, aplicando principios teóricos, optimizan el bienestar humano y el rendimiento general del sistema. Según el Modelo de Demandas y Recursos Laborales (JD-RM), las demandas laborales están relacionadas con la salud y el bienestar psicosociales de los empleados y con los resultados de la organización. El grado en que las condiciones de trabajo están en armonía con los recursos disponibles y el entorno determina su eficacia. Cuando los empleados manifiestan dificultades de productividad y salud, es posible que se creen efectos adversos en el desempeño de la empresa. El conflicto y la sobrecarga de funciones afectan a la capacidad de los empleados para gestionar el estrés y encontrar satisfacción en su trabajo, así como a la organización en la que trabajan. El objetivo principal de este estudio es investigar cómo afectan el conflicto y la sobrecarga a la satisfacción laboral de los trabajadores a lo largo del tiempo. Participaron 350 trabajadoras de la industria. Se llevó a cabo un estudio longitudinal durante dos periodos de tiempo. Se proporcionaron tres instrumentos a las trabajadoras: La escala de conflicto de roles, la escala de sobrecarga de roles, y la escala de satisfacción laboral (JSS). Se realizó un análisis de regresión jerárquica para determinar si las variables de interés explican una cantidad estadísticamente significativa de varianza en la variable dependiente después de tener en cuenta todas las demás variables. El nivel de significación de todas las pruebas fue del 1 %. El análisis de regresión jerárquica mostró que, en el primer periodo, el conflicto de rol tuvo una relación significativamente negativa con la satisfacción laboral (β = -0,68, $p<0{,}01$). Para el segundo periodo, el conflicto de rol establece una relación directa negativa con la satisfacción laboral (β = -0,25, p<0,01, β =0,36, p< 0,01), nuestros resultados confirman el efecto del conflicto de rol en la muestra. A partir del modelo JD-RM se esperaba encontrar una relación negativa significativa entre el rol de sobrecarga y el rol de conflicto y la satisfacción laboral en ambos periodos. Los resultados revelan una concordancia con el modelo. Dado que la sobrecarga y el rol conflictivo son una variable estructural, se sugiere que los directivos de las empresas den prioridad a sus empleados cuando sea necesario (por ejemplo, con plazos más ajustados). Esta parece ser una estrategia práctica para evitar los efectos perjudiciales de las demandas incoherentes sobre el nivel de satisfacción de los empleados. El aumento de la complejidad y la flexibilidad requiere tareas más exigentes desde el punto de vista cognitivo para los trabajadores. Para mantener el efecto de desafío o mitigar el posible efecto adverso de la carga de trabajo sobre la satisfacción laboral, los directivos deben ser conscientes de este hecho y proporcionar los recursos necesarios (como la orientación tarea-objetivo).

Palabras clave: Estresores, satisfacción laboral, estudio longitudinal, trabajadores industriales.

Relevancia para la ergonomía: Este estudio ha contribuido a la ergonomía organizativa mostrando, desde una perspectiva longitudinal y en entornos de trabajo reales, cómo las exigencias del trabajo influyen en la satisfacción laboral de los empleados.

Abstract: Human factors and ergonomics is a discipline concerned with the understanding of the interactions among humans and other elements of a system that applying theoretical principles, optimize human well-being and overall system performance. According to the Job Demands-Resources Model (JD-RM), job demands are related to employee psychosocial health and wellbeing and organizational outcomes. The degree to which working conditions are in harmony with the available resources and the environment determines how effective they are. Resources are constantly needed to be able to increase work productivity as well as the profits of the company. The company may be disrupted whenever there are employees with productivity and health difficulties. Role conflict and role overload affect employees' ability to manage stress and find fulfillment in their work, as well as the organization where they work. The main goal in this study is to find out how role conflict and role overload affect job satisfaction over time in industrial workers. Participants included 350 female industrial workers. A longitudinal study was carried out over two periods of time. Three instruments were provided to workers during the period of study: Role conflict scale (RCS) and the Role overload scale (ROS), and job satisfaction scale (JSS). A hierarchical regression analysis was carried out and variables to know if variables of interest explain a statistically significant amount of variance in the dependent variable after accounting for all other variables. Significance level for all test was 0.01%. The hierarchical regression analysis shown that for first period, that role conflict had a direct significantly negative relation with job satisfaction (β = -0.68, p=0.01). For the second period, role conflict establishes a direct, significantly negative relation with job satisfaction (β = -0.25, p<0.01, β

=0.36, $p< 0.01$), our results confirm the effect of role conflict in our sample. From the JD-RM model we could have expected a significant negative relation between the overload role and conflict role and job satisfaction at both periods. Results reveal an agreement with model. Since overload and conflict role are a structural variable, it is suggested that managers should try to give group members priority when it is called for (for example, with tighter deadlines). This would seem to be a practical strategy to prevent the detrimental effects of inconsistent demands on the level of satisfaction of employees. Increasing complexity and flexibility necessitate more cognitively demanding tasks for workers. To maintain the effect of challenge or to mitigate the potential adverse effect of workload on job satisfaction, managers should be aware of this fact and provide the necessary resources (such as task-goal orientation).

Keywords. Role stressors, job satisfaction, longitudinal study.

Relevance to Ergonomics: This study contributed to organizational ergonomics showing in a longitudinal perspective and real work settings how the job demands have a role on the self-perceived employee's job satisfaction.

1. INTRODUCTION

According to the International Ergonomics Association (IEA) (2000), Human factors and ergonomics (HFE) is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, that applying theoretical principles, data, and methods to design, optimize human well-being and overall system performance. The IEA also defines organizational ergonomics as a specialized domain of HFE concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes (International Ergonomics Association [IEA], 2023). According to the Job Demands-Resources Model (JD-RM), job demands are related to employee psychosocial health and wellbeing and organizational outcomes. Besides, this model indicates that the persistence of job demands produces an over consumption of energy and may influence employees' wellbeing, resulting in negative outcomes such lower levels of performance, job dissatisfaction and job disengagement (Demerouti et al.,2001).

Due to the global competition in the electronic and electric component sector, the level of job demands has increased, in this circumstance, the number and type of tasks required have changed, as well the relations at work (Bowling et al., 2015). In this context the workers have not only to accomplish the traditional manufacturing cognitive tasks, but they also must deal with the quality control, maintenance, logistics, problem solving and continuous improvement which demands more cognitive abilities (Crawford et al., 2010). Even though these new tasks had a motivational aspect, have also produced an increment in workers job demands (role conflict and role overload) that might block employees' growth due to poor job satisfaction (Croon et al., 2004).

A company requires to have good management to be able to maximize and maintain the quality of each mechanism in each line of business. A key aspect that must be managed is its human resources (Diestel and Schmidt, 2011). As a result, each company's human resources will determine the results to be achieved by the company based on their skills and competencies (Dormann and Zapf, 1999). The degree to which working conditions are in harmony with the available resources and the environment determines how effective they are (Erdogan et al., (2004). Resources are constantly needed to be able to increase work productivity to continue improving job satisfaction as well as the revenue and profits of the company. The company may be disrupted whenever there are many employees with productivity and health difficulties (Fisher, 2014).

The disruption in controversy includes a variety of factors, including a lack of employee passion, which lowers productivity and contributes to a routine that causes frustration and role conflict and overload (Glazer et al, 2005). Role conflict and role overload affect employees' ability to manage stress and find fulfillment in their work, as well as the organization where they work, which has an impact on the quality of work that falls short of expectations (Halbesleben et al., 2014). Role conflict makes workers feel like their work is a burden that must be completed. Work is compelled by circumstances, which prevents it from producing the best results possible in line with the expectations and objectives of the company (Harris et al., 2008). Role overload occurs when an individual is given more work than he or she is capable of handling on his or her own (Hobfoll, 2001).

Employees' emotional responses to their work can be either positive or negative, depending on their job satisfaction (Jensen et al, 2013). Employee perceptions of how well their work provides what is important have a direct impact on job satisfaction. You can use the elements that influence job satisfaction. There are four job descriptive indices including (LePine et al, 2015):

a) wages and salaries, among other payments
b) Do it yourself
c) job advancement
d) Supervision

Job satisfaction can be influenced by the following five factors (Williams and Anderson, 1991):

a) Fulfilling needs: Job satisfaction is based on the extent to which job characteristics allow workers to meet their needs (Le Pine et al., 2005).
b) Discrepancies: According to this model, satisfaction is the result of expectations being met. The degree to which expectations are met reflects the gap between what people want from their jobs and what they receive. People won't be satisfied if their expectations are higher than what they get. Instead, it is predicted that people will be content if they receive benefits that go above and beyond their expectations (Van Scotter et al, 2000).

c) Value attainment: According to the concept of value attainment, satisfaction is the outcome of perceived work that satisfies significant personal work values (Spector et al., 2000).
d) Equity: According to this model, employee satisfaction is a result of how fairly they are treated at work. People are satisfied when they believe that the comparison of work results and inputs is more profitable than the comparison of outputs and other work inputs (Netemeyer et al., 2005).
e) Genetic and dispositional factors: Some coworkers or friends seem to be okay with changes to the workplace, whereas others seem to be unhappy. This model is based on the idea that personal characteristics and genetic factors play a role in job satisfaction. According to the model, individual differences only matter in terms of explaining job satisfaction and workplace characteristics (Schaubroeck et al., 1989).

Role conflict is when there are two or more expectations for different roles in a job that are incompatible with one another (Tang et al, 2007). When a worker has a conflict between his responsibilities and the tasks he needs to complete, this is known as role conflict (Perrewé et al, 2005). The obligations he must fulfill that, in his opinion, are not a part of his work. Conflicting assertions made by people he regards as important, such as superiors, subordinates, or others. Going against his personal morals and convictions while performing his job duties (Örtqvist, 2006).

Employee perceptions of aspects connected to the type of role conflict are affected by several factors (Jex et al., 2001), including:

a) An employee's interpretation of conflicting role expectations from a role sender (such as supervisors, coworkers, or subordinates) is referred to as intra-sender conflict (Hobfoll, 1989).

b) The employee's interpretation of role expectations that are out of sync or in conflict with different role-set members (such as superiors, coworkers, or subordinates) is an example of inter-sender conflict (Grandey et al., 2012).

c) The employee's interpretation of the various demands of the two or more roles that must be played concurrently is included in inter-role conflict (Gilboa et al, 2008).

d) Conflict between the employee's perception of their role expectations and their values, codes of conduct, or abilities is known as a person-role conflict (Ford et al., 2014).

A situation known as role overload occurs when a person is given more work than they are capable of handling on their own. Role overload is a priority conflict that results from expecting someone to complete a big task that can't be done in a short amount of time.

Role overload's effects:

a) Harmful and counterproductive to achieving one's objectives.

b) Resulting in a lack of job satisfaction and a desire to remain employed by the company.

Role overload warning:

c) Work under time constraints (a deadline is imminent);

d). Work under pressure.
e) Complete challenging assignments.
f) Carrying out unimportant tasks.
g) Inconsistent supervisory attitude.

The main goal in this study is to find out how role conflict and role overload affect job satisfaction over time in industrial workers.

2. OBJETIVES

The aim of this study is to analyze the impact of job demands (role conflict and role overload) on job satisfaction over time (two periods in a year).

The following are the research questions:

a) What is the impact of role conflict on job satisfaction?
b) What is the impact of role overload on job satisfaction?

The following premise serves as the basis for this study:

a) There is a relationship between role conflict and job satisfaction.
b) Role overload and job satisfaction are related.

3. METHODOLOGY

3.1 Participants

This study was conducted after a new product line was installed in an electronics and electric connector manufacturing industry, during the product transferring process. Participants included 350 female industrial workers. Two hundred of participants were in the first period and the rest in the second one. The participants sample had to produce the optic fiber harnesses for automotive business. These workers had a variety of skills, and they oversaw production, quality, maintenance, problem-solving, and continuous improvement tasks. Participants voluntarily agreed to complete the questionnaire containing the relevant variables. They were made aware of the survey's anonymity policy and its intended use for research.

3.2 Study design

A longitudinal study was carried out over two periods of time. The first data collection was gathered after three months of work in the new process and the second data collection was accomplished a year after the first one. The sample consisted of 200 workers at first period and of 150 workers the second one. The sample size reduction at period two was due to the fact one of the 12-hour shift group was removed.

Two meeting were set in this study, the first one session was implemented to explain the purpose of study and procedures and the second session was conducted a year later to complete the two periods of analysis. Since the changes (workforce reduction at second period) were made at the company's discretion, no discernible difference was anticipated between the original sample and the dropouts. However, several t-tests between the first period and second period samples were run among the participants to validate the variables.

3.4 Materials

Three instruments were provided to workers during the period of study: Role conflict scale (RCS) and the Role overload scale (ROS), and job satisfaction scale (JSS). Instruments were self-answered by workers during the two periods of data gathering. Role conflict was assessed using the Rizzo et al. (1970) scale, which Peiró, Meliá, Torres, and Zurriaga (1986) modified and validated. This scale of six items measured the extent to which the subjects had to deal with conflicting demands, a lack of resources, or unnecessary tasks.

The Role overload scale was created for this research and consists of three items that ask workers whether they can handle their current workload, the current work pace required for the position, and the extent to which they must exert more effort than before to complete the task at hand. The job satisfaction scale (JSS), which consists of 8 items, was created using the traditional dimensions of job satisfaction, the questions considered inquired about inquired about employee satisfaction with coworkers, managers, the new working system, rewards, and group outcomes. The control variable was the period. As a control variable, the length of time spent on the same team was employed.

3.5 Procedure

The Independent variables (role conflict and role overload) were measured with the Role conflict scale (RCS) and the Role overload scale (ROS). The first scale asked to what extent the workers had to deal with incompatible demands, lack of resources or unnecessary tasks. The second scale asked whether the workers could deal with the current workload, the current work pace demanded for the job and to what extent they had to make more effort than before to get the work done. The dependent variable: job satisfaction was measured with the job satisfaction scale (JSS). The JSS asked for the satisfaction level with work mates, supervisors, new working system, rewards, and group outcomes. A Likert scale was used to all three instruments. The first data collection took place at the ending of the official first follow-up session, and the second collection took place after the formal follow-up session a year later.

The data measurements were made to identify potential areas for improvement within each group. To identify some areas for ongoing improvement for both the teams and their managers, the results of the questionnaire were presented to all groups and their managers as part of this follow-up process.

3.6 Statistical data analysis

Means, standard deviations, correlations, and internal consistency (Cronbach's alpha) was calculated for all variables. A hierarchical regression analysis was carried out and variables were introduced in blocks into the regression equation to know if variables of interest explain a statistically significant amount of variance in the dependent variable after accounting for all other variables. Significance level for all test was 1%.

4 RESULTS

4.1 Sample demographics

Participants of sample were woman (100%). Table 1 shows that women were aged between 21 and 45 years with a mean of 28.69 and standard deviation of 5.6 years. This was a young worker population.

Table 1 Demographic characteristics of the sample n=350.

Demographic Characteristics	Variables	Values
Age (years)	Mean	28.69
	Range	21-45
	Standard deviation	5.6
BMI (kg/m^2)	Mean	27.83
	Range	23.71-34.31
	Standard deviation	3.89
Marital status (%)	Married	125 (35.71%)
	Single	225 (64.29%)

Almost a third of the sample was married, and BMI is ranging between 23.71 and 34.31.

4.2 Standard Deviation, correlation index and internal consistency

Table 2 presents standard deviation, correlation, and internal consistency (Cronbach's Alpha index). Reliability coefficients were satisfactory for all variables.

Table 1 Means, standard deviations, correlations, and scale's reliability.

Period	Variable	Mean	Standard deviation	1	2	3	4	5
1	Role conflict	3.25	0.85	0.25				
1	Role overload	4.31	0.69	0.12	(0.89)			
1	Job satisfaction	3.85	0.58	0.09	-0.05	(0.85)		
2	Role conflict	3.58	0.26	-0.15	-0.65*	-0.15	(0.87)	
2	Role overload	2.89	0.86	-0.25	0.46*	-0.27*	-0.68	(0.76)
2	Job satisfaction	4.28	0.15	-0.09	-0.42*	-0.28	-0.09*	0.12

Note: Cronbach's Alpha is shown along the diagonal in parenthesis.
n first period = 200, n second period 2=
150, *p <0.01

4.3 Hierarchical regression analyses

There were several hierarchical regression analyses performed. Three blocks were used to add variables to the regression equation. The control variable was the length of first period. The primary effect of role conflict was covered in Step 1. The Role overload effect was added in Step 2, and the interaction between role stressors was entered in Step 3. The value of the variables included in role stressors were multiplied earlier to create new variables. We examined the change in variance explained (ΔR^2) in Step 3 to assess the interaction.

The hierarchical regression analysis shown in Table 3 pertaining to first period, it demonstrates that role conflict establishes a direct significantly negative relation with job satisfaction at period one (β = -0.68, p=0.008).

Table 3 Moderated Role conflict on job satisfaction on first period.

Variable	Step 1	Step 2	Step 3
Control variable:			
First Period	0.00	0.00	0.00
Main effects:			
Role Conflict		-0.68	-0.87
R2	0.005	0.218	0.458
Model F change	0.5	18.28*	25.5*
ΔR^2	0.005	0.258*	0.187*

Note: Coefficientes reported are non-standardized regression
coefficientes. Sample size period one= 200 workers.
* p<0.01

Role conflict maintains its negative predictive effect across the three steps tested. From these results we can determinate that role conflict has a negatively related to job satisfaction.

For second period, role conflict establishes a direct, significantly negative relation with job satisfaction, according to the hierarchical regression analysis (β = -0.25, p<0.01, β =0.36, p< 0.01), as shown in Table 4.

Table 4 Moderated Role conflict on job satisfaction on second period.

Variable	Step 1	Step 2	Step 3
Control variable:			
Period 2	0.00	0.00	0.00
Main effects			
Role Conflict		-0.25	-0.36
R2	0.085	0.445	0.447
Model F change	1	23.5*	68.5*
ΔR^2	0.015	0.356*	0.698*

Note: Coefficientes reported are non-standardized regression
coefficientes. Sample size period two= 150 workers.
* p<0.01

Role conflict maintains its direct negative predictive effect even though group members have been working together for a year. Role conflict is the variable that establishes a significant negative relationship with job satisfaction in both periods.

Role overload establishes a direct positive connection with job satisfaction at period one in all steps (β =0.33, *p* < .01; β =0.89 p=0.019, as shown in table 5. The same direct positive connection is found in period two ((β =0.45, *p* <0.01, β =0.78 p<0.01 (Table 6).

Table 5 Moderated Role overload on job satisfaction on first period.

Variable	Step 1	Step 2	Step 3
Control variable:			
Period 1	0.08	0.08	0.07
Main effects.			
Role Overload		0.33	0.89
R2	0.036	0.365	0.486

Model F change	1.58	15.23	17.88
ΔR^2	0.025	0.354*	0.488*

Note: Coefficients reported are non-standardized regression coefficientes. Sample size period two= 200 workers.
* p<0.01

Table 6 Moderated Role overload on job satisfaction on second period.

Variable	Step 1	Step 2	Step 3
Control variable:			
Period 2	0.05	0.04	0.03
Main effects:			
Role Overload		0.45	0.78
R2	0.085	0.445	0.447
Model F change	1	23.5*	68.5*
ΔR^2	0.025	0.345*	0.789*

Note: Coefficients reported are non-standardized regression coefficients
Sample size period two= 150 workers.
* p<0.01

Hierarchical regression analysis showed that role conflict has a direct significantly negative relation with job satisfaction at both periods of study. In relation to role overload there is a positive connection with job satisfaction in the two periods.

5 CONCLUSIONS

To explain job satisfaction over time, this paper examined the direct and modulated roles of two role stressors (conflict and overload). The study was carried out in a real working environment using the same sample at two different periods, with a year elapsing between the first and second data collection. It's important to emphasize at this point how little research there is on this topic over the long term. They were found the following results: First (Hypothesis 1a), our data support the notion that role conflict has a direct negative impact on job satisfaction, as has also been extensively reported in Eatough et al., (2011), Gilboa et al., (2008); Griffeth et al., (2000), and LePine et al., (2005). In line with the two-factor stressors theory (Cavanaugh et al., 2000; Podsakoff et al., 2007), our results confirm the effect of role conflict in our sample. From the JD-RM model we could have expected a significant negative relation between the overload role and conflict role and job satisfaction at both periods. Results reveal an agreement with model. Since overload and conflict role are a structural variable, it is suggested that managers should try to give group members priority when it is called for (for example, with tighter deadlines). This would seem to be a practical strategy to prevent the detrimental effects of inconsistent demands on the level of satisfaction of employees. Increasing complexity and flexibility necessitate more cognitively demanding tasks for workers. To maintain the effect of challenge or to mitigate the potential adverse effect of workload on job satisfaction, managers should be aware of this fact and provide the necessary resources (such as task-goal orientation).

Declaration of competing interest

The authors affirm that no commercial or financial connections existed that might be interpreted as creating a conflict of interest during the conduct of the study.

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APPLICATION OF NOM-035-STPS-2018 THROUGH PDCA METHODOLOGY, IN A METAL MECHANICAL COMPANY

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Abstract: The purpose of this project was to evaluate and analyze, as well as carry out a part of the application of NOM-035-STPS-2018, in a manufacturing plant located in the city of Tijuana, said plant belongs to the business of metal mechanics, a plant with risk level IV. The main objective was to generate an investigation through the partition of the reference guide questionnaires I, III and V, to generate a study with the purpose of evaluating the psychometric properties in relation to the psychosocial risks that may arise.
Keywords: Psychosocial, ergonomics, stress, risk, NOM-035-STPS-2018.
Relevance for ergonomics: This Research has an impact on the analysis, identification and prevention of factors that may be a psychosocial risk in the health of company workers.

1. INTRODUCTION

Stress is one of the most common psychosocial factors, it is even associated with the symptom of being burned or also called Burnout (for its translation into English); It is characterized by being a response to chronic work stress that entails activities of a negative nature in their work performance (Intriago, 2019). It is a pathology derived from the interaction of individuals with certain criteria or under psychosocial conditions considered harmful, also another of the increasingly recurring factors is workplace harassment or mobbing.

Stress is one of the main problems in the work environment that causes mental repercussions as a consequence of the work environment (R Mejia, et al., 2019).

According to the World Health Organization (WHO, 2015) defines stress as "Work stress is a series of emotional, psychological, cognitive and behavioral reactions that result from overwhelming events or require a certain type of content, organization and environment, which in this case it is work".

According to Cruz Martínez, López, Cruz, & Llanillo (2016) "Stress represents a loss between 0.5% and 3.5% of the countries' GDP. Although there are no statistical data on the economic losses that work stress produces in Mexico, these estimates would mean approximate losses between 5,000 and 40,000 million dollars (USD), on average about 0.3 trillion Mexican pesos per year."

The Secretary of Labor and Social Welfare (2018) establishes the official standard NOM-035-STPS-2018, which aims to "establish the elements to identify, analyze and prevent psychosocial risk factors, as well as promote a favorable organizational environment in the workplaces" (STPS, 2018).

A favorable organizational environment must be promoted to promote the good performance and development of workers, as well as their physical and mental well-being (Duarte Castillo, 2021).

2. OBJECTIVE

The objective of this research is to apply the NOM-035-STPS-2018 in the metal-mechanic company, as a precautionary measure of stress and consent of stress in employees, to avoid economic impacts in fines, closures and loss of permits.

3. DELIMITATIONS

The project takes shape in a laminating and sewing company located in the city of Tijuana, Baja California, through the medical service company V y R occupational health advisers.

4. METHODOLOGY

This project is based on a methodology with a history of success to solve problems and is based on continuous improvement through phases that allow planning against the current situation, developing the project, verifying results and implementing a solution, known as: PDCA by its acronym in English from Planing, Do, Check and Act (Dewi, Rachmawatyc, & Kadek, 2021).

4.1 Plan

The planning was the first part of the research cycle where the first structure of this was defined, a previous planning was carried out where various scenarios were contemplated to which the research could be presented, reflected in the following flowchart see Figure 1.

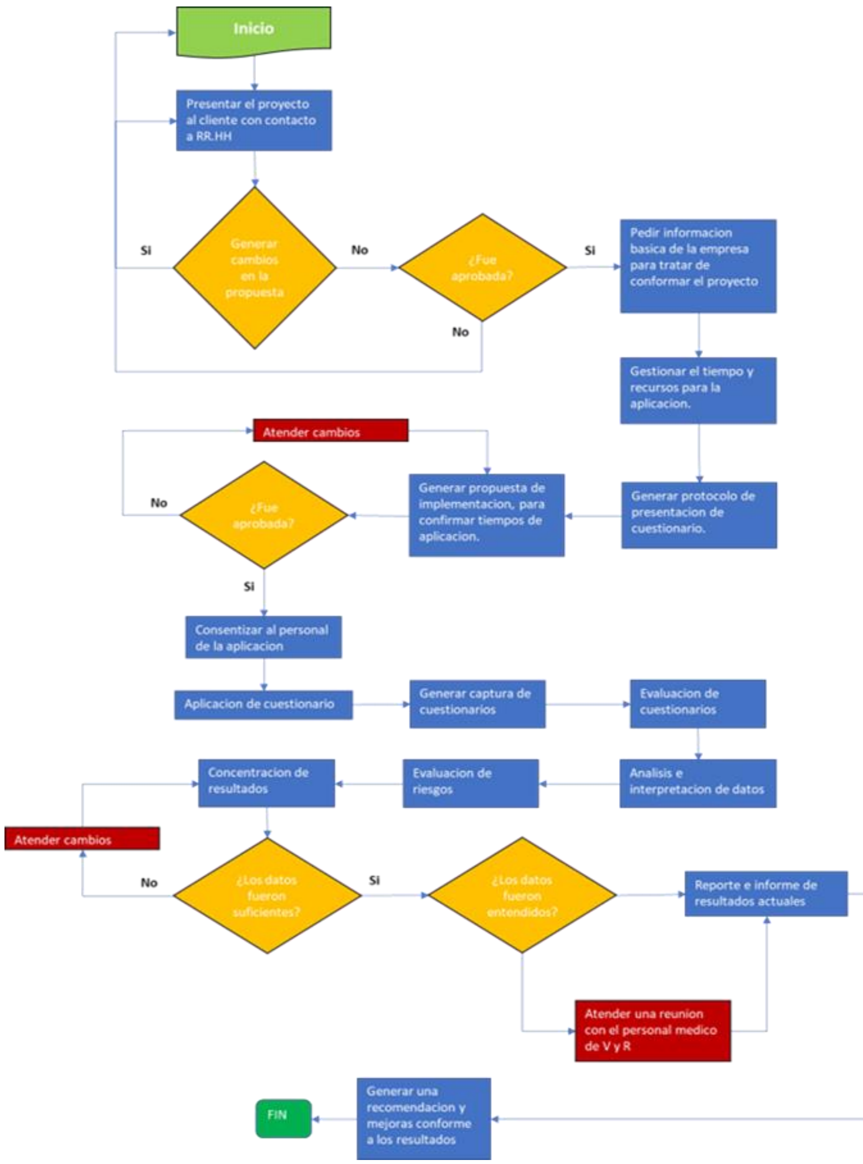

Figure 1. Flowchart according to previous planning.

4.2 Do

The project was developed continuing with the stage of doing and the rest of the phases to expose the actions that impact the identified causes, verify the improvements and propose improvement measures (Espinoza Arias, 2019). The application process took about 3 weeks, it began with the protocol previously established at the start of the survey, which consisted of 3 parts: the presentation of the company, the consent and the explanation of completion.

Likewise, the reference questionnaire I is applied, followed by the completion of the reference questionnaire III and finally, for population analysis, the reference questionnaire V, to all the plant personnel, which is a total of 381.

4.4 Verify

The concentration of results is a block of work, which consisted of taking the population analysis together with the risk levels, this concentrated in an empty format, presenting it to the company doctor in V and R, which was in charge of ruling on the clinical analysis of the plant together with the analysis of the resulting severe cases.

The questionnaire was applied with the recommendation of numeral 7., subparagraph b), within the NOM-035-STPS-2018 that recommends carrying out a sample for employees with a number greater than 51, for this application no sample is carried out, the entire population to be evaluated is contemplated. However, Reference Guide III is used to cover the evaluation with the specific points of numeral 7.2, 7.3 and 7.4, which as a whole is the focus of the psychosocial factors of the company, as well as the regulations.

This analysis contemplates in broad strokes without going into details, that after the application of the reference questionnaire I, which is to determine the severe cases where a series of circumstances of workplace violence is answered yes or no, where out of 76 possible severe cases were confirmed 38 and the relationship to area as shown in table 1.

Table 1. Severe cases by area.

Genero/Área	Número de casos severos
Femenino	**3**
ALMACEN	1
INGENIERIA	1
LOGISTICA	1
Masculino	**35**
ALMACEN	2
AXUILIAR GENERAL	1
BASTIDORES	3
CALIDAD	1
HIDROSOLUBLE	2
LOGISTICA	1
MANTENIMIENTO	2
MATRICERIA	1
PERFILADORA	8
PINTURA	4
PRENSAS	5
SOLDADURA	4
VIGAS	1
Total general	**38**

4.5 Act

The action before the company and within it is related in its entirety by the follow-up, in such a way that with the analyzes presented and the reports described and delivered; 66% compliance has been generated in accordance with sections I, II, III and IV of Article 43 of the Federal Occupational Safety and Health Regulations, where up to now the savings generate between 35,000 and 700,000 pesos in the change of UMAS may vary depending on the state, but sections V and VI of article 43 of the Federal Regulations on Safety and Health at Work must be complied with; Otherwise, an economic loss can be estimated due to fines between 26,000 and 627,000 pesos.

Next, the results obtained from the questionnaire, firstly; It is displayed in figure 2, with the male sex being the highest percentage, with 91% working in the plant or 347 employees and 9% female or 34 employees, appearing in administrative positions or minor operating activities.

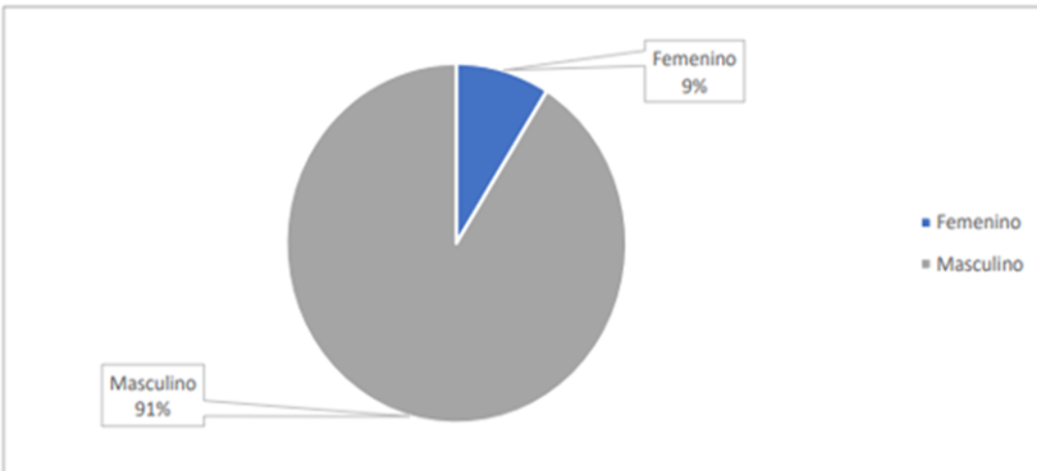

Figure 2: Sex.

The population results of the survey, in the age category, demonstrate through figure 3 Pareto diagram, age range, that the plant is integrated in a 78.74% in the age range of 20 to 44 years or 300 employees and the other 20% or the remaining 81, are very young staff with barely the age of majority and people close to retirement.

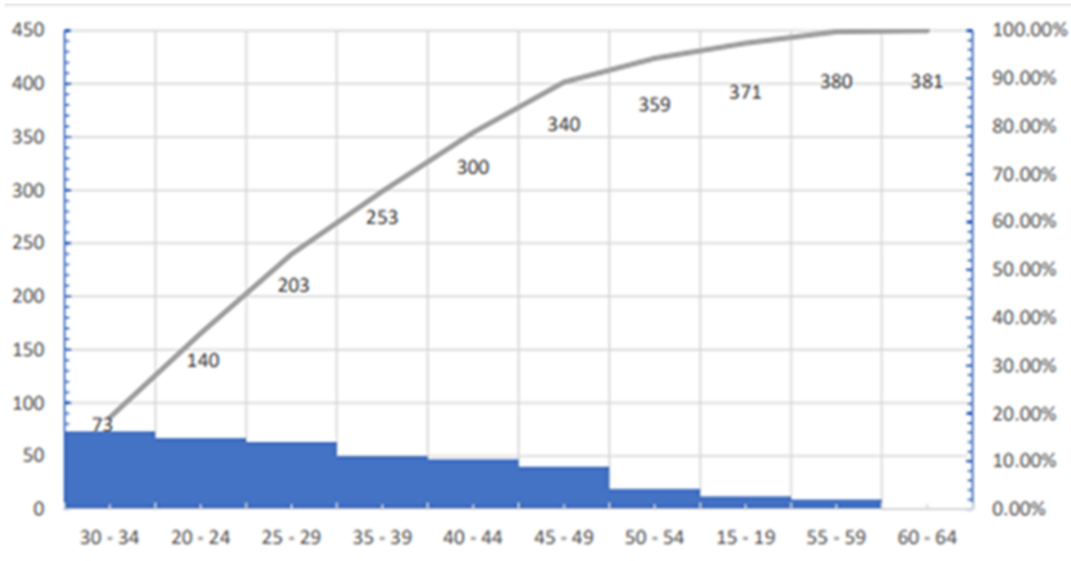

Figure 3: Pareto diagram, age range.

At the level of study, it is identified in figure 4. Pareto diagram, level of schooling, that; Only 15% of the employees have reached more than a technical level higher than a bachelor's degree or the equivalent of 57 employees, and 2.5% was obtained from answering their level of education or 10 employees, being the operational occupation with a lower level of study to high school or 82.63% of the school level of the plant.

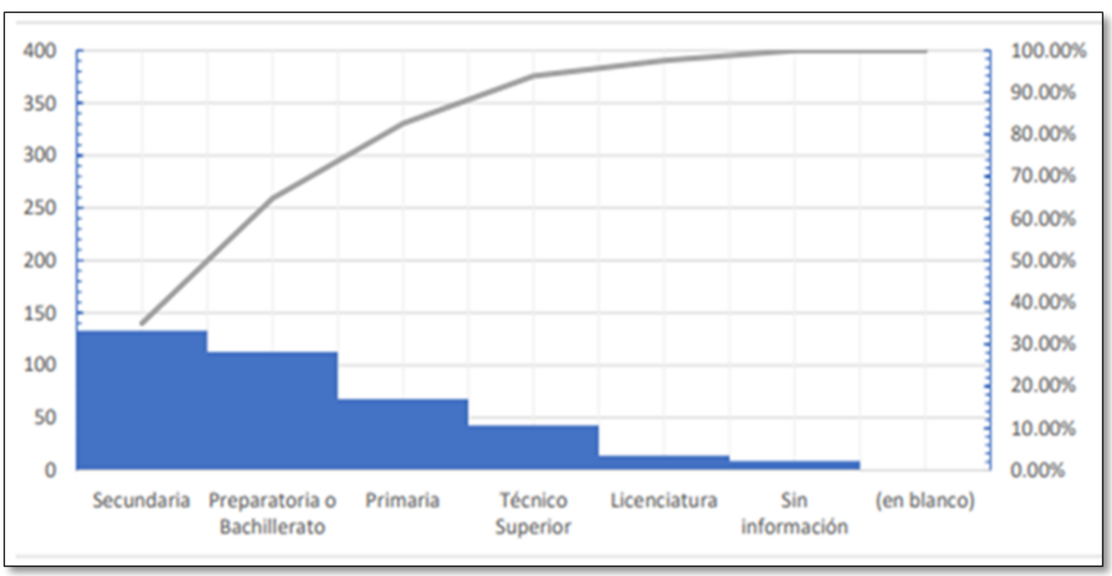

Figure 4: Pareto diagram, level of education.

Likewise, the plant has 2 shifts where it distributes its largest number in the daytime shift between 6:00 and 20:00, in figure 5. Distribution of shifts, it is possible to visualize that 68% of the personnel is in the first, equivalent to 268 employees and 32% in the day shift equivalent to 120 employees.

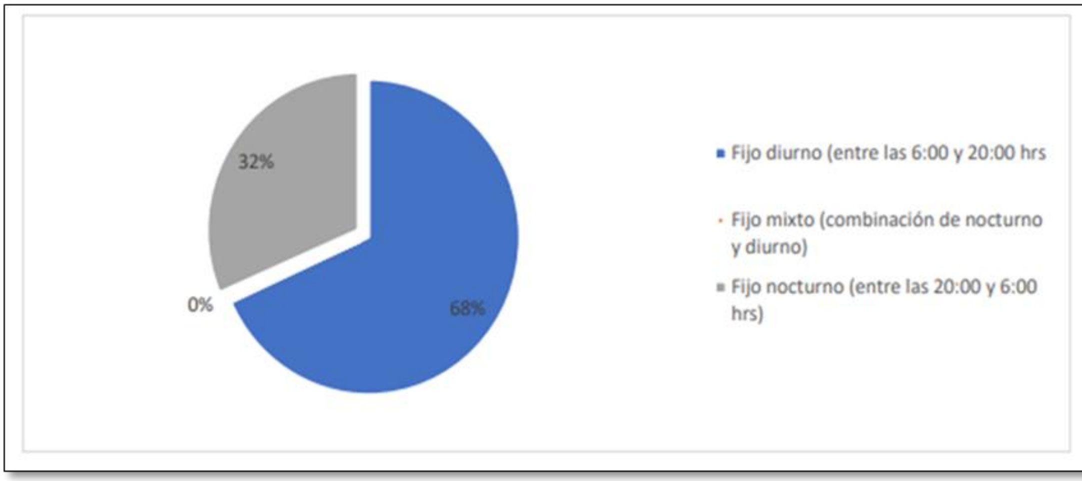

Figure 5: Distribution of shifts.

5. RESULTS

The category analysis is revealed in table 2. Category risk level results, in the first work environment section, the number of respondents begins to be distributed in High-Medium with a distribution of 40% equivalent to 151 respondents, with a higher accumulation in low of 31% equivalent to 119 employees, the Organizational Environment, has an accumulation of 41% in null equivalent to 157 employees, but the percentage of 39% of the respondents begins to be distributed in the cases of Very High -High-Medium equivalent to 149 employees. In the factors inherent to the activity, the risk is distributed 75% in High-Medium levels equivalent to 278 employees; For the categories of leadership and relationships at work and Organization of work time, the distribution of risk is very acceptable with a distribution of 72% in equivalent Low-Nil risk between 272 and 273 employees.

Table 2. Category risk level results.

Resultados de categoría	Nivel de riesgo					No. de encuestados
	Muy alto	Alto	Medio	Bajo	Nulo	
Ambiente de trabajo	33	71	80	119	78	381
Entorno organizacional	34	50	65	75	157	381
Factores propios de la actividad	8	94	184	92	3	381
Liderazgo y relaciones en el trabajo	9	27	70	113	162	381
Organización del tiempo de trabajo	11	39	55	70	206	381

The results of the domain seen in table 3, reveal that the workload is found in a distribution of 82% between the levels of Medium-Low-Nil risk, the equivalent of 311 employees, for the conditions in the work environment the highest distribution is 72% between Medium-Low-Nil risks, in the lack of control over work they reveal a distribution of 59%, worrying between Very high-High-Medium risk, in insufficient sense of belonging and instability, not generating Worrying data, given that only 8% of employees are between Very high-high, as well as the domains of Interference in the work-family relationship and work schedule, recognition of performance, relationship at work, but leadership reveals from 21 % between the levels of risk Very high-high, where a risk concern could be generated due to these qualities in the personnel, the data that has a lower distribution of 13% in the risks Very high-high is violence, which is a dominance of red focus even when slightly greater than 5%; Given that violence is one of the factors with the greatest influence and impact on the severe cases that can be created in the workplace, generating traumatic impacts on the personnel, it should not be conceived as atypical data.

Table 3. Domain risk level result.

Resultados de Dominio	Etiquetas de columna					Total general
	Muy alto	Alto	Medio	Bajo	Nulo	
Carga de trabajo	8	62	104	113	94	381
Condiciones en el ambiente de trabajo	33	71	80	118	78	380
Falta de control sobre el trabajo	68	58	98	85	72	381
Insuficiente sentido de pertenencia e, inestabilidad	14	18	44	161	144	381
Interferencia en la relación trabajo-familia	9	14	35	72	251	381
Jornada de trabajo	25	88	144	28	96	381
Liderazgo	49	31	47	42	212	381
Reconocimiento del desempeño	25	48	75	88	145	381
Relaciones en el trabajo	0	10	17	47	307	381
Violencia	23	28	35	53	242	381

The distribution of severe cases can be seen in table 4. Areas and severe cases, where it was revealed that 21% of the cases are being caused in the Profiled area, but 80% of all cases occur in the areas of Profiling, Presses, Painting, Welding, Racks, Warehouse, Water-soluble and Maintenance with a total of 31 cases, equivalent to 81.58%.

Table 4. Areas and severe cases.

Áreas	Número de casos	Casos acumulados	Porcentaje acumulado
PERFILADORA	8	8	21.05%
PRENSAS	5	13	34.21%
PINTURA	4	17	44.74%
SOLDADURA	4	21	55.26%
BASTIDORES	3	24	63.16%
ALMACEN	3	27	71.05%
HIDROSOLUBLE	2	29	76.32%
MANTENIMIENTO	2	31	81.58%
LOGISTICA	2	33	86.84%
MATRICERIA	1	34	89.47%
INGENIERIA	1	35	92.11%
VIGAS	1	36	94.74%
CALIDAD	1	37	97.37%
AXUILIAR GENERAL	1	38	100.00%
Total general	**38**		

In table 5 talks about risk rating, reference is made to NOM-035-STPS-2018 on the classification and distribution of risks in which it belongs.

Table 5. Risk rating and distribution.

Resultado del cuestionario	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Calificación final del cuestionario Cfinal	Cfinal<50	50<Cfinal<75	75<Cfinal<99	99<Cfinal<140	Cfinal>140

After the results weighted in the final score, there was a total of cases at a null level of 63 employees, equivalent to 16.5% at a low risk level, 110 cases were obtained, equivalent to 28.9%, at a medium level, a distribution of 23.1% was obtained, equivalent to 88 cases, at a high level 103 cases were obtained, equivalent to 27%, and the very high risk level obtained 4.5%, equivalent to 17 cases (see table 6).

Table 6. Results of risk distribution in the final score.

Nivel de riesgo	Numero de caso
Nulo	**63**
Bajo	**110**
Medio	**88**
Alto	**103**
Muy alto	**17**
Total general	**381**

It is shown that there is no control in the category of work environment, organizational environment and in the domain of Conditions in the work environment, lack of control over the work and a very bad management in the leadership of the employees; This lack of control means that the risk levels are high at these points. Likewise, the risk level of the plant is at medium risk for a score of 82.5, but the deviation is too high with 32.88 points, generating an even higher index towards cases of high-risk level.

As a recommendation, it is to give more follow-up to severe cases, with medical and psychological attention; generate gender inclusion campaigns, given that the most severe case with a score of 200 going to the Very High index, is of the female gender, with damage in the work environment and violence, the hypothesis of harassment is generated, given that the plant has a history of harassment of female staff, in addition to the fact that 91% of the staff is male, further reaffirming the hypothesis.

Thus, in this way, contemplate the last stage of the certification with section V and VI of article 43 of the Federal Regulation of Safety and Health at Work, where the cost-benefit of the application itself is determined (see table 7).

Table 7. Cost benefit of application.

Articulo 43	UMAS	Valor de la UMA 2022	Costo por empleado	Aplicación por empleado (381)
Fracción I	100	$9,622.00	$15.00	$5,715.00
Fracción II	100	$9,622.00	$10.00	$3,810.00
Fracción III	5,000.00	$481,100.00	$280.00	$106,680.00
Fracción IV	3,000.00	$288,660.00	$250.00	$95,250.00
Fracción V	5,000.00	$481,100.00	$350.00	$133,350.00
Fracción VI	2,000.00	$192,440.00	$80.00	$30,480.00
		$1,462,544.00	**$985.00**	**$375,285.00**

6. CONCLUSIONS AND RECOMMENDATIONS

It is recommended to generate a greater monitoring of severe cases, with medical and psychological care; generate gender inclusion campaigns, given that the most severe case with a score of 200 above the Very High index, is of the female gender, with damage in the work environment and violence. Psychological care in accident cases should be carried out immediately, even in the oldest cases, to attend to a historical trauma or to show signs of recovery from the trauma.

Likewise, the Medium result of the recommendation of NOM-035-STPS-2018 that says "It is necessary to review the psychosocial risk prevention policy and programs for the prevention of psychosocial risk factors, the promotion of a favorable organizational environment and the prevention of workplace violence, as well as reinforcing its application and dissemination, through an intervention program." But given the number of severe cases, the signaling of the case with a score greater than 200, and a deviation of 32.88 points, the high level of NOM-035-STPS-2018 is recommended, which mentions "An analysis of each category and domain, so that the appropriate intervention actions can be determined through an intervention Program, which may include a specific evaluation and must include an awareness campaign, review the psychosocial risk prevention policy and prevention programs of psychosocial risk factors, the promotion of a favorable organizational environment and the prevention of workplace violence, as well as reinforcing its application and dissemination", for which the analysis of the categories and domains was delivered to the client.

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SELF EFFICACY, INSTRINSIC MOTIVATION AND ITS RELATIONSHIP WITH JOB PERFOMANCE IN THE MANUFACTURING INDUSTRY

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Resumen: Uno de los criterios de la gestión de recursos humanos es el rendimiento laboral. Por su importancia para el contexto organizativo y los sistemas sociotécnicos, el análisis del rendimiento en el trabajo es un enfoque para mejorar el desarrollo personal a nivel individual y de equipo. El rendimiento en el puesto de trabajo se refiere a los comportamientos que contribuyen a la producción de un bien o a la prestación de un servicio. El rendimiento laboral impacta a los objetivos de la organización contribuyendo a su entorno social y psicológico, incluye tareas que van más allá de las obligaciones laborales, iniciativa, proactividad, cooperación con los demás o entusiasmo. El rendimiento laboral no eficiente se define como el comportamiento voluntario que perjudica el bienestar de la organización, comprende el comportamiento desatento, la queja, la realización de tareas incorrectas a propósito. En este marco, la autoeficacia se convierte en un factor clave, ya que se ha demostrado su efecto tanto en el bienestar laboral como en el psicosocial. La motivación intrínseca es un instrumento para regular el comportamiento laboral de los trabajadores, por lo que la optimización del comportamiento laboral puede lograrse motivando a los trabajadores. La autoeficacia y la motivación intrínseca son factores cruciales para mejorar el rendimiento laboral de los empleados. Por lo tanto, el propósito de este estudio es investigar la motivación intrínseca y el impacto de la autoeficacia laboral en el rendimiento laboral, así como el efecto de la autoeficacia en la motivación intrínseca. Se ha propuesto un modelo de investigación y se ha comprobado su idoneidad con un modelo de ecuaciones estructurales. En el estudio participaron 300 trabajadoras del área de producción de arneses de fibra óptica. Se distribuyeron en línea tres instrumentos de investigación titulados escala de motivación intrínseca (IMS), escala de autoeficacia (SES) y las encuestas de los informes anuales de evaluación del rendimiento (APER). La validación y la fiabilidad del modelo propuesto se llevaron a cabo con el software IBM AMOS v. 24. Los resultados demuestran la idoneidad del modelo propuesto, de esta manera, quedó demostrado que la autoeficacia y la motivación intrínseca tienen una relación positiva con el rendimiento laboral. Además, los resultados encontrados demuestran que la autoeficacia afecta positivamente a la motivación intrínseca.

Palabras clave: Motivación, autoeficiencia, rendimiento laboral, trabajadores industriales.

Relevancia para la ergonomía: El análisis de la relación entre autoeficacia, motivación intrínseca y rendimiento laboral contribuye a que la ergonomía organizativa permita conocer los mecanismos que influyen en el rendimiento laboral, así como la magnitud de dicha influencia. Este conocimiento puede servir de apoyo a las decisiones administrativas sobre los trabajadores.

Abstract: One criterion in human resource management, is job performance. Because of its attention to the organizational context and sociotechnical systems, job performance analysis is an approach to improve personal development at the individual and team levels. Task performance refers to behaviors that contribute to the production of a good o the provision of a service, some task performance indicators include completing job tasks, keeping knowledge up to date. The contextual performance is a behavior that contributes to the goals of the organization by contributing to its social and psychological environment, it includes tasks beyond job duties, initiative, proactivity, cooperating with others, or enthusiasm. The counterproductive work behavior is defined as the voluntary behavior that harms the wellbeing of the organization, comprises of-task behavior, presentism, complaining, doing tasks incorrectly on purpose. Within this framework, self-efficacy becomes a key factor since its effect on both workplace and psycho-social wellbeing has been demonstrated. Intrinsic motivation is an instrument for regulating work behavior of workers, thus the optimization of work behavior can be best achieved by motivating the workers. Self-efficacy and intrinsic motivation are crucial factors for improving job performance in employees. Therefore, the purpose of this study is to investigate intrinsic motivation and the impact of occupational self-efficacy on job performance, as well as the effect of self-efficacy in intrinsic motivation. A research model has been proposed and its suitability has been tested with a structural equation model to test the effects of self-efficacy and intrinsic motivation on job performance, as well as the effect of self-efficacy on intrinsic motivation. Three hundred female workers from fiber optic harness production area participated in the study. Three research instruments titled intrinsic motivation scale (IMS), Self-Efficacy scale (SES) and the Annual Performance Evaluation Reports (APER) surveys were distributed online to gather data in a survey-style manner. The validation and reliability of proposed model was conducted using a structural equation model assisted with IBM AMOS software v. 24. Results demonstrate the suitability of the proposed model. The findings of this study demonstrate that self-efficacy and intrinsic motivation have a positive relationship with job performance. Additionally, it demonstrates that self-efficacy affects positively intrinsic motivation.

Keywords: Motivation, self-efficacy, job performance, industrial workers.

Relevance to Ergonomics: The analysis of the relationship between self-efficacy, intrinsic motivation, and work performance contributes to organizational ergonomics to know the mechanisms that influence work performance, as well as the magnitude of that influence. This knowledge can support administrative decisions about workers.

1. INTRODUCTION

One criterion in human resource management, is job performance. Because of its attention to the organizational context and sociotechnical systems, job performance analysis is an approach to improve personal development at the individual and team levels, as well as the operational efficiency of the whole system (Barrick and Mount, 1991). In this context, job performance is a psychosocial aspect of work that pertains to the domain of organizational ergonomics, and it is a construct that comprises behaviors under workers' control that contribute to organizational goals (Hurtz and Donovan, 2000). There are three major domains of job performance: task performance, contextual performance, and counterproductive work behavior, these dimensions provide a comprehensive approach to job performance (Koopmans et al., 2013). Task performance refers to behaviors that contribute to the production of a good o the provision of a service, some task performance indicators include completing job tasks, keeping knowledge up to date (Podsakoff et al., 2009). Working accurately and neatly, planning and organizing, and solving problems, among others (Organ and Paine, 1999). The contextual performance is a behavior that contributes to the goals of the organization by contributing to its social and psychological environment, it includes tasks beyond job duties, initiative, proactivity, cooperating with others, or enthusiasm (Pulakos, et al. ,2000). The counterproductive work behavior is defined as the voluntary behavior that harms the wellbeing of the organization, comprises of-task behavior, presentism, complaining, doing tasks incorrectly on purpose (Salgado et al., 2005). These behaviors are related to negative consequences at the personal and organizational levels. Within this framework, self-efficacy becomes a key factor since its effect on both workplace and psycho-social wellbeing has been demonstrated, which includes variables such as job satisfaction, performance, and work conditions (Sacket, 2002). The importance of self-efficacy in successful job performance must not be underestimated. Self-efficacy is the personal disposition of the job holder. It is the belief that it affects a person´s choice of behavior, motivation, and perseverance (Rehman and Shahnawaz, 2018). Strong self-efficacy beliefs are associated with higher job satisfaction, greater commitment, and lower absenteeism in workers, according to research on the relationship between self-efficacy and job performance (Sackett and DeVore, 2001). The success of a worker's career is then known to be significantly influenced by their occupational self-efficacy (Smidt et al., 2018). According to numerous studies (Buric and Moe, 2020; Cetin and Askun, 2018; Islam and Ahmed, 2018; Youn et al., 2018; Shin et al., 2019), self-efficacy and intrinsic motivation are crucial factors for improving job performance in employees. In addition, self-efficacy affects occupational stress (Sharma & Marwaha, 2020), and Nisar and Rasheed (2020) found that as occupational stress increases, worker performance declines. Additionally, occupational self-efficacy lowers job stress and boosts job satisfaction (Troesch and Bauer, 2017). As job satisfaction rises, so will job performance (Dinc, 2017; Kishen et al., 2020; Syah et al., 2021). It is also known to mediate job satisfaction in relation to intrinsic motivation (Gheitani et al., 2019). Intrinsic motivation is an instrument for regulating work behavior of workers, thus the optimization of work behavior can be best achieved by motivating the workers (Gorgievski et al., 2010). Financial rewards and incentives (extrinsic motivation) are important, but they are not sufficient positive motivation (Fine and Edward, 2017). Intrinsic motivation are the natural or personal drives, desires, impulse belonging to a person internally has a role to play in job performance of workers. Commitment to the workplace have been found to be enhanced by psychotic rewards (acknowledgement of competence), meaningful and varied work, task autonomy and participatory decision-making, positive feedback, collaboration, administrative support, reasonable workload, adequate resources and learning opportunities providing challenge and accomplishment (DeNisi and Murphy, 2017). A person with high intrinsic motivation will have high occupational self-efficacy, which will increase their level of engagement at work (Liu and Huang, 2019). The working environment and self-efficacy then have an impact on employees' motivation (Tannady et al., 2019). Additionally, motivation—both intrinsic and extrinsic—will impact both job performance and job satisfaction (Riyanto, 2017). According to additional research, transformational leadership will increase intrinsic motivation, which will enhance employee performance and increase contributions to the achievement of organizational goals (Nguyen et al., 2019).

According to Rigotti et al. (2008), employees with high levels of self-efficacy believe they have the skills necessary to succeed in carrying out tasks related to their job functions. This increases intrinsic motivation because the employee thinks that by doing activities related to his job well, he will receive benefits and enjoyment for himself (Deci and Ryan, 2008). According to earlier research (Etin and Aşkun, 2018; Klaeijsen et al., 2018), increasing occupational self-efficacy will increase intrinsic motivation. Therefore, the purpose of this study is to investigate intrinsic motivation and the impact of occupational self-efficacy on job performance, as well as the effect of self-efficacy in intrinsic motivation. Based on the above hypothetical framework, the research model can be described as shown in figure 1.

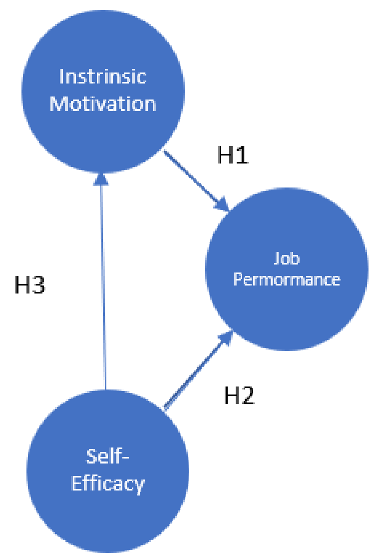

Fig 1 Research model framework.

2. OBJETIVES

According to Rigotti et al., 2008 and Rhew et al., 2018, employees with high occupational self-efficacy will be more likely to stay in their jobs, which will improve their ability to complete tasks. Occupational self-efficacy has been shown to improve job performance for employees from different organizations (Etin and Aşkun, 2018). Then, it has been demonstrated that self-efficacy has a positive impact on job performance along with work engagement (Carter et al., 2018). The relationship between organizational culture and job performance is also mediated by work engagement and self-efficacy (Song et al., 2018). Therefore, we propose the following objective:

a) To test if job performance is positively impacted from self-efficacy.

Additionally, the level of the employee's performance will increase in direct proportion to their level of motivation. This is clear from several earlier studies that explain how motivation affects job performance in a favorable way (Carvalho et al., 2020). The relationship between occupational self-efficacy and job performance is mediated by intrinsic motivation, which also has a direct impact on job performance (Etin and Aşkun, 2018). As a result, the following objetive is stated:

b) To test if job performance is positively impacted by intrinsic motivation.

According to Rigotti et al. (2008), employees with high levels of self-efficacy believe they have the skills necessary to succeed in carrying out tasks related to their job functions. Therefore, is proposed the following objetive:

c) To test the effect of self-efficacy on intrinsic motivation.

3. METHODOLOGY

3.1 Participants

Three hundred female workers from fiber optic harness production area participated in the study, ranging in age from 29 to 68 (Mean = 27.00, SD = 8.41. They had an average job tenure of 10.45 years (SD = 3.3). To reach workers, it was distributed the questionnaires after a non-probability sampling. Participants voluntarily agreed to complete the questionnaire containing the relevant variables. They were made aware of the survey's anonymity policy and its intended use for research.

3.2 Materials

Three research instruments titled intrinsic motivation scale (IMS), Self-Efficacy scale (SES) and the Annual Performance Evaluation Reports (APER) surveys were distributed online to gather data in a survey-style manner. To give respondents, the opportunity to make decisions based on their personal preferences, measurements were conducted using a Likert scale with a scale of 1–5 (1 = strongly disagree and 5 = strongly agree). Data collection took place in 2022. Self-efficacy scale considers six questions were taken from Tomas, Masli Seri, and De Witte (2019). Intrinsic motivation scale comprehends eight questions which was taken from Sheldon, Arndt, and Houser-Marko's 2003 work. Job performance survey consists of 4 questions adopted from Cetin & Askun (2018).

3.3 Procedure

All participants of the sample responded the administered surveys. One hundred respondents were given the initial questionnaire (pre-test) to perform a factor analysis for each instrument. The exploratory multivariate factor analysis technique was used to explore the underlying dimensions of the observed variables in a previous pilot study by the authors. Then the structural equation model method was applied to analyze proposed research model.

3.4 Statistical data analysis

The exploratory multivariate factor analysis technique was used to explore the underlying dimensions of the observed variables, to determine to what extent, the items that make up the instrument used represent the latent dimensions of the research construct in a previous pilot study by authors.

A structural equation model method was conducted and, IBM SPSS 26 and IBM AMOS v 24 software were used for data processing and analysis. The validation and reliability of proposed model was conducted using IBM AMOS software.

4 RESULTS

4.1 Sample demographics

One hundred percent of participants were women, who works for fiber optic harness manufacturing, from two shifts. Age average is 24.36 years (SD 2.55) and almost a third of sample is married according to Table 1.

Table 1 Demographic characteristics of the sample n=300.

Demographic Characteristics	Variables	Values
Age (years)	Mean	24.36
	Range	20-42
	Standard deviation	2.55
Marital status (%)	Married	105 (35.0%)
	Single	195 5.0%)

4.2 Structural equation model analysis

4.2.1 Construct reliabilit

The indicator for each variable has a loading factor of more than 0.50, which is in accordance with Hair et al. (2014) which says that the measurement of construct validity can be accepted and declared valid if all loading factors are above 0.50. The results of the calculation of construct reliability (CR) and variable extracted (VE) found that Self-efficacy (CR = 0.69; VE = 0.61), intrinsic motivation (CR = 0.83; VE = 0.65), and job performance (CR = 0.77; VE = 0.63), can be said to meet the overall requirements which are in accordance with Hair et al. (2014) that the value of construct reliability must meet the reliability requirements with CR above 0.60 and VE value above 0.50.

4.2.2 Suitability test

Based on the analysis of suitability test, most of the variables showed a good match including Likehood Ratio p-value 0.075, Relative X^2/df = 1.93, CMIN/DF= 1.36, GFI= 0.91, AGFI=0.95, CFI= 0.90, and RMSEA = 0.048. Thus, there is a goodness of fit for the whole model.

4.2.3 Hypothesis testing

According to the above hypothesis test table, each hypothesis has a T-Value value greater than 1.96 for significance level of 5%. Thus, the data support defined hypothesis (Table 2).

Table 2 Hypothesis Test results

Hypothesis	Statement	T-VALUE Alpha= 5%	Result
H1	Self-efficaty has a positive effect on job performance	5.23	The data support the hypothesis
H2	Intrinsic motivation has a positive effect on job performance	2.45	The data support the hypothesis
H3	Self-efficacy has a positive effect on intrinsic motivation	3.38	The data support the hypothesis

4.2.4 Model research results

Table 3 shows the path coefficients of the SEM, which demonstrate a strong relationship between the model variables and in all cases are significantly.

Table 3 Results of path coefficients

Independent variable	Dependent variable	Path Coefficient	SE	p-value
Self-efficacy	Job performance	0.72	0.05	0.001
Intrinsic motivation	Job performance	0.85	0.01	0.002
Self-efficacy	Intrinsic motivation	0.98	0.03	0.007

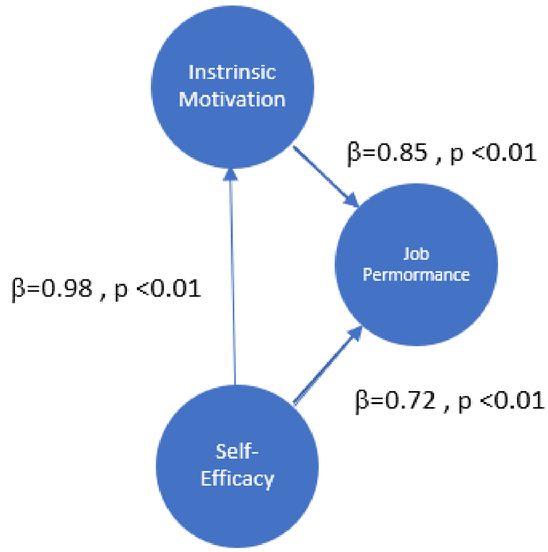

Fig. 2 Model research results

Results demonstrate the suitability of the proposed model. This study explains how self-efficacy and intrinsic motivation impact job performance. Additionally, the impact of self-efficiency on intrinsic motivation. It has been demonstrated that occupational self-efficacy enhances intrinsic motivation. In other words, self-efficacy factors like an employee's ability to remain composed in the face of challenges or the belief that they can overcome challenges at work will increase intrinsic motivation in employees like the desire to make a difference in other people's lives and to show others affection. Self-efficacy was found to influence job performance. This shows the employee's belief that he or she can be successful at work has a positive effect on the ability of workers to carry out tasks according to job descriptions or other standard requirements as requested by the company. This is in accordance with previous studies (Carter et al., 2018; Çetin and Aşkun, 2018). In this study, it was found that intrinsic motivation had positive effect on job performance, no other studies were found that have the same results.

5. CONCLUSIONS

The findings of this study demonstrate that self-efficacy and intrinsic motivation have a positive relationship with job performance. Additionally, it demonstrates that self-efficacy affects positively intrinsic motivation.

The managerial implications of this research are as follows: Company leaders need to boost occupational self-efficacy by, for example, offering training so that employees become more competent by enhancing the competencies they possess. This will increase employees' intrinsic motivation and job performance. Employees will feel more confident in themselves, which will improve their performance.

The relationship between the measures of intrinsic motivation and the measures of self-efficacy were significant but the degree of signification was not assessed in this context, since the kind of intrinsic motivation focused on here is only one of the kinds of motivation that affects performance, and motivation is only one of the factors that influences performance. It will be interesting to consider in further analysis all the variables considered in motivation.

Declaration of competing interest

The authors affirm that no commercial or financial connections existed that might be interpreted as creating a conflict of interest during the conduct of the study.

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APPLICATION OF THE NOM-035-STPS-2018 IN COMPANIES OF LAMINATING AND SEAMING BY AGILE METHODOLOGY

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Resumen: Este proyecto presenta la aplicación de la NOM-035-STPS-2018, a través de la metodología AGILE, que lleva el proyecto a un cliente como maquiladora de laminados. Permitiendo definir una estrategia de planificación, requerimientos y necesidades del propio cliente, con el fin de implantar un servicio de psicología laboral una vez finalizado el proyecto de aplicación de la norma.

Palabras clave: Estrés, riesgo, ergonomía.

Relevancia para la ergonomía: Contribuir a la seguridad y salud de los empleados, reduciendo riesgos y promoviendo un ambiente de trabajo favorable.

Abstract: This project presents the application of NOM-035-STPS-2018, through the AGILE methodology, which takes the project to a client as a laminate maquiladora. Allowing to define a planning strategy, requirements and needs of the client himself, in order to introduce an occupational psychology service once the project of the application of the standard is finished.

Keywords: Stress, risk, ergonomics.

Relevance for ergonomics: Contribute to the safety and health of employees, reducing risks and promoting a favorable work environment.

1. INTRODUCTION

Work stress is considered as the interaction between the psychological demand under control on work and social support, an unpleasant work environment and conflictive relationships (Vidotti, Trevisan Martins, Quina Galdino, Perfeito Ribeiro, & do Carmo Cruz Robazzi, 2019).

According to the National Institute for Occupational Safety and Health (INSST, 2022) mentions that "stress is the second most frequent health problem among workers after musculoskeletal disorders. For this reason, awareness is also increasing, at an international level, about the need to act against stress at work."; On the other hand, the Mexican Institute of Social Security (IMSS, 2020) mentions that 75% of Mexicans suffer from fatigue due to work stress, surpassing countries like China and the United States, as well as, "Stress is potentially contagious, since it being around or visualizing other people in stressful situations can increase the cortisol levels of the observer."

The implication of the NOM-035-STPS-2018 provides a new relationship between employers on the treatment that must be made to employees, this regulation has entered into force since 2019, firstly, as the implication of risk prevention policies, and in its second stage in 2020 as a follow-up to an employee analysis control.

Since its publication in 2016 to be submitted to public consultation, it has been considered that there is a huge effort on the part of the Mexican authorities to promote the prevention of psychosocial risks caused by work (STPS, 2018).

2. OBJECTIVE

Comply with the certification and federal regulations on safety and health at work, related to NOM-035-STPS-2018, to avoid economic impacts and follow up on findings of violence, in the departments of the plant through the method AGILE.

3. DELIMITATIONS

The project takes shape in a laminating and sewing company located in the city of Tijuana, Baja California, through the medical service company V y R occupational health advisers.

4. METHODOLOGY

The laminating and sewing company are level II, in the last 2 years it has presented 8 serious accidents, the risk levels in the last two years have increased, it can be seen in the situation in figure 1.

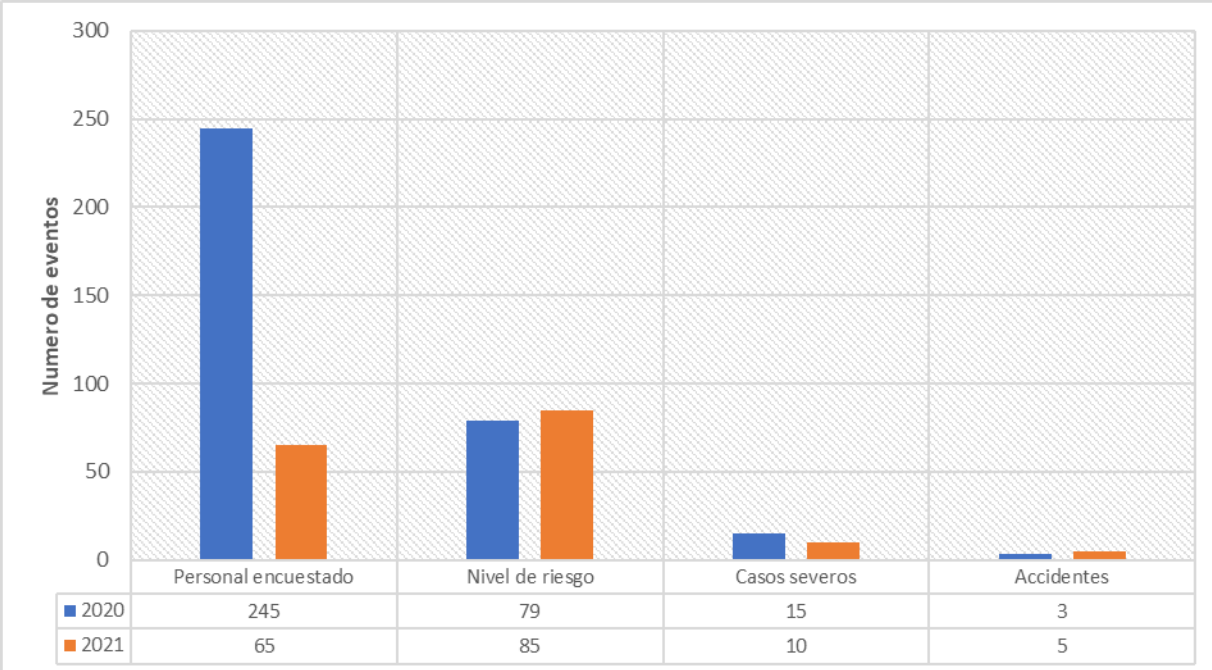


Figure 1. Histograms of results for the year 2020 and 2021.

In 2020, about 95% of the staff participated with a medium level of risk with a rating of 79, a total of 15 severe cases, in 2021 the staff did not fully participate and it was obtained from answering the questionnaire, but the intake was enough to comply with the norm, in addition an increase in the risk score was seen, but even so it classifies for the medium level of risks, from the sampling there were 10 severe cases, remembering that only 28% of the total personnel participated.

Without leaving aside the safety point, in 2020 there were 3 accidents, for 2021 there were 5 accidents, it should be noted that they were not high-grade accidents. There was no follow-up on the severe cases of 2021, the client fears that he will lose the trust of his staff for the participation of the NOM-035-STPS-2018, likewise in 2021 the company paid a little more than 100 thousand pesos in fines for continuous non-monitoring of obligations.

The methodology used was established by NOM-035-STPS-2018 but complemented with the AGILE methodology, which was created with the aim of improving the functionality of software projects by reducing the probability of failure due to underestimation of costs and time (Ruiz Sanchez & De la Posa Perez, 2018).

The AGILE methodology is divided into 5 stages which are shown in Figure 1; the stages of the AGILE methodology do not have a sequence, opening and closing, where these stages can be managed according to the client's principles:

1. Evaluation of processes and current structure of the company.
2. Suggestions for improvement and optimization of processes.
3. Design of the application together with the client.
4. Construction and implementation of the application.
5. Evaluation and monitoring.

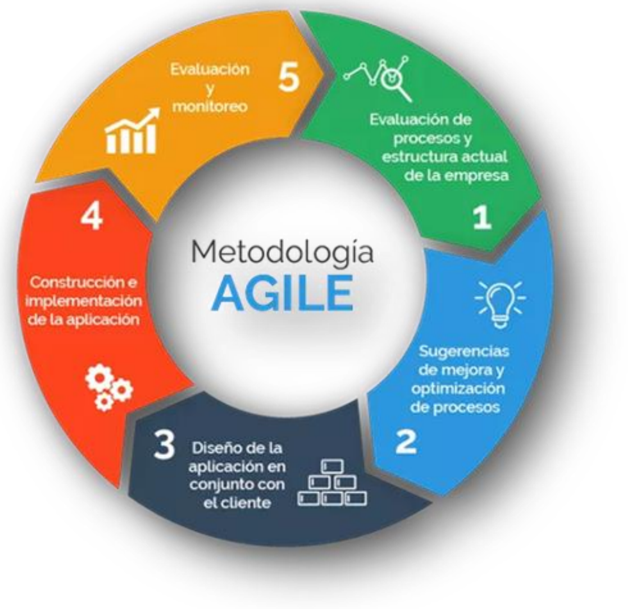


Figure 2. Cycle of the AGILE methodology.

4.1 Projection of the project plan with the client

The first stage of the AGILE methodology was to divide the project into 3 work levels, where the sets of work packages are presented to the client, without breaking down internal or external activities.

The Work Breakdown Structure or WBS was also carried out (see figure 2), with the specific percentages of progress of the project administration, at this point activity times are not established, since the importance is based on the projection of completion and not the punctuality of delivery of activities. A WBS make up the baseline of the project scope and has a hierarchical structure that represents the work to be done of the deliverables or tangible results, each of these can be assigned to a specific worker; Likewise, it is the input for the development of the schedule (Rojas Puentes, Parada, & Leal Pabón, 2022).

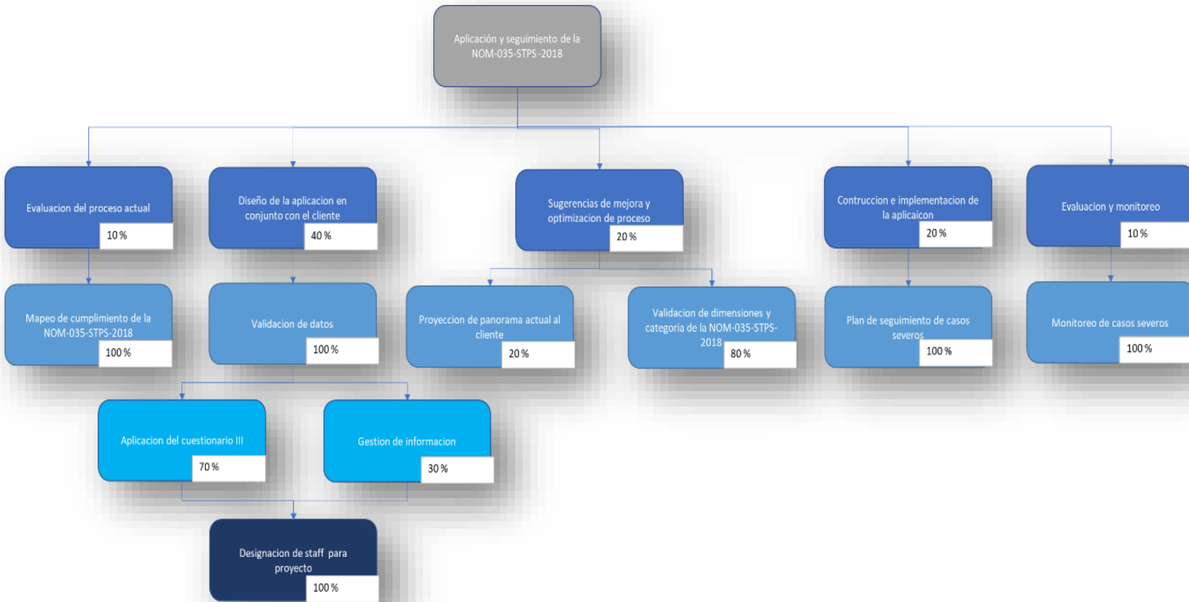


Figure 3. Work breakdown structure or WBS.

4.2 Application of the questionnaires

The application is generated in an organized way for the 201 company employees of the 2 different shifts of different sex, through printed questionnaires where the reference guide I is used to identify severe cases, then the reference guide III. , to identify psychosocial risk factors, also as an informative source of population data, the reference guide V was used.

Once the questionnaire is finished, a brochure is delivered indicating what NOM-035-STPS-2018 is and what function it has, as part of the consent policy for psychosocial factors, a quick review is also carried out, to Verify that no questions have been skipped or any question has been answered incorrectly, in order not to answer a question twice or leave blank spaces.

The files are kept for at least a period of 1 year as proof of application and management of the NOM-035-STPS, of section I and II of article 43 of the federal regulation of safety and health at work that mentions "Disease de Work is any pathological state derived from the continuous action of a cause that has its origin or motive at work, or in the environment in which the worker is forced to provide his services. In any case, occupational diseases will be those consigned in the Federal Labor Law.” and it is requested according to fraction I and II:

I. Identify and analyze jobs with psychosocial risks due to the nature of their functions or the type of working hours.

II. Identify workers who were subjected to severe traumatic events or acts of workplace violence, and assess them clinically.

4.3 Validation of dimensions and category of NOM-035-STPS-2018

The risk levels are defined according to the score related to the table of results of the questionnaire, as well as the qualification of the category and result of domain all, all in the section of the Reference Guide III.

In such a way that the qualification results of the category, highlighting a very favorable work environment, as well as an organization of time at work, but the criteria points are submitted to factors specific to the activity, as well as leadership and relationships. at work and in the organizational environment, with a medium level of risk.

The evaluation at the lower levels, corresponding to the domain (table 1), the medium risk levels and with greater care in the following domains, there is a lack of control over work, work hours and performance recognition, where it is visualizing that employees may not be rewarded or recognized for their dedication and feel overwhelmed in their own days; however, it is revealed that violence is at a high risk level, which indicates a very consistent grievance in the system itself, which has to be resolved, interfering forcefully.

Table 1. Domain risk levels.

Condiciones en el ambiente de trabajo	NULO
Carga de trabajo	BAJO
Falta de control sobre el trabajo	MEDIO
Jornada de trabajo	MEDIO
Interferencia en la relación trabajo-familia	BAJO
Liderazgo	BAJO
Relaciones en el trabajo	NULO
Violencia	ALTO
Reconocimiento del desempeño	MEDIO
Insuficiente sentido de pertenencia e, inestabilidad	BAJO

6. RESULTS

In the results, the interpretation of the data is cross-related with each of the questionnaires, standardizing each information in a report, such as the database of filtration results, made up of a Dashboard tool (see Figure 4 and 5).

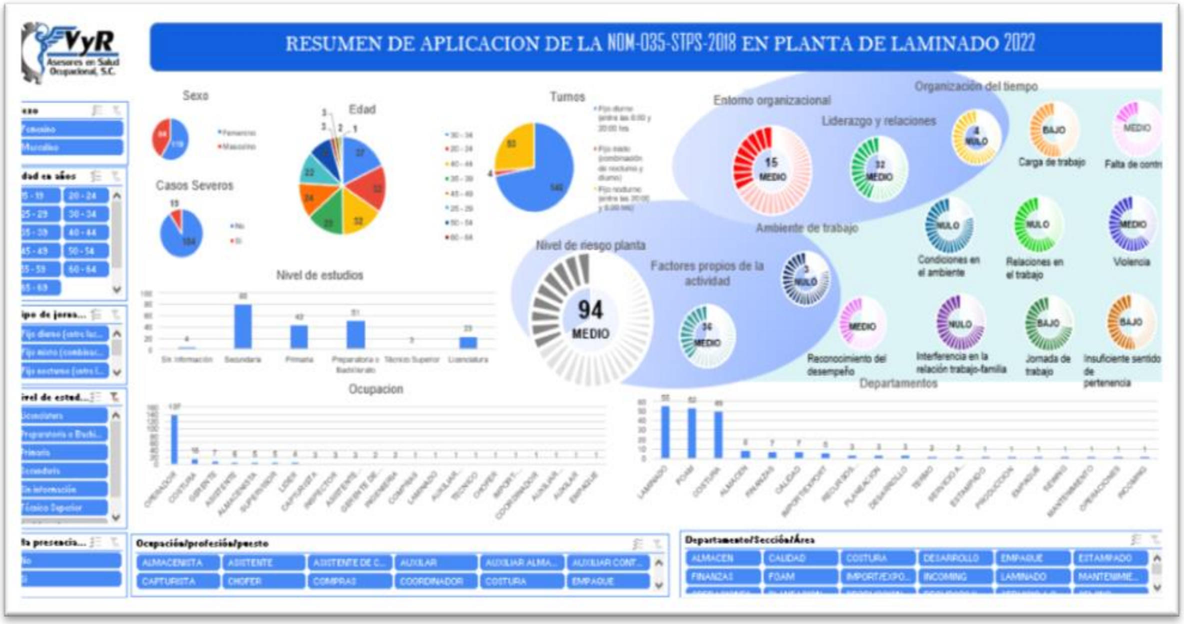


Figure 4. Dashboard, plant filtration.

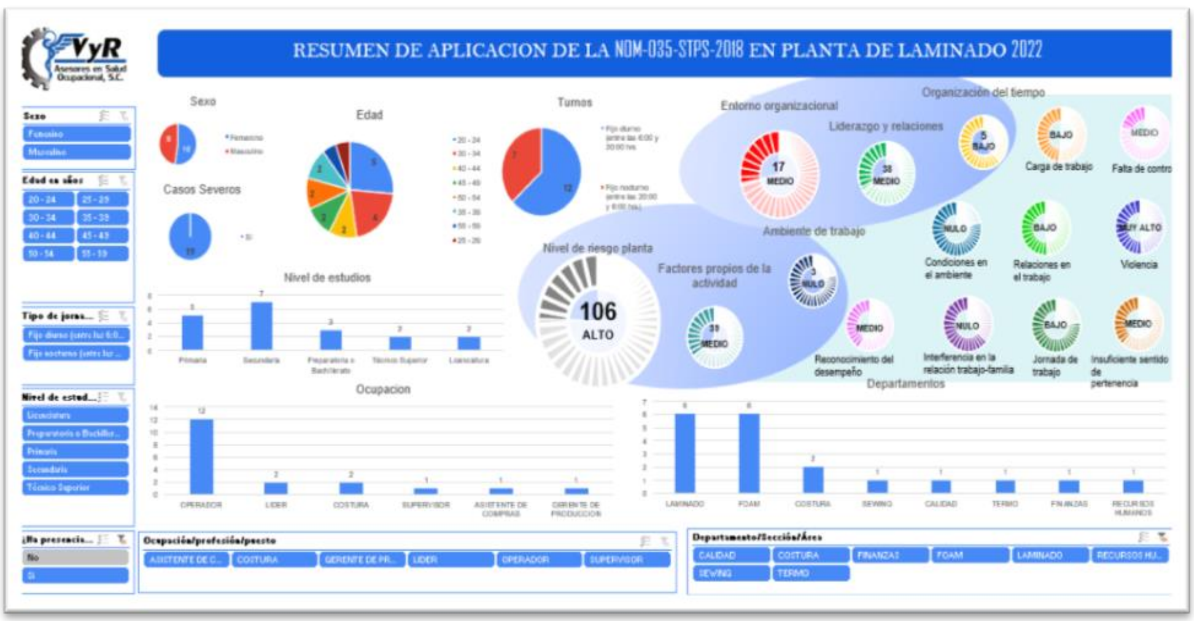
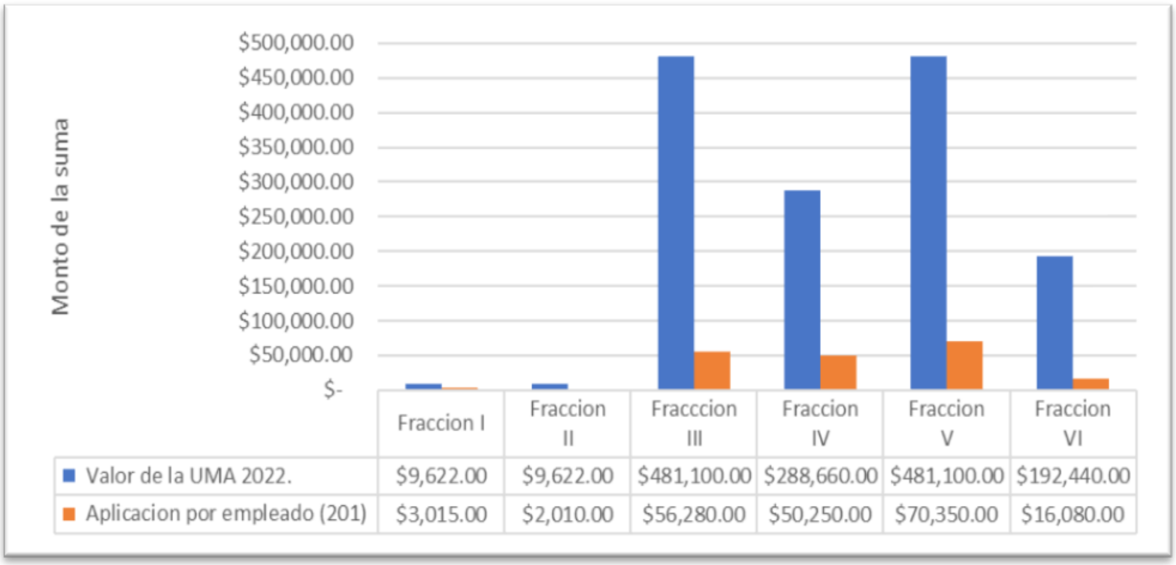


Figure 5. Dashboard, filtering due to severe cases.

The application of the NOM-035-STPS-2018, is applied jointly with the client, covering all the aspects that are required for the certification to carry out the certification, avoiding economic sanctions, but the monitoring of the standard is dependent on the client. according to the contracting of the additional service.

Also situating the cost benefit that was contracted with the application of the standard, which was charged for the number of employees analyzed (201), where the savings are graphed according to the value of the UMAS of what the fines for non-compliance with each fraction represented in a total direct expense of 1,462,544.00 MXN, without contemplating the indirect ones due to some closure of the plant and the investment expense in the total application was 197,985.00 MXN, being 13.53% of the total sum of the fines in the value of the UMAS by 2022 in Baja California, Mexico (see table 2).

Table 2. Cost Benefit.



6. CONCLUSIONS AND RECOMMENDATIONS

It is recommended to follow the defined strategy to solve medium and high risk problems, as well as to make stronger participations by the plant, it is recommended to make a second evaluation related to Burnout and mobbing in severe cases, to determine some type of problems related to workplace harassment or problems of professional burnout, since the severe cases are related to events of greater risk, it is pertinent to carry out the evaluation in these employees.

They are also recommended to hold more inclusion and leadership events to strengthen team ties and fellowship.

Likewise, how to confirm with the STPS the events that were carried out of the evaluation and the results to have a valid certification, and also make use of it at the time of a visit.

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DETERMINATION OF GOOD PRACTICES OF COLLABORATION IN THE SUPPLY CHAIN FOR THE MANAGEMENT OF ERGONOMICS.

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INTRODUCTION

Nowadays, there is increasing attention to sustainable supply chain (SC) management (Blome et al., 2014) and large-scale adoption of sustainable practices (Pagell et al., 2010; Rocha et al., 2018) to contribute to the profitability of the SC, eliminate or reduce negative impacts on environmental and social aspects. Therefore, it is in this last aspect where Ergonomics Management (EM) finds its most significant contribution due to the need to perform comprehensive Ergonomics studies throughout the SC and to propose an evaluation of all links through a holistic vision (Perttula, 2011). These considerations have led companies to collaborate with their suppliers and customers (Klassen & Vachon, 2003), fostering collective initiatives to develop strategies to improve the efficiency of the entire CS. To achieve social gains and mutual benefits, collaborative practices (CPs) are expected to be present in the relationships between SC links for EM as well; this research aims to identify the most significant collaborative practices in SC for this purpose.

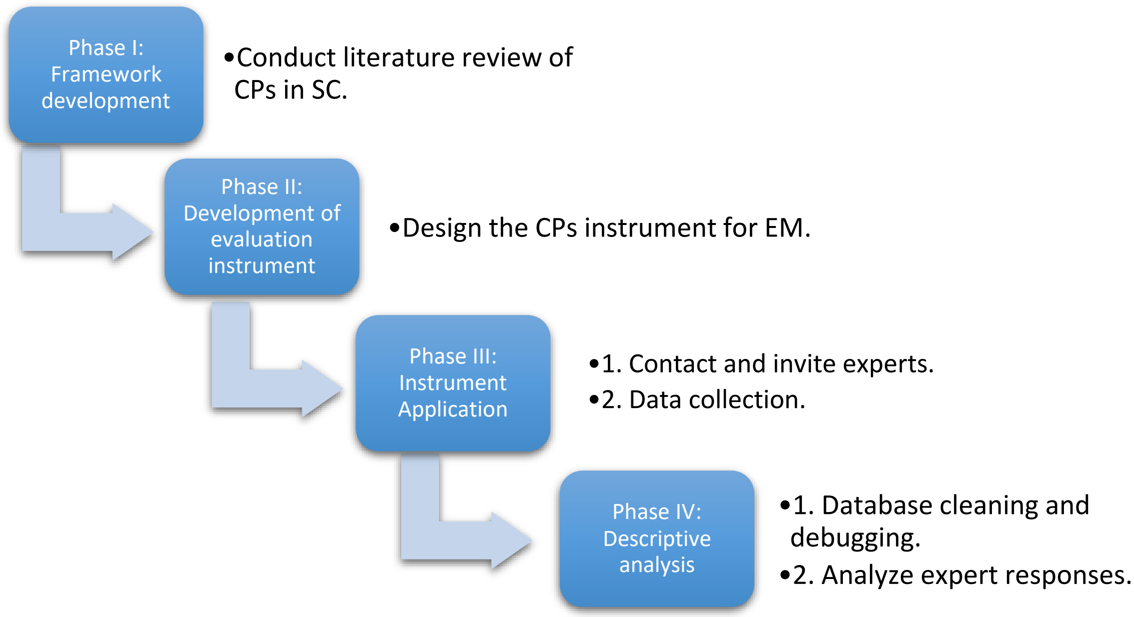
Key words: Ergonomics Management, Supply Chain, Collaboration, Interorganizational Relationships

Objective: Determine collaborative best practices in the supply chain for ergonomics management

Delimitation: A convenience sample of experts in the following areas of knowledge will be studied, ergonomics, occupational health and safety, management systems, and logistics.

METHODOLOGY

This research is a cross-sectional, non-experimental study under a convenience sample of experts. A four-stage methodology was considered:



In Phase I, a literature review was conducted to propose the constructs and items. In Phase II, the instrument is developed with Likert-type questions. Phase III consists of inviting the experts and collecting the data through the digital instrument, and finally, in Phase IV, the descriptive analysis of the experts' responses is carried out with SPSS, using the median, quartiles, and interquartile range as measures of description

RESULTS

Twenty-seven papers were identified, and two constructs (suppliers and customers) were determined. The instrument was reviewed by six experts. The final version consists of 12 items: closed Likert scale questions, where 1 = Strongly Disagree and 5 = Strongly Agree regarding the degree of agreement with the collaborative practice in SC for EM. Around 286 invitations were sent electronically, but only 34 experts responded. The experts have at least five years of experience in one of the areas of knowledge, where 76.4% are men and 23.6% are women, from Mexico (64.71%), South America (32.31%) and Cuba (2.94%), of which 58.82% belong to the private sector and the rest to the academic area.

From the highest medians and smallest interquartile ranges, it is determined that the experts express total agreement that the leading CPs between links for EM are:

- Total management commitment to collaborating with their SC EM suppliers and customers.
- Participate in the planning process together with suppliers and customers on ergonomic aspects.
- Establish collaborative actions on ergonomic aspects with their suppliers and customers.
- Share information and experiences of EM practices with suppliers and customers.

Share the results and control measures for identifying ergonomic risk factors with its suppliers and customers.

CONCLUSIONS

It is important to determine the main CPs in the SC related to EM since by complying with them, it is possible to improve the overall efficiency of the SC, implementing ergonomics projects or programs as a whole that benefit the members of the SC. In addition, it is feasible to evaluate the level of EM of the SC through compliance with them. The objective was met since the main CPs recommended by the experts was determined, highlighting that management commitment in the ergonomics management process is one of the fundamental practices so that, through collaboration, there are reasonable means of planning among the members of the chain and sharing experiences, prevention actions and control measures for the risk factors identified that may affect its performance and social sustainability.

Contribution to Ergonomics: This research contributes to the characterization of collaborative practices in supply chain for ergonomics management

PSYCHOSOCIAL RISK FACTORS AT WORK: CASE STUDY MIPyME

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Resumen La presente investigación se lleva a cabo en una mediana empresa de bebidas embotelladas, donde se implementó un nuevo control para el Análisis de Peligros y Operatividad (HAZOP) para el examen de sistemas y la gestión de riesgos. El sistema cumplió con la protección del equipo e identificación de posibles riesgos; sin embargo el clima laboral se tornó denso. Los trabajadores presentaron dolores de cabeza, fatiga crónica y se incrementó el ausentismo e incapacidades, además de accidentes en personal y baja productividad. La población de estudio fue de 30 trabajadores de ambos sexos (18 mujeres y 12 hombres) con una edad de entre 15 y 21 años aplicando el cuestionario Mindful Attention Awarness Scale (MAAS), es el instrumento más utilizado en el mundo para evaluar la atención plena. Los resultados revelan una buena fiabilidad de la escala general, así mismo, confirman que las cuatro dimensiones del inventario son factores sustantivos de la conciencia plena. Un análisis factorial confirmatorio muestra que los datos se ajustan de manera adecuada al modelo. Se concluye que al evaluar la conciencia plena de los trabajadores, se encontró que la incertidumbre surge como una percepción subjetiva del ante la amenaza, desconfianza y temor sobre las consecuencias de los procesos de reestructuración de la organización, la falta de información sobre su competencia respecto a sus iguales que propicia que los individuos trabajen bajo la inseguridad laboral, lo cual influye en el comportamiento social del trabajador tanto dentro de su área de trabajo como en sus relaciones interpersonales.

Palabras clave: riesgo, salud, enfermedad de trabajo, factores psicosociales.

Relevancia para la ergonomía: Es un estudio integral de análisis de riesgos desde la perspectiva, física (ambiental), intelectual y emocional.

Abstract: The present investigation is carried out in a medium-sized bottled beverage company, where a new control for Hazard Analysis and Operations (HAZOP) was implemented for the examination of systems and risk management. The system complied with the protection of the equipment and identification of possible risks; however, the work environment became dense. The workers presented headaches, chronic fatigue and increased absenteeism and disabilities, in addition to accidents in personnel and low productivity. The study population consisted of 30 workers of both sexes (18 women and 12 men) with an age between 15 and 21 years old, applying the Mindful Attention Awareness Scale (MAAS) questionnaire, it is the most used instrument in the world to evaluate mindfulness. The results reveal a good reliability of the general scale, likewise, they confirm that the four dimensions of the inventory are substantive factors of full consciousness. A confirmatory factor analysis shows that the data fit the model well. It is concluded that when evaluating the full awareness of the workers, it was found that uncertainty arises as a subjective perception of the threat, mistrust and fear about the consequences of the restructuring processes of the organization, the lack of information about their competence regarding to their peers that encourages individuals to work under job insecurity, which influences the worker's social behavior both within their work area and in their interpersonal relationships.

Keywords. Risk, health, occupational disease, psychosocial factors

Relevance to Ergonomics: It is a comprehensive study of risk analysis from the physical (environmental), intellectual and emotional perspective.The following order in the paper is strongly recommended: Introduction, Objectives, Methodology, Results, Discussion/Conclusions and References

1. INTRODUCTION

The world has experienced the incorporation of new forms of employment which has caused that in some countries not only are emerging factors considered as occupational hazards, but also talk about their prevention. With this, it is intended to demonstrate the current problem regarding psychosocial risks and their relationship with decent work contemplated in article 5°1 of the political constitution of the United Mexican States as an internationally recognized human right, as well as the right to health contained in article 4 of the same legal system, in a local Mipyme soft drink company. From an ergonomic point of view, individuals, when carrying out any work activity, are forced to tolerate a workload, be it physical or mental. The physical workload is made up of the biomechanical, physiological and caloric requirements imposed by the task on people; meanwhile, the mental workload is made up of the cognitive processing requirements inherent to the task for its proper performance.

Objectives: Identify risk factors and their relationship with the mental health of workers.

1.1 Delimitation

It only includes the risk factors emerging from work in its content, the physical or psychological illnesses generated as a result of said factors, as well as their prevention and, where appropriate, the measures to make the human rights of the working class affordable. mental health mental health: “the set of emotions, lifestyle and working conditions that allow people to feel emotionally and physically calm and that allows them to have a dignified life.

2. METHODOLOGY

Methods of systematic observation are used to identify potential risks in a job. According to the INSHT, the hazophazard and operability analysis method has been used as risk analysis techniques to assess quantitatively and qualitatively the different risks also the mathematical evaluation based on "the magnitude of the risk", to estimate the relative danger caused by each type of risk.

The report offers detailed information on how the workers of the chosen sample position themselves before each question, allowing to know the percentage of choice of each response option, which provides data on specific aspects related to each risk factor. This information can help guide the particular actions to be undertaken to improve a given factor. From our perspective, this method is quite broad since, in elements such as autonomy, the questions are focused on knowing the possibilities of the worker to resolve their personal conflicts and attend to labor conflicts; information can also be obtained regarding autonomy in the labor decision making.

On the other hand, it is also possible to know the degree of intellectual demand that the job requires, as well as the degree of emotional demand. On the other hand, it is also possible to know the degree of intellectual demand that the job requires, as well as the degree of emotional demand.

2.1 Definitions

The SYSTEM is the subject of a risk assessment and generally includes a process, a product, an activity, a facility often described as: A brainstorming technique a qualitative risk assessment tool.

An inductive risk assessment tool, meaning it is a "bottom-up" risk identification approach, where success depends on the ability of subject matter experts (SMEs) to predict deviations based on past experience and in general knowledge of the subject.

Addition to its utility in quality risk management, HAZOP is also commonly used in risk assessments for industrial and environmental health and safety applications.

HAZOP in the context of the accepted Quality Risk Management process consisting of Risk Assessment, Risk Control, Risk Review and Communication and is intended to complement (not replace or repeat) the guidance available within the International Standard IEC 61882

Danger - Potential source of damage. Deviations from design or operational intent may constitute or produce a hazard. Hazards are the focus of HAZOP studies, and it should be noted that a single hazard can lead to multiple forms of harm.

Damage Physical injury or damage to people's health or damage to property or the environment. Harm is the consequence of a hazard occurring and can take many forms: patient or user safety, employee safety, business risks, regulatory risks, environmental risks, etc.

Risk: Combination of the probability of harm occurring and its severity.

In a strict sense, "risk" is not always explicitly identified in HAZOP studies, as the basic methodology does not require identification (also called qualification) of the probability or severity of harm. However, risk assessment teams may choose to rank these factors to quantify and prioritize risks if necessary.

The HAZOP is the most suitable for evaluating the hazards in facilities, equipment and processes, and is capable of evaluating systems from multiple perspectives:

Design

- Assess the design capability of the system to meet user specifications and safety standards.
- Detection of weak points in the systems Physical and operational environments
- Assess the environment to ensure that the system is properly located, supported, serviced, contained.

2.2 Operational and procedural controls

- Evaluation of engineering controls (eg automation), sequences of operations, procedural controls (eg human interactions).
- Evaluation of the different operating modes: start-up, standby, normal operation, stationary and unstable states, normal stop, emergency stop.

The definition phase usually begins with the preliminary identification of the members of the risk assessment team. HAZOP is conceived as a cross-functional team effort and is based on specialists (SMEs) from various disciplines with the right skills and experience demonstrating intuition and good judgment.

SMEs should choose carefully to include those with extensive and up-to-date knowledge of system deviations. HAZOP should always be conducted in a climate of positive thinking and candid discussion.

During the definition phase, the risk assessment team must carefully identify the scope of the assessment to focus the effort.

This includes defining the study boundaries and key interfaces, as well as the key assumptions under which the assessment will be conducted.

- The preparation phase typically includes the following activities Identifying and locating supporting data and information.
- Identification of the audience and users of the study results
- Preparations for project management (for example: scheduling of meetings, transcription of minutes, etc.)

- Consensus on the format of the template for recording the results of the study
  Consensus on the HAZOP guide words to be used during the study

2.3 Examination phase

The examination phase begins with the identification of all elements (parts or stages) of the system or process to be examined. For example:

- Physical systems can be broken down into smaller parts as needed
- The processes can be divided into different stages or phases
- Similar parts or steps can be grouped to facilitate evaluation

2.4 Documentation and monitoring phase

Documentation of HAZOP analyzes is typically provided using a record form template, as detailed in IEC 61882. Risk assessment teams can modify the template as needed based on factors such as:

- Regulatory requirements
- Need for a more explicit classification or prioritization of risks (for example: classification of probability of deviation, severity and/or detection).
- Company documentation policies
- Needs for traceability or preparation for audits
- Other factors
- Hazard and operability analysis (HAZOP)

After the HAZOP analysis is complete, the results and conclusions of the study should be documented according to the nature of the risks assessed in the study and according to each company's documentation policies. As part of the closure of the HAZOP analysis, it should be verified that a process is in place to ensure that assigned actions are closed satisfactorily.

2.5 Risk review

In the long term, the operational information must confirm that the evaluation and control measures adequately address the issue of risk. If not, it may be necessary to review all assumptions. The feedback should correspond to the guarantee that the assumptions made about the level of residual risks are still valid. Residual risks are risks that are expected to remain after risk control strategies have been exercised. It is also important to note that new risks may arise from risk control practices. Sometimes risks that were not originally identified or leaked during the initial risk assessment can become aggravating factors due to the application of risk control measures.

2.6 Risk communication

The HAZOP is a powerful communication tool. The output of the tool should always be presented with a level of detail suitable for the various stakeholders. This is important not only for presenting the results, but also for gaining early acceptance of the approach.

In cases where the HAZOP is used as the basis for a "GxP" decision or some other regulated authorization, the approach should be documented in a standard operating procedure. Detailed scoring algorithms or steps may not need to be included in the procedure, but should be documented in a controlled report. Updates to the portfolio should also be controlled.

Psychosocial and ergonomic factors are the most frequent detrimental exposures to health in the working population of the manufacturing industry, the foregoing as a consequence of the demand for activities such as load handling, operating machines, tools, and assembly. Emerging risks are described in relation to the creation of new jobs, the globalization of markets and the inclusion of technology in the workplace.

One of the main causes that generate job uncertainty in workers is the lack of coping strategies that leads to emotional disorders such as affective distancing, impatience and irritability with coworkers. Likewise, there are consequences such as absenteeism, low productivity, lack of motivation towards the exercise of work and violent behavior (Cervantes, 2021).

Research approach: study with a quantitative approach, since statistical procedures were used for its descriptive analysis, thus Hernández et al. (2014), refer that this approach collects information in order to test assumptions based on numerical measurements and later the analysis, through the use of statistics.

Type of research: the study was descriptive, cross-sectional, in relation to the above, Hernández-Sampieri and Mendoza (2018), point out that the descriptive level is responsible for knowing the profiles, properties, peculiarities, processes of any situation that is subjected to analysis of a given sample.

Research method: hypothetical-deductive, by initially observing the. Consistent with the above, Pimienta and de la Orden, (2017) express that this method gives way to the structuring of reasoning from which they are derived or acquired through conclusions of one or several hypotheses.

Population, sample and sampling: it was made up of 100% of the population of the private institution, therefore, a convenience sample was taken, taking into account compliance with the following characteristics: personnel who will voluntarily sign the informed consent, and who They will be working full time.

Measurement instruments: 2 instruments were used for data collection: The personal data exprofesa certificate made up of 18 items that inquire about biological and sociodemographic data that include age, sex, education, family situation, job position, working days , turn, among others.

The instrument used to measure the full attention of the participants as a fundamental part of the coping strategies was KENTUCKY MINDING AWARENESS SKILLS INVENTORY, translated and adapted to Spanish by Cebolla et al, (2012).

Through 39 items, this instrument collects five mindfulness skills: Observation, description of the experience, acting with awareness, absence of judgment (inverse item) and absence of reaction (not reacting). The items are answered on a Likert-type scale from 1 (never) to 5 (always). The validation study of the questionnaire in Spanish showed good internal consistency indices (Cronbach's alpha equal to or greater than α= 0.70), while in this study the questionnaire in general presented a Cronbach's alpha of α= 0.80. Likewise, the questionnaire has shown factorial validity, convergent and divergent validity (Meda et al., 2015).

It is worth mentioning that each of the techniques were guided by the facilitator, who used a modulated and slow voice to understand the instructions given to the participants.

2.7 Ethical considerations

The study adhered to the provisions of the Regulations of the General Health Law on Research for Health (Secretary of Health [SSA], 2014), which aims to protect the well-being and dignity of the participants who were part of the study. Of the investigation.

Firstly, the authorization of the directors of the institution was obtained; The participation of the personnel was voluntary, through the signing of the informed consent, they were informed about the risks, where they were told that it was a study with minimal risk, they were informed that filling out the instruments could cause sensation of discomfort in the participants, therefore, if at any time any of the participants refused to carry out any of the activities, it was not forced and this did not have any affectation in their work or personal field.

Likewise, the data obtained was confidential, in addition to having granted a respectful and professional treatment to each participant.

3. RESULTS

The sociodemographic profile was as follows: There was a participation of (100%); 50% live with a partner, while 16.7% live alone and 66.7% reported having children. 10% have a degree, 83.3% work from Monday to Friday and only 16.7% do it from 3 to 4 days; 66.7% of the staff reported practicing physical activity on a regular basis; however, it was identified that 50% consume caffeine, 16.7% alcohol and stimulant medications. (Muñoz et al., 2019).

4. CONCLUSIONS

Regarding the result of The instrument used to measure the full attention of the participants as a fundamental part of the coping strategies was the KENTUCKY

MINDING AWARENESS SKILLS INVENTORY, It was found that 75% of the personnel who have had accidents and who are fatigued, are dispersed without fully perceiving the environment, showing fear for the possible results of their failure analysis and with uncertainty of being able to keep their job. This has generated a tense work climate and mistrust among workers.

The objective was to identify if the environment influenced accidents, low productivity and disabilities and with the results obtained it can be concluded that fear results in mental dispersion, generating a high incidence in all the identified problems affecting the psychosocial area of the work group. .

It is suggested to carry out the application of integration methodologies based on Organizational and Cognitive Economics, as well as providing sufficient information to workers to avoid stress and uncertainty.

It is suggested to expand the sample to other manufacturing companies and with different types of business.

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EMPIRICAL APPROACHES FOR ERGONOMIC ANALYSIS

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Palabras clave: Análisis ergonómico, aproximación empírica, factores de riesgo ergonómico

Keyword: ergonomic analysis, empirical approach, ergonomic risk factors

Introduction. Through the practice of ergonomics in work environments, it can be seen that the scientific foundations for the identification of risk factors, the evaluation methods to estimate the level of exposure to risk and the proposal of controls and measures of mitigation, are relevant, as well professional training in ergonomics, however, the tacit knowledge that practice entails, is also relevant.

Objective. This paper presents the elements to ergonomic analysis from work design, identifying ergonomic risk factors, including those related to modular factors; awkward posture, effort and repetition. In addition to modular factors, is necessary the review of the risk factors associated with the organization of work and the cognitive elements of the work activity.

Delimitation. This paper is limited to the personal experience of the authors, but could be extrapolated to different work environments and to different professional profiles, even when it starts from experience, is based, also, on scientific knowledge.

Methodology. To capture the empirical approach of ergonomic analysis, especially in industry, the first phase consisted of the necessary considerations to observe the ergonomic risk factors in the task activity, mainly the modular and organizational ones, the way in which they should be record and quantify to establish common scenarios for the different jobs. The second phase includes the use of a selection map of ergonomic evaluation methods, to quantify the level of exposure to risk; the selection of the method must correspond to the identified risks and the work activity, highlighting repetitive work and handling. Manual material handling, as well as the considerations of the method towards the factors of origin in the organization of the work. The third phase deals with strategies to react to the results of the risk assessment, recognizing the level of urgency in changes to a job; Changes to work method, work items, or work organization. In this phase, low-cost innovation and product lifecycle management are included. Additionally, aspects of work regulations are considered.

Results. As a result, the ergonomic process of work analysis and the considerations that, from an empirical approach, are suggested for approaching the practice of ergonomics are exposed. This paper presented decision maps, alternatives on human modeling technologies through information technologies, effort quantification resources in support of recovery times and the development of force standards for industrial processes. The work design intervention process, based on anthropometry is included. The cognitive approach to work analysis is included, as well as the concepts of participatory ergonomics and macroergonomics.

Conclusions. Based on the experience in the practice of ergonomics, a series of recommendations and suggestions have been presented that are not found in scientific research, from which are derived what, but how, are located in the field of professional practice. This work provides that empirical basis that can serve as a reference for those who carry out interventions in the field of health at work, under the field of occupational ergonomics.

Contribution to ergonomics. Through this work, an approach to the ergonomic analysis of the work activity is shown. Based on the experience: performing evaluations on work places, training professionals in work design and safety at work, conducting research and supporting practice in scientific knowledge, with these elements, you can consider a reference of ergonomic analysis to work design, conceptualizing it, as the basis of causes and effects on people, specifically in the prevention of musculoskeletal disorders work related.

"IDENTIFICATION, ANALYSIS AND PREVENTION OF PSYCHOSOCIAL FACTORS WITH THE GREATEST IMPACT IN A COMPANY IN THE CONSTRUCTION INDUSTRY"

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Resumen. La evolución de la actividad laboral ha tenido consigo una mejora de la calidad de vida de los trabajadores, pero además es también responsable de la aparición de una serie de efectos negativos en la salud de estos.

La relación entre el trabajo y la salud puede abordarse de distintos ámbitos. Desde la perspectiva psicosocial, los riesgos a los que los trabajadores están expuestos en el transcurso de su jornada laboral tienen su origen en el terreno de la organización del trabajo, y aunque sus consecuencias no son tan evidentes como las de los accidentes de trabajo y las enfermedades profesionales, no por ello son menos reales.

El objetivo de la investigación es realizar un diagnóstico para la identificación, análisis y prevención de los riesgos psicosociales con el fin de reconocer los que influyen en el desempeño laboral de los trabajadores del estudio en caso. Siendo así; la pregunta de investigación, ¿Cuáles son los Factores de Riesgo Psicosocial (FRPS) que mayor impactan en los trabajadores de una industria de la construcción?, se responde a través de la Norma Oficial Mexicana NOM-035-STPS-2018, Factores de riesgo psicosocial en el trabajo, Identificación, análisis y prevención. El mencionado documento establece los requisitos para identificar y analizar los factores de riesgo psicosocial y evaluar el entorno organizacional.

Así mismo, orientará a adoptar medidas de prevención y acciones de control de acuerdo a la clase de factores de riesgo obtenidos del diagnóstico.

En este contexto los factores de riesgo psicosocial que tienen lugar en el mundo, y en particular en México, exigen un compromiso gubernamental para fortalecer la seguridad y la salud en el trabajo que permitan lograr un trabajo digno y decente.

Palabras clave: Factores de riesgo psicosocial, industria, construcción

Relevancia para la ergonomía. Al establecer la Secretaría del Trabajo y Previsión Social (STPS) la obligatoriedad de las empresas de desarrollar estrategias para la disminución o eliminación de los FRPS y la generación de un ambiente organizacional favorable este estudio permite a las empresas desarrollar estrategias para mantener la salud organizacional, así mismo pretende ser un referente para estudios relacionados con la temática.

Abstract. The evolution of work activity has brought with it an improvement in the quality of life of workers, but it is also responsible for the appearance of a series of negative effects on their health.

The relationship between work and health can be approached from different areas. From a psychosocial perspective, the risks to which workers are exposed during their workday have their origin in the field of work organization, and although their consequences are not as obvious as those of accidents at work and occupational diseases, are no less real for this.

The objective of the research is to carry out a diagnosis for the identification, analysis and prevention of psychosocial risks in order to recognize the factors that influence the work performance of the study workers in each case. Being so; The research question, What are the Psychosocial Risk Factors (FRPS) that have the greatest impact on workers in a construction industry?, is answered through the Official Mexican Standard NOM-035-STPS-2018, Risk Factors psychosocial at work-Identification, analysis and prevention. The aforementioned document establishes the requirements to identify and analyze psychosocial risk factors and assess the organizational environment.

Likewise, it will guide the adoption of prevention measures and control actions according to the class of risk factors obtained from the diagnosis.

In this context, the psychosocial risk factors that take place in the world, and in particular in Mexico, require a government commitment to strengthen safety and health at work to achieve dignified and decent work.

Keywords: Psychosocial risk factors, industry, construction

Contribution to ergonomics. By establishing the Ministry of Labor and Social Welfare (STPS) the obligation of companies to develop strategies for the reduction or elimination of FRPS and the generation of a favorable organizational environment, this study allows companies to develop strategies to maintain organizational health, It also aims to be a reference for studies related to the subject.

1. INTRODUCTION

In Mexico, as of 2015, the Federal Occupational Safety and Health Regulation (RFSST, 2014) has entered into force, where, as part of Article 32, the general provisions for occupational health are established and which includes the numeral XI that includes Psychosocial Risk Factors (FRPS). It is also mentioned that the provisions will be complemented with the regulations that are applicable, for that matter, NOM-035-STPS-2018; Psychosocial risk factors at work, Identification, analysis and prevention.

The psychosocial risks at work constitute a great concern on the part of the world organizations related to health and work, such as the WHO and the ILO, and they are making efforts so that the States and all the actors involved in the world of work take aware of the magnitude of the problem. The negative effects on the health of workers and the impact on productivity, due to various types of illnesses and absenteeism.

The International Labor Organization (ILO) has recognized psychosocial factors as a fundamental part of development in organizations, considering them a positive component that promotes the conservation and, sometimes, the improvement of health. However, the negative component has been associated -with a certain relative importance- with the appearance of diseases that can arise in practically all the environment where people interact, particularly in the work environment, in certain aspects of the organization, in the systems and physical aspects of work and human relations, affecting the company's social climate and the physical and mental health of workers (ILO, 1984).

Throughout history, work has been a risk to health, so evaluate the conditions that allow optimizing the health and well-being of workers; It has become an important factor for all organizations. Occupational risks are not only physical and environmental, attention in recent years has focused on occupational risks that go beyond having an inadequate work space, such as psychosocial risks, since they directly affect the worker physically. , psychological and social having repercussions at the level of working and non-professional life.

Work then represents a psychosocial risk for both workers and employers, causing an increase in illnesses and accidents in the work environment. For this reason, the health of employees has been affected in such a way that comprehensive care and special attention by companies to the people who provide their services minimizes these risk factors in favor of a better quality of life.

For (Moreno Jimenez & Baez Leon, 2010), one of the first official and international documents to address the issue of psychosocial factors at work was "Psychosocial Factors at Work: Recognition and Control" a document published by the International Organization for Work. Work in 1984. Where his main contribution is to document the importance and effects of psychosocial risks at work on the health of workers.

This document first recognizes the complexity of psychosocial risks at work, since they represent a set of experiences and perceptions of the worker, making every company include them in its policies to promote the health and well-being of its workers. The International Labor Organization (ILO, 2016) affirms "Psychosocial factors at work consist of interactions between work, its environment, job satisfaction and organizational conditions, on the one hand, and on the other, the capabilities of the worker, their needs, their culture and their personal situation outside of work, all of which, through perceptions and experiences, can influence health, performance and job satisfaction" in a certain sense Psychosocial risks at work refer to the characteristics of work organization, relationships and work culture that can affect the well-being of workers.

In context, the Ministry of Labor and Social Welfare, in exercise of its normalization powers, prepared NOM-035-STP-2018 Psychosocial risk factors: Identification, analysis and prevention, through which provisions are established that must be adopted in the workplaces, in order to identify and prevent psychosocial risk factors, as well as to promote a favorable organizational environment in the workplace.

2. OBJECTIVE

Carry out a diagnosis for the identification, analysis and prevention of psychosocial risks in a company in the construction industry.

3. DELIMITATION

The study is carried out in a construction industry company, considering this as a pilot study.

4. BACKGROUND

In Mexico, as of 2015, the Federal Occupational Safety and Health Regulation (RFSST, 2014) has entered into force, where, as part of Article 32, the general provisions for occupational health are established and include in the numerals X and XI to Ergonomic Risk Factors (ERF) and Psychosocial Risk Factors (FRPS) respectively. It is also mentioned that the provisions will be complemented with the regulations that are applicable, for that matter, NOM 035 STPS 2018; Psychosocial risk factors at work-Identification, analysis and prevention.

Article 43 of the aforementioned regulation establishes the obligations in the workplaces, they are listed below:

Regarding the Psychosocial Risk Factors of the Work Center, employers must:

I. Identify and analyze jobs with psychosocial risk due to the nature of their functions or the type of working hours;

II. Identify workers who were subjected to severe traumatic events or acts of Workplace Violence, and assess them clinically;

III. Adopt the pertinent preventive measures to mitigate Psychosocial Risk Factors;

IV. Carry out examinations or clinical evaluations on Personnel Occupationally Exposed to Psychosocial Risk Factors, as required;

V. Inform workers about possible changes to health due to exposure to Psychosocial Risk Factors, and

VI. Keep records on the preventive measures adopted and the results of the examinations or clinical evaluations.

Aspects to be considered within the Psychosocial Risk Factors that derive from the nature of the functions of the job: Dangerous Conditions inherent to it; when performed under Unsafe Conditions; that demands high responsibility, or requires intense concentration and attention for prolonged periods.

Also understanding the need to have a safety and health program at work to avoid risks in the workplace. The process of identifying psychosocial risk factors must start from a diagnosis of safety and health at work and consequently establish the set of actions aimed at prevention and correction, in accordance with the provisions of NOM 030 STPS 2009.

The same regulation mentions in Article 55 about the promotion of a favorable organizational environment and the prevention of workplace violence. This aspect is strongly linked to the effects of FRPS.

Article 476 of the Federal Labor Law refers to the following: "In all cases, occupational diseases will be considered those determined by this Law and, where appropriate, the update carried out by the Ministry of Labor and Social Welfare." This could have implications for the diagnosis of occupational diseases associated with psychosocial risk factors and consequently affect the Social Security premium. Hence the importance of anticipating events and establishing the strategy for the prevention and control of psychosocial and ergonomic risks, added to those derived and associated with safety and hygiene in the workplace.

The consequences of exposure to FRPS can be reflected in health effects, for example, in the presence of musculoskeletal disorders or that can cause anxiety disorders, non-organic disorders of the sleep-wake cycle and severe stress and adaptation , derived from the nature of the functions of the job, the type of work day and exposure to severe traumatic events or acts of labor violence to the worker, due to the work carried out.

4.1 Psychosocial Risk Factors.

The International Labor Organization (ILO, 1984) has recognized psychosocial factors as a fundamental part of development in organizations, considering them a positive component that promotes the conservation and, sometimes, the improvement of health. However, the negative component has been associated -with a certain relative importance- with the appearance of diseases that can arise in practically all the environment where people interact, particularly in the work environment, in certain aspects of the organization, in the systems and physical aspects of work and human relations, affecting the social climate of the company and the physical and mental health of workers (OIT, 1984).

Psychosocial Factors are defined as the interactions, on the one hand, between work, the environment, satisfaction and the conditions of the organization and on the other, the worker's abilities, their needs, culture and the personal situation that prevails outside of work. , considering for this the perceptions and experiences manifested by the worker in the company.

5. METHODOLOGY

The data was collected through the application of a questionnaire to identify Psychosocial Risk Factors and Evaluate the Organizational Environment in the workplace, proposed in NOM-035-STPS-2018 Reference Guide III since the company has more than 50 employees, to identify Psychosocial Risk Factors. The interpretation of the risk levels of the questionnaire data is given through the scale of the Level of risk and color suggested by the Standard:

0 = Null Risk, which is identified by the blue color

1 = Low Risk, identified by the green color

2 = Medium Risk, yellow color

3 = High Risk, orange color

5 = Very High Risk. Red color

To obtain the sample size, the NOM-035-STPS-2018 formula was used:

$$n = \frac{.9604N}{0.0025(N-1) + .9604}$$

Which already establishes criteria to determine how many workers should apply the questionnaire depending on the number of these in the company.

For the purposes of this study, the sample of employees is 144

To obtain the qualification, Tables 1 must be considered, which groups the items by category, domain and dimension, and proceed as follows:

1) Qualification of the domain (Cdom). It is obtained by adding the score of each of the items that make up the domain;

2) Category rating (Ccat). It is obtained by adding the score of each of the items that make up the category, and

3) Final score of the questionnaire (Cfinal). It is obtained by adding the score of each and every one of the items that make up the questionnaire.

The results are presented according to the classification suggested by NOM-035-FRPS-2018 for its interpretation (Table 1).

Table 1. Analysis Factors Reference Guide III

CATEGORÍA	DOMINIO	DIMENSIÓN	ÍTEM
Ambiente de trabajo	Condiciones en el ambiente de trabajo	condiciones peligrosas inseguras	1, 3
		condiciones deficientes e insalubres	2,4
		trabajos peligrosos	5,
factores propios de la actividad	carga de trabajo	cargas cuantitativas	6,12
		ritmos de trabajo acelerado	7,8
		carga mental	9,10,11
		cargas psicologicas emocionales	65,66,67,68
		cargas de alta responsabilidad	13,14
		cargas contradictorias o inconsistentes	15,16
	falta de control sobre el trabajo	falta de control y autonomia sobre el trabajo	25,26,27,28
		limitada o nula responsabilidad de desarrollo	23,24,48
		insuficiente participacion y manejo del cambio	29,30
		limitada o inexistente capacitación	35,36
organización del tiempo de trabajo	jornada de trabajo	jornadas de trabajo extensas	17,18
	Interferencia en la relacion trabajo-	influencia del trabajo fuera del centro laboral	19,20
		influencia de las responsabilidades familiares	21,22
Liderazgo y relaciones en el trabajo	Liderazgo	escasa claridad de funciones	31,32,33,34
		caracteristicas del liderazgo	37,38,39,40,41
	elaciones en el traba	relaciones sociales en el trabajo	42,43,44,45,46
		deficiente relacion con los colaboradores que supervis	69,70,71,72
	Violencia	violencia laboral	57,58,59,60,61,62,63,64
Entorno Organizacional	Reconocimiento del desempeño	escasa o nula retroalimentacion del desempeño	47,48
		escaso o nulo reconocimiento y compensacion	49,50,51,52
	Insuficiente sentido de pertenencia e	limitado sentido de pertenencia	55,56
		inestabilidad laboral	53,54

The results of each questionnaire must be within the following ranges:

1) For the final grade:

Resultado del cuestionario	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Calificación final del cuestionario C_{final}	$C_{final}<50$	$50\leq C_{final}<75$	$75\leq C_{final}<99$	$99\leq C_{final}<140$	$C_{final}\geq 140$

2. For the classification by categories

Calificación de la categoría	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Ambiente de trabajo	$C_{cat}<5$	$5\leq C_{cat}<9$	$9\leq C_{cat}<11$	$11\leq C_{cat}<14$	$C_{cat}\geq 14$
Factores propios de la actividad	$C_{cat}<15$	$15\leq C_{cat}<30$	$30\leq C_{cat}<45$	$45\leq C_{cat}<60$	$C_{cat}\geq 60$
Organización del tiempo de trabajo	$C_{cat}<5$	$5\leq C_{cat}<7$	$7\leq C_{cat}<10$	$10\leq C_{cat}<13$	$C_{cat}\geq 13$
Liderazgo y relaciones en el trabajo	$C_{cat}<14$	$14\leq C_{cat}<29$	$29\leq C_{cat}<42$	$42\leq C_{cat}<58$	$C_{cat}\geq 58$
Entorno organizacional	$C_{cat}<10$	$10\leq C_{cat}<14$	$14\leq C_{cat}<18$	$18\leq C_{cat}<23$	$C_{cat}\geq 23$

3. For qualification by domains

Resultado del dominio	Nulo o despreciable	Bajo	Medio	Alto	Muy alto
Condiciones en el ambiente de trabajo	$C_{dom}<5$	$5\leq C_{dom}<9$	$9\leq C_{dom}<11$	$11\leq C_{dom}<14$	$C_{dom}\geq 14$
Carga de trabajo	$C_{dom}<15$	$15\leq C_{dom}<21$	$21\leq C_{dom}<27$	$27\leq C_{dom}<37$	$C_{dom}\geq 37$
Falta de control sobre el trabajo	$C_{dom}<11$	$11\leq C_{dom}<16$	$16\leq C_{dom}<21$	$21\leq C_{dom}<25$	$C_{dom}\geq 25$
Jornada de trabajo	$C_{dom}<1$	$1\leq C_{dom}<2$	$2\leq C_{dom}<4$	$4\leq C_{dom}<6$	$C_{dom}\geq 6$
Interferencia en la relación trabajo-familia	$C_{dom}<4$	$4\leq C_{dom}<6$	$6\leq C_{dom}<8$	$8\leq C_{dom}<10$	$C_{dom}\geq 10$
Liderazgo	$C_{dom}<9$	$9\leq C_{dom}<12$	$12\leq C_{dom}<16$	$16\leq C_{dom}<20$	$C_{dom}\geq 20$
Relaciones en el trabajo	$C_{dom}<10$	$10\leq C_{dom}<13$	$13\leq C_{dom}<17$	$17\leq C_{dom}<21$	$C_{dom}\geq 21$
Violencia	$C_{dom}<7$	$7\leq C_{dom}<10$	$10\leq C_{dom}<13$	$13\leq C_{dom}<16$	$C_{dom}\geq 16$
Reconocimiento del desempeño	$C_{dom}<6$	$6\leq C_{dom}<10$	$10\leq C_{dom}<14$	$14\leq C_{dom}<18$	$C_{dom}\geq 18$
Insuficiente sentido de pertenencia e, inestabilidad	$C_{dom}<4$	$4\leq C_{dom}<6$	$6\leq C_{dom}<8$	$8\leq C_{dom}<10$	$C_{dom}\geq 10$

Based on the result of the qualification of each questionnaire, the level of risk is determined and analyzed, as well as the actions that must be adopted to control the psychosocial risk factors, through an intervention program for medium, high levels. and very high, based on the following table:

Table 2. Criteria for taking action

Nivel de riesgo	Necesidad de acción
Muy alto	Se requiere realizar el análisis de cada categoría y dominio para establecer las acciones de intervención apropiadas, mediante un Programa de intervención que deberá incluir evaluaciones específicas1, y contemplar campañas de sensibilización, revisar la política de prevención de riesgos psicosociales y programas para la prevención de los factores de riesgo psicosocial, la promoción de un entorno organizacional favorable y la prevención de la violencia laboral, así como reforzar su aplicación y difusión.
Alto	Se requiere realizar un análisis de cada categoría y dominio, de manera que se puedan determinar las acciones de intervención apropiadas a través de un Programa de intervención, que podrá incluir una evaluación específica1 y deberá incluir una campaña de sensibilización, revisar la política de prevención de riesgos psicosociales y programas para la prevención de los factores de riesgo psicosocial, la promoción de un entorno organizacional favorable y la prevención de la violencia laboral, así como reforzar su aplicación y difusión.
Medio	Se requiere revisar la política de prevención de riesgos psicosociales y programas para la prevención de los factores de riesgo psicosocial, la promoción de un entorno organizacional favorable y la prevención de la violencia laboral, así como reforzar su aplicación y difusión, mediante un Programa de intervención.
Bajo	Es necesario una mayor difusión de la política de prevención de riesgos psicosociales y programas para: la prevención de los factores de riesgo psicosocial, la promoción de un entorno organizacional favorable y la prevención de la violencia laboral.
Nulo	El riesgo resulta despreciable por lo que no se requiere medidas adicionales.

Source: Official Mexican Standard NOM-035-STPS-2018

6. RESULTS

The General risk level of the company is 107.49, (table 3) considering the data of NOM-035 it is at high risk, which requires that in general terms an analysis of each category and domain be carried out , so that the appropriate strategies can be determined through an intervention program, which may include a specific evaluation and an awareness campaign, review the psychosocial risk prevention policy and programs for the prevention of Psychosocial Risk Factors, the promotion of a favorable organizational environment and the prevention of workplace violence, as well as reinforcing its application and dissemination.

Table 3 shows the results of each analyzed section of the Company and it can be seen that there is a high level of general risk in all the analyzed sections, with the exception of the Depto. 6, which has a medium level.

Table 3. Global results

		RESULTADO GLOBAL	DEPTO. 1	DEPTO. 2	DEPTO. 3	DEPTO. 4	DEPTO. 5	DEPTO. 6
CALIFICACION FINAL		107.49	98.33	114.62	119.00	114.51	115.07	83.42
CATEGORIA								
Ambiente de trabajo		6.15	1.67	7.69	8.80	8.55	6.47	3.75
Factores propios de la actividad		46.65	43.00	51.25	48.60	49.36	47.80	39.92
Organización del tiempo de trabajo		7.38	5.67	9.06	10.00	8.87	6.47	4.25
Liderazgo y relaciones en el trabajo		32.44	33.67	29.40	36.80	31.08	38.93	24.75
Entorno organizacional		14.86	14.33	17.23	14.80	16.66	15.40	10.75
CATEGORÍA	DOMINIO							
Ambiente de trabajo	Condiciones en el ambiente de trabajo	7.85	1.67	7.69	8.80	8.55	6.47	3.75
Factores propios de la actividad	Cargas de trabajo	30.12	22.00	32.02	32.00	29.30	29.53	26.42
	Falta de control sobre su trabajo	19.39	21.00	19.23	16.60	20.06	18.27	13.50
Organización del tiempo de trabajo	Jornada de trabajo	3.43	1.33	3.89	3.60	3.71	1.87	1.00
	Interferencia en la relacion trabajo-familia	5.08	4.33	5.17	6.40	5.16	4.60	3.25
Liderazgo y relaciones en el trabajo	Liderazgo	12.64	19.67	11.83	11.00	12.62	14.20	11.00
	Relaciones de trabajo	11.93	10.67	10.11	15.00	9.61	14.53	9.00
	Violencia	8.49	3.33	7.46	10.80	8.84	10.20	4.75
Entorno organizacional	Reconocimiento del desempeño	11.41	10.67	11.57	10.40	11.76	10.60	7.75
	Insuficiente sentido de pertenencia e inestabilidad	4.98	3.67	5.66	4.40	4.90	4.80	3.00

The categories of leadership and relationships at work and organizational environment present a medium risk in all the sections analyzed.

A high level of risk can be observed, especially in workloads, lack of control over work in most of the sections analyzed and medium risk in the work day, work relationships, violence, and evidence is shown in all sections. Lack of recognition by workers for performance.

The results found in the data analysis indicate a high level of psychosocial risk 119.00 in the Department. 3 , in the same way as in the previous sections, a strong incidence of risk was found in the category of Factors specific to the activity with 48.60, and in this section the category of organization of work time with a high level of risk was also detected.

In relation to the analyzed domain of interference in the work-family relationship, this risk is reflected with low levels of risk in all departments except department 3, which shows a medium level, so it is important to carry out mitigation measures for this risk.

7. CONCLUSIONS AND RECOMMENDATIONS

Identifying the negative psychosocial factors that impact the worker implies an in-depth evaluation and analysis by the organization to generate a map of risks inherent to the company.

The difficulty lies in the perception factor that prevails in the behavior of the worker. The attitude, knowledge, experiences, social and family environment that are part of the context in which the worker operates can affect their job performance and what for a worker is a normal situation without any particularity that worries him, for other people it can be an emotional trigger that impacts their work and group work.

Strategies to address FRPS can be broken down in two ways:

The first, regarding the obligations set out in Article 43 of the RFSST and reflected in NOM 035 STPS 2018, specifically in the process of informing and training workers about the FRPS.

The second related to the results obtained with the application of the questionnaire.

All the management of the process of compliance with the Standard must be done under the guidelines of NOM 030 STPS 2009.

In order to have an objective diagnosis and according to data provided by the workers, and following the suggestions of NOM-035-STPS-2018 in accordance with numeral 7.4, the method used for this diagnosis was the application of the Reference Guide III considering the number of workers of the company that is greater than 50.

The overall results showed a high level of risk for the company, with an indicator of 115.31 and according to the NOM-035, an analysis of each category and domain is required in organizational terms (see risk map) so that the appropriate strategies can be determined through an intervention program, which may include a specific evaluation and an awareness campaign, review the psychosocial risk prevention policy and programs for the prevention of Psychosocial Risk Factors, the promotion of a favorable organizational environment and the prevention of workplace violence, as well as reinforcing its application and dissemination.

A high level of risk can be observed, especially in workloads, lack of control over work in most of the sections analyzed and medium risk in the work day, work relationships, violence, and evidence is shown in all sections. Lack of recognition by workers for performance.

RECOMMENDATIONS

Taking as a reference the Psychosocial Risk Factors is attached below, specifying the Risk Factor found, its level, section or area detected, as well as application suggestions according to what is established by NOM -035-STPS-2018.detected in the diagnosis, the information obtained in the analyzed company.

In the following table there is information on the Company considering the high level in the first place since according to the risk it is the one that must be attended to with greater urgency, later the table with medium risk is presented.

Table 4. intervention level

Risk Factor Sections involved Interventions

Risk factor	Sections involved	Interventions
Workloads	All the Depts.	1er . level
Lack of control over work	All but Dept. 5	1er . level
Working day	2, 3, 5	2do. level
Work-family relationship interference	3	2do. level
Leadership	1, 4 y 5	2do. level
Work relationships	3 y 5	2do. level
Violence	3 y 5	2do. level
performance recognition	All but Dept. 5	1er . level

The results shown in the risk map present high levels of risk in 5 of the 6 departments analyzed, which requires level 1, 2 and 3 interventions according to what NOM-035 suggests, Organizational, Departmental and Individual respectively.

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ANALYSIS OF MANUAL HANDLING OF LOADS IN THE DISTRIBUTION OPERATION IN THE BEHEADING AREA OF A SHRIMP FREEZER

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Resumen: El presente estudio se realizó en el área de descabece de camarón de una empresa congeladora, con la intención de observar las condiciones en que los operarios realizan sus actividades y con base en esto conocer las repercusiones que sus operaciones podrían ocasionar al realizar su trabajo considerando el manejo manual de cargas. La elaboración de este estudio se llevó a cabo mediante observación directa de las actividades realizadas por el operador tomando en cuenta posturas y cargas aplicadas en su trabajo para posteriormente evaluar desde el método MAC TOOL. Dentro de los objetivos específicos se incluyeron observar y analizar el proceso que se lleva a cabo para surtir el área de descabece, identificar las condiciones en las que se realizan las cargas de camarón que se debe transportar manualmente, realizar la evaluación bajo la NOM-036-1-STPS-2018 Factores de riesgo ergonómico en el Trabajo-Identificación, análisis, prevención y control. Parte 1: Manejo manual de cargas., además de proponer las acciones de mejora necesarias para disminuir y eliminar los riesgos. Como resultado se plantearon diferentes propuestas e ideas orientadas a alcanzar las mejoras adecuadas para esta situación.

Palabras clave: Carga, postura, riesgo, análisis, aplicación.

Relevancia para la ergonomía: La evaluación de manejo de cargas permite prevenir y controlar los riesgos ergonómicos, mediante la mejora de la gestión del talento humano, planificando y organizando al personal según sus capacidades y condiciones de trabajo, forjando un sistema más eficiente en sus operaciones, cuidando la seguridad y salud del trabajador.

Abstract: The present study was carried out in the shrimp deveining area of a freezing company, with the intention of observing the conditions in which the operators carry out their activities and, based on this, to know the repercussions that

their operations could cause when performing their work, of course, analyzed from an ergonomic point of view. The elaboration of this study was carried out through direct observation of the activities performed by the operator taking into account postures and loads applied in their work to subsequently evaluate from the MAC TOOL method. The specific objectives included observing and analyzing the process carried out to supply the deboning area, identifying the conditions under which the shrimp loads that must be transported manually are carried out, carrying out the evaluation under NOM-036-1-STPS-2018 Ergonomic risk factors at work-Identification, analysis, prevention and control. Part 1: Manual handling of loads., and proposing the necessary improvement actions to reduce and eliminate the risks. As a result, different proposals and ideas were put forward to achieve the appropriate improvements for this situation.

Keywords: Load, posture, risk, analysis, application.

Relevance to Ergonomics: The evaluation of load handling allows the prevention and control of ergonomic risks, by improving the management of human talent, planning and organizing personnel according to their capabilities and working conditions, forging a more efficient system in its operations, taking care of the safety and health of the worker.

1. INTRODUCTION

In Sinaloa, specifically in the municipality of Guasave, one of the most common activities is aquaculture. The municipality has 100 shrimp farms, with an estimated surface area of 7000 ha of water mirror. (H. Ayuntamiento de Guasave, 2023).

This practice converts dams, lakes and lagoons into areas for exploiting natural marine resources. Aquaculture techniques allow the production of various high demand foods such as: farmed shrimp, catfish, tilapia, trout, among many others (Secretaría de Agricultura y Desarrollo Rural, 2019).

That is why, in the region this type of actions is very common, this article focuses on shrimp production and the activities derived from this, especially in the areas of decapping of this raw material.

Taking into account that each job represents a degree of difficulty according to its own practices, it is important to recognize the importance of evaluating these activities, and it is here where the important application of ergonomics is introduced.

> Ergonomics is an activity that encompasses different disciplines, such as mathematics, physics, biology, social sciences and anthropometry, among others, which is responsible for the study of working conditions, to adapt man to them, thus ensuring the promotion of health and prevent injuries such as muscular-skeletal disorders or posture alterations mainly (Maestre, L. M., 2017).

In this way, it is sought to make the appropriate modifications and corrections according to the characteristics and skills of each worker, thus promoting a better experience in their work.

For this reason, it is of utmost importance to evaluate this type of situations with appropriate tools such as the Mexican Official Standard NOM-036-1-STPS-2018. The manual handling of loads is a fairly frequent task in all sectors of activity and, in many cases, is responsible for the appearance of physical fatigue or injuries, which can occur suddenly or by accumulation of small, apparently unimportant traumas.

The most frequent injuries are, among others: contusions, cuts, wounds, fractures and, above all, musculoskeletal injuries. These injuries, although not fatal, can be long and difficult to heal, and in many cases require a long period of rehabilitation, causing great economic and human costs, since the worker is usually unable to perform his usual work and his quality of life may be deteriorated.

Due to this problem, in Mexico the Official Mexican Standard NOM-036-1-STPS-2018 has been published in the Official Journal of the Federation DOF (2018), which consists of establishing the elements to identify, analyze, prevent and control ergonomic risk factors in workplaces derived from the manual handling of loads, in order to prevent alterations to the health of workers.

2. OBJECTIVE

Evaluate load handling conditions to identify risk factors and, based on the results, propose actions to improve worker and process conditions.

3. DELIMITATION

The study applies to shrimp hauling and emptying operations at the deveining tables in the production area of a freezer company in the municipality of Guasave, Sinaloa.

4. METHODOLOGY

1. Observation and analysis of the process that is carried out to supply the shrimp de-boning area.
2. Identification of the conditions under which the shrimp loads that must be transported manually are carried out.
3. Perform the evaluation under the Official Mexican Norm NOM-036-1 of ergonomic risks.
4. Propose the necessary improvement actions to reduce or eliminate the risks.

5. RESULTS

5.1 Current analysis of the supply process of the shrimp deheading area

First of all, a survey was made of the process carried out in the deboning area, identifying the specific operations and the personnel that perform them, and based on this diagnosis, the following diagram was drawn up showing the distribution of the study area.

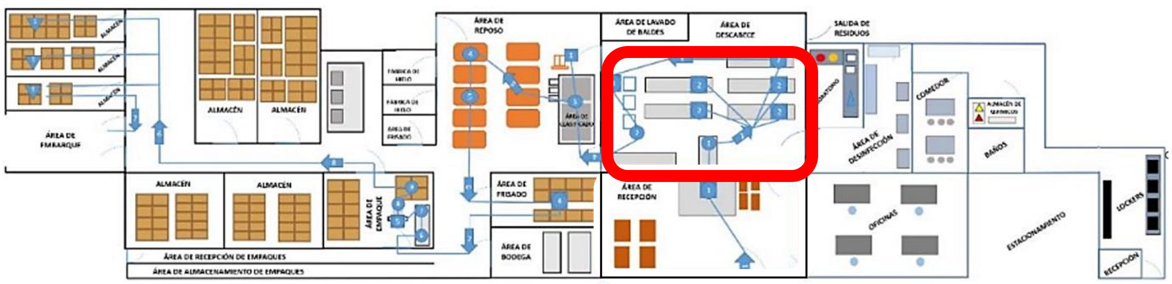

Figure 1. Location of the distribution operation in the shrimp beheading area.

The assortment process is relatively short, starting with the filling of yellow containers with a capacity of 32 kg, which are stacked 3 by 3 on top of another empty green or brown container. Once stacked, they are dragged by a dispenser to the work tables. After their arrival, the containers are emptied onto the tables where the destemming process will begin. As for the empty containers, they are dragged back to the place of origin for the next filling. The following figure shows graphically the above mentioned process.

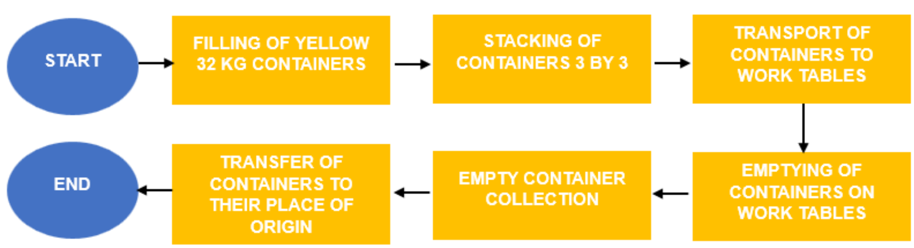

Figure 2. Process Diagram of the shrimp distribution process.

5.2 Identification of risk factors

After the observations made in each of the operations carried out in the area, the following risk factors were identified:

- The floor is wet.
- The weight exceeds that established by NOM-036 STPS 2018.

- There are obstacles on the raw material transfer route, which could cause an accident.
- The load being transported is not insured, which could cause product spillage and loss.
- The transported load is excessive, so it is possible that the load slips.
- When the load tends to be unstable, this can cause uneven muscle strain and injury to the operators.
- The physical effort used is too great or repeated.
- The environmental conditions in which the operation is carried out are of low humidity and temperature.
- No type of transport is used, making the transfer more risky.
- There are no signs for transporting cargo, so other workers may cross paths and cause accidents.

5.3 Application of the MAC TOOL method according to the Official Mexican Standard NOM-036-1 of ergonomic risks

According to the nature of the operations, it was identified that manual handling of loads and repetitive work is performed in the operations for the purpose of this article, the evaluations are shown based on NOM-036-1-STPS-2018

In Figure 3 it can be seen how the shrimp containers are dragged to the tables.

Figure 3. Transportation shrimp to tables.

Table 1. MAC TOOL evaluation of pushing operation.

RISK FACTOR	COLOR (G, Y, R, P)			SCORE		
	ROLLING	TURNING ON ITS BASE	DRAGGED, PULLED OR SLIDING	ROLLING	TURNING ON ITS BASE	DRAGGED, PULLED OR SLIDING
WEIGHT OF THE LOAD			P			8
STANCE			Y			3
HAND GRIP			R			2
PACE OF WORK			Y			1
DISTNACE PER TRIP			Y			1
WORK SURFACE			R			4
OBSTACLES ALONG THE RUTE			Y			3
OTHER FACTORS			R			2
	TOTAL SCORE					24

Figure 4 illustrates the process of emptying the shrimp onto the tables where it will be beheaded.

Figure 4. Placing shrimp on work tables.

Table 2. MAC TOOL evaluation of the load lifting operation.

RISK FACTOR	COLOR (G, Y, R, P)			SCORE		
	PULL UP	UPLOAD	TEAM	PULL UP	UPLOAD	TEAM
WEIGHT/FRECUENCY	P			10		
DISTANCE HAND-LOWER BACK	Y			3		
VERTICAL LIFTING ZONE/ASYMMETRICAL LOADING	Y			1		
TWISTING AND/OR LATERALIZATION	Y			1		
POSTURALRESTRICTIONS	Y			1		
GRIP QUALITY	Y			1		
FLOOR AREA	Y			1		
OTHER ENVIRONMENTAL FACTORS	Y			1		
TRANSFER DISTANCE						
OBSTACLES ON THE ROUTE						
COMMUNICATION, COORDINATION AND CONTROL						
	SCORE TOTAL			19		

Table 3. Risk level and priority.

RISK LEVEL	PRIORITY	TOTAL SCORE
Low - Acceptable	No corrective actions required	0 to 4
Medium - Possible	Short-term corrective actions are required	5 to 12
High - Significant	Corrective actions are required soon	13 to 20
Very high - Unacceptable	Corrective actions are required immediately	21 to 32

Table 4. Necessary actions.

RISK LEVEL	ACTIONS
Low - Acceptable	Only the most vulnerable groups, such as pregnant women or underage workers, need to be followed up.
Medium - Possible	The tasks should be examined in greater detail by applying a specific assessment, or control measures should be implemented through an ergonomics program for manual handling of loads.
High - Significant	Prompt action is required, so control measures must be established through an ergonomics program for manual handling of loads.
Very high - Unacceptable	Activities should be stopped and control measures implemented through an ergonomics program for manual handling of loads.

According to the analysis carried out when applying the evaluation, a value of 24 points was obtained for the pushing operation, which indicates that corrective actions are required immediately, because its risk level is unacceptable, the activities must be stopped and control measures must be implemented through an ergonomics program for manual handling of loads.

On the other hand, in the lifting operation, a score of 19 points was obtained for the unloading operation, with which it can be concluded that it represents a significant risk level, which indicates that corrective actions are required soon, quick action is required, and control measures should be established through an ergonomics program for manual handling of loads.

5.4 Improvement actions

- **Moving smaller weights:** In the pushing operation the weight exceeds the limit established by the standard, in addition it should be taken into account that the containers are stacked one on top of the other in groups of 3, each container has a weight of 32 kg, which adds up to a total of 96 kg.

Less than 25 kg	Low	0
From 25 kg to 50 kg	Medium	2
From 50 kg to 80 kg	High	4
More than 80 kg	Very high	8

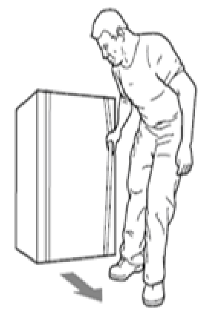

Figure 3. Maximum weight allowed for one person according to NOM-036-1-STPS-2018

- **Equipment requirements:** Another viable alternative for this problem is the implementation of equipment to transport the containers, this would make the operator's work easier due to the fact that it would decrease the effort and would propitiate a better grip when moving the loads.

Figure 4. Example of loading equipment

- **Assign the work according to the capabilities of each operator:** These operations as can be seen in the evaluation represent a significant physical effort, for such reason, one of the alternatives could be to assign this type of activities to the younger operators, since they are the ones who could perform the work better due to their physical condition in better condition.

- **Improve the distribution of work areas to reduce obstacles on the route**: with fewer obstacles, hauling can be carried out more freely and safely.

6. DISCUSSION/CONCLUSION

The realization of the work provided a clear idea that operators will be subjected to different activities that according to their nature will represent a physical effort of different magnitude.

It was concluded that the handling of loads manually by the operator is an issue that should be given the attention it deserves, since the correct evaluation of the situations to which the operator is exposed will prevent injuries that could negatively affect the person's performance and, of course, affect production in this case, in activities such as shrimp de-hooking.

The application of the Official Mexican Norm NOM-036-1 on ergonomic risks is a great tool that allowed us to know the current situation of the process and effectively evaluate the working conditions of the workers within this context, because once the weak points were identified, i.e., those where it is not covered with the necessary according to what the norm establishes, we were able to generate the modifications to the process, this with the intention of creating a positive impact on the operator's work, avoiding injuries and accidents that could be suffered.

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INERTIAL SENSORS TECHNOLOGY FOR POSTURAL EXPOSURE ASSESSMENTS: A SYSTEMATIC LITERATURE REVIEW

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Resumen: La evaluación postural confiable y económica en entornos laborales es un tema relevante en ergonomía. Los sensores inerciales de dimensiones reducidas y con generación de señales inalámbricas, ofrecen una posibilidad para medir grandes cantidades de datos cinemáticos en entornos laborales y en laboratorios. Esta revisión sistemática de literatura examinó el estado actual de las aplicaciones de la tecnología de sensores inerciales para evaluaciones posturales en entornos ocupacionales. Se realizó una revisión y una síntesis de 50 estudios. Los resultados de la revisión permitieron a definir las contribuciones de esta tecnología de sensores para identificar factores de riesgo de trastornos musculoesqueléticos (DM) relacionados con el lugar de trabajo. La revisión demostró que las tecnologías de detección inercial están recibiendo más atención para la investigación en ergonomía, y su uso en aplicaciones ocupacionales está creciendo. Adicionalmente, los resultados demuestran que existen variaciones en los puntos de fijación de los sensores, la calibración y los procedimientos de validación. Aunque las tecnologías de detección inercial son cada vez más populares en la investigación ergonómica, su adopción en entornos ocupacionales sigue siendo limitada. Este capítulo de libro investiga las aplicaciones actuales de los sensores inerciales para identificar factores de riesgo posturales de DM.

Palabras clave: Evaluación, sensor, inercial, postura.

Relevancia para la ergonomía: La principal contribución de esta revisión de literatura es aumentar el conocimiento sobre las aplicaciones más recientes de la tecnología de sensores en las evaluaciones posturales.

Abstract: Posture assessments in occupational settings that is accurate, dependable, and economical is a hot topic in ergonomics. Body-worn inertial sensors that are wireless and small provide opportunities to measure vast amounts of kinematics data in occupational settings as well as laboratory scenarios. This review examined the current state of art of applications of wearable inertial sensing technology in occupational ergonomics studies concerning the evaluation of posture in occupational settings. 50 studies were the subject of a systematic literature review and synthesis. Review results aid in defining the contributions of this sensing technology to the objective of identifying musculoskeletal disorders (MD) risk factors related to the workplace. The review demonstrated that inertial sensing technologies are receiving more attention for ergonomics research, and their use in occupational applications is growing. The review also found variations in sensor attachment points, calibration, and validation procedures. Although inertial sensing technologies are becoming more popular in ergonomics research, their adoption in occupational settings remains lagging. This book chapter investigates the current applications of inertial sensing technology for identifying posture risk factors for MD.

Keywords. Assessment, sensor, inertial, posture.

Relevance to Ergonomics: The main contribution of this literature review is to increase knowledge about most recent applications of sensor technology in postural assessments.

1. INTRODUCTION

Inertial sensing refers to sensing technologies that use the property of inertia. Inertial sensors include accelerometers, inclinometers, gyroscopes, and inertial measurement units (IMUs), which are a combination of accelerometers, gyroscopes and/or magnetometers.

Postural stress during physical work is often characterized by three main dimensions: intensity, repetition, and duration. The first dimension includes the magnitude of the load and the extent of non-neutral postures. The second dimension refers to the frequency or number of force exertions. The duration comprehends to the time the physical activity is performed. When studying repetitive work, postural strain is measured by sampling work to estimate all three strain dimensions. Besides, non-repetitive tasks may include repetitive elements, but the intensity, repetition and duration of the task may vary over time. In such cases, posture assessment is performed in a discrete-interval work sampling that may not capture the work exposures and musculoskeletal risks, which means that assessment may need to be performed over long periods of work to estimate exposures. In this context, accurate and reliable quantification of exposures defines the motivation for this review.

Human movement analysis was defined by Cappozzo et al. (2005) as the science that allows acquiring quantitative data about the mechanics of the musculoskeletal system during the development of a task. Picerno (2017) points out that joint kinematics is one of the key concepts to describe and evaluate human movement. The same author points out that the study of joint and body segment kinematics has been limited to the laboratory environment. However, the miniaturization of sensors and electronic components, usually associated with wireless communication, has opened a new perspective, allowing this technology to be taken out of the laboratory at relatively low cost.

Delp et al. (2007) indicate that devices for obtaining data on the movement and posture of body segments involve the use of wearable sensors and cameras. Peppoloni and Ruffaldi (2014) point out that real-time monitoring and feedback of a worker's postures can be carried out using direct methods of measuring body segment angles, which provide intuitive and more accurate results than other methods. Wearable sensors include inertial sensors, electromyography, motion capture systems, and reflective sensors, which track the movement of body segments producing kinematic data. In addition, Barkallah et al. (2017) note that reflective sensors with data processing through machine learning algorithms can provide very accurate assessments for posture.

Lee et al. (2017) indicate that sensor technology has gained attention in measuring human movement both in laboratory and natural environments. Hsu and Lin (2019) point out that the interest in this technology stems from improvements in sensor size and weight, as well as reduced production costs, wireless connectivity, availability of processing software, as well as increased battery life and data bandwidth that allow monitoring over long periods of time. Besides, Huang et al. (2020) consider that the portability of the sensors and their low interference with natural working postures have made them suitable for direct measurements of postural and movement parameters.

Despite the growing interest in sensor technology for ergonomic research, its adoption in areas of non-repetitive tasks lags (Lim and D'Souza, 2020). When studying cyclical tasks, the ergonomic risk level is estimated from a work sampling to determine exposure dimensions such as intensity, repetition, and duration, which can be extrapolated for longer periods of time and thus estimate cumulative exposure Diego-Mas et al. (2017). These same authors point out that non-repetitive tasks, which are defined as those in which there is variation and diversity in terms of frequency, duration and/or content, present challenges for ergonomic evaluations. Gaglio et al. (2015) consider that, under the conditions of non-recurring tasks, the assessment is carried out on a small group of subjects, or a discrete sample is used that may not capture exposures to risk factors, which may involve having to perform the evaluation for long periods of time. Obtaining a precise and reliable risk profile under the exposed conditions motivates the use of sensor technology, which can provide real-time information of ergonomic risk factors in a task.

Cuesta-Vargas et al. (2010) point out that among the technology used in laboratory environments are electromagnetic and optoelectronic video-based systems. Electromagnetic tracking systems consist of a source that emits an electromagnetic field, which is used to determine the location and orientation of the sensors; however, these systems are affected by the presence of metals and their accuracy decreases when the subject wearing them approaches the defined operating limit, which limits the analysis of the task being evaluated. On the other hand, Wren et al. (2011) points out that optoelectronic video systems are methods in which reflective markers are used within several cameras and, thanks to their flexibility, allow various regions of the body to be visualized. In this way, it is possible to track movements in three dimensions, however, such systems are affected by the characteristics of the environment surrounding the task under analysis.

According to (Lee et al., 2017) one of the emerging technologies in health and safety research (OHS) is wearable sensors, which can be classified into two categories:

a) Simple systems that are based on sensor signals located on segments of the body and serve to monitor movement.

b) Complex systems comprising multiple sensors that collect information on movement and physiological parameters.

The first category of wearable sensors has been represented by accelerometer-based monitors that track the movement of a single body segment by measuring acceleration parameters in three dimensions, estimating other parameters such as physical activity, vibration, and tilt based on acceleration measurements. Another device for measuring body motion are inertial measurement units that collect acceleration and magnetic data and can be placed on different body segments, allowing real-time data transmission through wireless data transfer systems.

The second category comprises microelectromechanical systems (MEMS), which include inertial sensors and their basic components: accelerometers, gyroscopes, and magnetometers. Piacerno (2017) indicates that in conventional technologies for motion analysis (stereophonies) the position and orientation of a body segment is established considering an external reference frame and that other kinematic magnitudes, such as linear acceleration and angular velocity, are calculated from linear and angular displacement measurements, and can be measured without an external reference system due to the principle of inertia (Woltring, 1985). This same author refers that inertial sensor, being portable elements and having an internal reference frame, can measure both their movement and that of a rigid body to which they are fixed, as well as linear velocity and angular acceleration. On the other hand, Piacerno (2017) points out that, as the kinematics of joints is defined from the relative orientation of two adjacent body segments, it is possible to establish this orientation using an inertial sensor.

According to Porta et al., (2021), wearable inertial measurement sensors (IMU) are devices that allow the estimation of orientation and kinematics of angles between body segments. Wearable inertial measurement sensors consist of a tri-axial accelerometer and a gyroscope to measure the acceleration and angular velocity of the sensor with respect to gravity (Sedighi et al., 2020). Calculating three-dimensional sensor rotations using accelerometer and gyroscope signals has advantages over using either individual signal, as each sensor data can compensate for the limitations of the other with the use of sensor data fusion algorithms such as a Kalman filter or a complementary filter (Huang et al., 2020). Gatti et al. (2016) consider that the effects of drift error introduced by integrating gyroscope data can be corrected by accelerometer-based orientation estimates. Lee et al., (2017) note that the orientation error that is affected by the earth's gravity in the accelerometer can be corrected by gyro-based rotation estimates. Often, inertial measurement sensors also include a triaxial magnetometer to measure the geomagnetic field to estimate the heading of the sensor relative to the earth's magnetic polarity. Certain algorithms combine information on the direction and magnitude of the earth's magnetic field from magnetometers with measurements from accelerometers and gyroscopes to obtain a single estimate of the three-dimensional orientation (Porta et al., 2020). However, magnetometers are susceptible to local magnetic field disturbances from local ferrous objects and electrical appliances, which affects the accuracy of 3D orientation estimates (Bachmann et al., 2007) and may limit the use of IMU in some conditions.

Lim and D'Souza (2020) note that the first study showing the use of devices to estimate the kinematics of angles between body segments dates to 1990. Since then, a variety of devices for estimating kinematics in two and three dimensions have emerged and are described below.

Accelerometers are devices that measure acceleration in different orientations, so that movements can be seen in all three dimensions from triaxial accelerometers, which come from uniaxial models. Accelerometers also operate as inclinometers when used to measure slopes or angles of inclination with respect to the gravitational field vector, when the acceleration is very small compared to that of gravity. In ergonomic applications, this type of accelerometer is used to measure orientations (bending/extension) of a specific body segment. However, the estimation of slopes can be unstable when one of the rotation axes is aligned with the gravitational line, because in this application the accelerometer is insensitive to rotation with respect to the gravitational field vector (Ngabo and El Beqqali,2018). According to (Cheung et al., 2011) data extracted from accelerometers provide information on postures and transitions between them. Accelerometers can respond to gravity or constant acceleration, although these devices cannot differentiate between a seated posture and an upright posture because they are placed in an upright position (Karantonis et al., 2006). However, this deficiency is solved by placing multiple accelerometers to observe the different orientations of the body segments. In this way, the seated and standing positions can be differentiated by placing a sensor on the torso and another on the thigh (Lyons et al., 2005). Moreover, transitions between a seated and a standing posture can be recognized with a single accelerometer placed at the waist (Yang & Hsu, 2010).

The gyroscope is a type of force sensor, which detects angular motion in one or two axes (Yang & Hsu, 2010). According to Abyarjoo et al. (2014) the gyroscope can measure axial rotation as well as provide information about orientation. The gyroscope also measures the angular velocity when the sensor rotates relative to the inertial reference frame, so this sensor allows determining angular displacement besides, estimating the angle of rotation of the sensor axis. However, its use generates drifts over time due to noise and compensation of the original signal, in the case of exceeding a duration greater than 5 seconds, the use of filters is required to compensate for drift (Ligorio and Sabatini, 2015). The data generated by the gyroscope and accelerometer are combined to calculate the rotation angles of the sensors. When these devices are placed on the chest, it is possible to measure the variation in trunk bending in tasks where there are transitions of sitting postures to standing (Najafi et al., 2002). Although the gyroscope is not as precise as the accelerometer to provide posture information of the body segments, with the combination of the gyroscope and accelerometer a measurement accuracy of 95% can be achieved (Incel, 2015). On the other hand, the error when using a single gyroscope can be reduced with the use of a magnetometer, which allows calibrating the device with the magnetic field of the earth. The combination of accelerometer and magnetometer can determine an orientation in a static state through measurements of gravity and vectors of the earth's magnetic field (Zhao & Wang, 2012).

Simpson et al. (2019) indicate that inertial measurement units consist of accelerometers and gyroscopes that may include magnetometers, and that therefore allow the measurement of a rotation angle of a body segment, from the main axis of motion under the premise that two body segments are connected by a joint with a degree of freedom for rotation. Table 1 shows the different configurations that an inertial measurement unit can have considering its degrees of freedom.

Table 1. Components, uses and characteristics of an inertial measuring unit.

Components	Degree of freedom	Level of accuracy	Uses/Limitations
3D accelerometer, 3D gyroscope and 3D magnetometer	9	High	Measure acceleration, angular velocity on all three axes.
3D accelerometer and 3D gyroscope	6	Medium	Low accuracy in determining sensor orientation.
3D accelerometer and 2D gyroscope	5	Medium	The gyroscope cannot make 3D measurements.
3D accelerometer and 1D gyroscope	4	Low	The gyroscope can only measure in one dimension.

1.1 Number of sensors and their location in the body

Results of studies by Gatti et al. (2016), Schall et al., (2016) and Slater et al. (2015) have indicated that the placement of sensors is critical to establish the reliability and validity of physical activity measurements. Faber et al. (2009) have studied the optimal locations for the location of inertial sensors to measure the bending angles of the lower back and trunk. Yan et al. (2017) used inertial sensors mounted on the head and back to measure postural angles in real time. Schall et al (2015), Thamsuwan and Johnson (2015) placed accelerometers in the thorax between the sternum and sternal notch to make measurements of the front and lateral bending angle of the trunk. Lee et al. (2017) investigated the effect of placing a sensor to analyze the posture of the trunk using single parameter portable sensors, placed in six locations in the body and a multiple parameter sensor located in two positions.

According to Adel et al. (2020) recognition of human activity is a growing field of research, especially with the use of smart devices such as smart watches and cell phones. The use of inertial sensors integrated to these devices allows recording the movement and then analyzing it. Additionally, sensor technology has been used to identify certain conditions of the human body. Inertial sensors have been placed in different locations of the human body (wrists, legs, arms, head, neck, legs), and the variety of locations in which sensors can be placed has an impact on the acquisition of information through them (Primo et al., 2014). Kunze et al. (2005) determined the location of inertial sensors using only the signals produced by them, through different algorithms (Naive Bayes, Naive Bayes simple and the nearest neighbor algorithm). The locations of inertial sensors were determined by the specific segments or angles to be measured in the studies of Holmes et al. (2010), Noccerino et al. (2011), Faber et al. (2012), Kim and Nussbaum (2013). The number of sensors used in the studies ranges from 1 to 17, with a median of 3 sensors per study. In the same way, in these studies, the sensors were placed bilaterally, that is, for the members of the left side as for the members of the right side. In this sense, the location of the sensors is determined by the type of measurement to be performed and the particular interest of the segments to be analyzed.

1.2 Promotion of ergonomic postures through postural analysis within assessment devices

According to Mullineaux et al. (2012) postural assessment using sensor technology provides some benefits. If the system provides the worker with information on non-ergonomic postures acquired while performing work tasks, these postures can be modified immediately. Studies by Obonyo, (2018) and Yoong et al. (2019) have explored the detection of non-neutral postures with inertial sensors. Other authors have employed smart devices with sensor technology (Akhavian and Behzadan, 2016 and Ryu et al. 2019. The indicated studies mainly focus on optimizing models to analyze motion data and detect postures. In all cases, the first step is to recognize posture and then analyze and transform it into diagnostic information for the purpose of establishing user feedback actions to modify postures and obtain favorable outcomes from an ergonomic perspective.

Zhao et al. (2021) developed a wearable sensor system to monitor postures and prevent injuries in construction workers. The sensor system has a preventive approach and consists of an assessment device for the worker. However, the posture promotion system focuses on the assessment itself and on the premise that the worker, knowing the result of his or her assessment, will promote the elimination of the risk factors associated with the posture.

2. OBJETIVES

The objective of this review was to examine the current state of the science of inertial sensing technologies applied to posture assessment in identifying MD. Specifically, a systematic literature review was conducted on inertial sensing-based technologies for assessing the worker's awkward postures with the intention of identifying them for action measures to reduce risk factors of work-related MD. This review begins with an introduction to inertial sensing technologies, followed by the methodology, results, and discussion of findings.

3. METHODOLOGY

3.1 Search strategy

This systematic review approach followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology for conducting and reporting systematic reviews in health sciences. For the review, articles published through June 2022 were looked up in four databases (Sciencedirect, PubMed, Taylor and Francis, MDPI). Only studies in English were searched. The search keywords used to identify studies on the use of inertial sensor technology included ['work*' or 'postural*'or 'occupational*'] and ['assessment' or 'exposure or 'evaluation'] and ['inertia*' or 'wearable'].

3.2 Exclusion criteria

Based on the title, abstract, and keywords, 672 studies were found in the initial search after duplicate articles were removed. The chosen studies (n = 137) were examined in their entirety based on the study's title, abstract, and full text (Step 1 in Fig 1), and they were disqualified from further analysis if they: did not use human subjects; used inertial sensing for purposes other than measuring a particular aspect of body posture or postural kinematics such that focused on health recovery (Step 2 in Fig 1), studies that used accelerometers to measure the vibration or movement of inanimate objects or machinery, for instance, were not included. After full review were selected 41 articles.

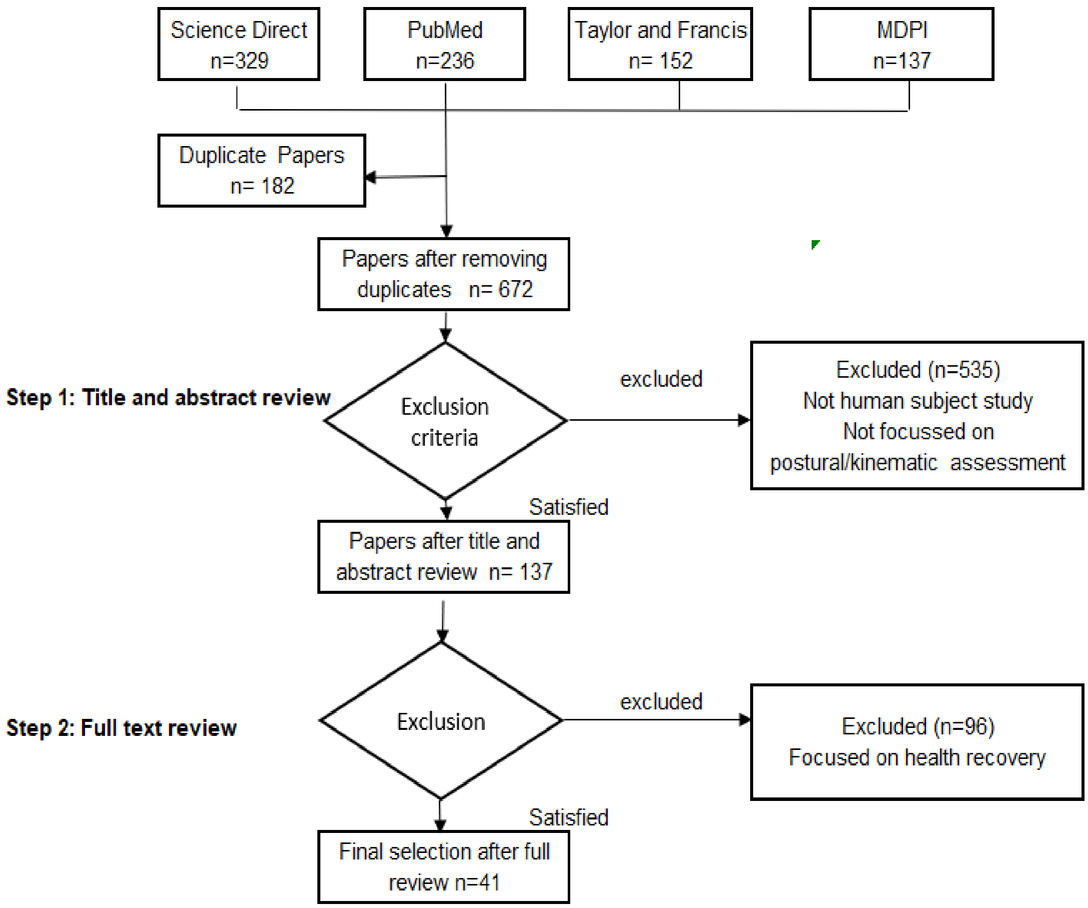


Fig 1. Flowchart of the document and selection process.

3.3 Data extraction and analyses

The data extraction and analysis phase included the following: author (s), year of publication, title, journal, study objective, study sample, study location, location of sensor in body, type of tasks performed, exposure characteristics, type of statistical technique used for analysis, purpose of the analysis.

4 RESULTS

Table 2 gives a general overview of the 41 studies that were examined, including the sample size and composition for each, the study's design (such as whether it was conducted in a lab or field setting), the occupational activities that were looked at, the number of sensors that were placed on the subjects, and the precise methods of analysis and evaluation. According to the review's findings, over the past five years, an increasing number of studies have used inertial sensors to evaluate the risk of MD.

Table 2 Publications selected after final review.

Study	Authors (Year)	Participants	n	Study location	Occupational activities	Number of sensors	Analysis
1	Xu et al. (2022)	Students	9	Lab	Assymetric postures	8	Descriptive
2	Maxwell et al. (2022)	construction workers	10	Field	construction	16	Inferential
3	Villalobos and Mac Cawley (2022)	Slaughterhouse workers	20	Field	Slaughterhouse meat cutters	1	Predictive
4	Porta et al. (2021)	Metalworking employees	33	Field	Metalworking	1	Descriptive
5	Petz et al. (2021)	Healthy participants	1	Lab	Sit to stand	8	Descriptive
6	Vikas et al. (2021)	Healthy participants	6	Lab	Sit to stand	1	Descriptive
7	Paloschi et al. (2021)	bending and sit to stand activities	1	Lab	bending and sit to stand	1	Descriptive
8	Bingcheng et al. (2021)	Badminton players	N/A	Lab	Badminton players	12	Descriptive
9	Hu et al. (2020)	Professional badminton players	N/A	Field	Sport professionals	N/A	Predictive
10	Zhao et al. (2020)	Construction workers	18	Field	Construction	5	Inferential
11	Tsao et al. (2020)	Manufacturing workers	18	Field	Assembly operations	N/A	Predictive
12	Zhao and Obonyo (2020)	Construction workers	4	Field	Construction and managing tasks	5	Inferential
13	Lind et al. (2020)	Material handlers	14	Lab	Simulated material handling	N/A	Descriptive
14	Tsao et al. (2020)	Precision assembly simulated workers	1	Lab	Precision assembly line simulation	17	Descriptive
Study	Authors (Year)	Participants	n	Study location	Occupational activities	Number of sensors	Analysis
15	Su et al. (2020)	Sit to stand activities	7	Lab	sit to stand	4	Descriptive

16	Vu et al. (2020)	astronauts	12	Lab	Astronauts static postures of torso	10	Predictive
17	Norasi et al. (2020)	Vascular surgeons	16	Field	Vascular surgery tasks	2	Inferential
18	Robert-Lachaine et al. (2020)	Material handlers	10	Lab	Manual material handling tasks	15	Descriptive
19	Mokhlespour et al. (2019)	Manual lifting, pushing and pulling simulation	11	Lab	Manual lifting, pushing and pulling tasks	11	Descriptive
20	Bootsman et al. (2019)	Nurses	15	Field	Patient lifting	2	Inferential
21	Han et al. (2018)	Students	31	Lab	Smartphone talks	1	Descriptive
22	Brand et al. (2018)	Constructio n workers	80	Field	Heavy lifting	8	Inferential
23	Fisher et al. (2018)	Office workers	13 1	Field	Static reaching and lifting	1	Descriptive
24	Ribeiro et al. (2017)	Healthcare workers	10 8	Field	Nursing tasks	1	Inferential
25	Lee et al. (2017)	Constructio n workers	1	Lab	Simulated construction tasks	7	Descriptive
26	Bergsten et al. (2017)	Baggage handlers	44	Field	Handling jobs	2	Inferential
27	Heiden et al. (2017)	Paper mill workers	28	Field	Package activities	3	Predictive
28	Yu et al. (2017)	Surgeons	10	Field	Instrument handling	5	Inferential
29	Dinu et al. (2016)	Osteopathy students	20	Lab	Sit to stand	17	Descriptive
30	Wick et al. (2016)	Office workers	38	Field	Work day activities	1	Predictive
31	Dahlqvist et al. (2016)	Healty individuals	12	Lab	Painting work	4	Descriptive
32	Bertrand et al. (2016)	Reach tasks	n/a	Lab	Reach tasks	3	Descriptive
33	Gholipour and Arjmand (2016)	Healty men	40	Lab	Static reaching and lifting	3	Descriptive
34	Schall et al. (2015)	Dairy workers	10	Field	Dairies tasks	4	Inferential
35	Breidahl et al. (2015)	Fishermen	4	Field	Fishing activities	1	Predictive
36	Battini et al. (2014)	Manual material handling	n/a	Field	Picking and packing	17	Descriptiv e
37	Vignais et al. (2013)	Healrth individuals	12	Lab	Manual tasks	8	Inferential
38	Moriguchi et al. (2013)	Electricians	24	Field	Electrician's task	4	Descriptiv e

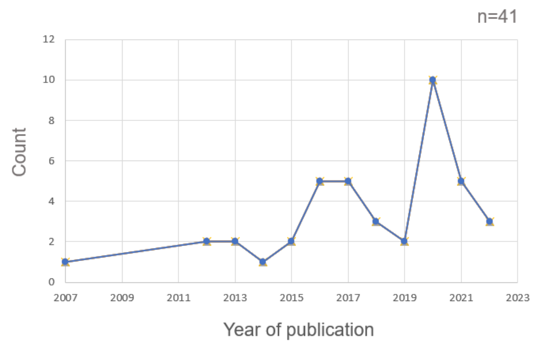
39	Doupharate et al. (2012)	Milkers	9	Field	Lifting and dispatching activities	2	Descriptive
40	Samani et al. (2012)	Cleaners	18	Field	Cleaning tasks	1	Inferential
41	Bonnet and Heliot (2007)	Sit/stand activities	n/a	Lab	Sit to stand	1	Inferential

Twenty two of the 41 studies collected data in field settings, with 19 (45%) of the studies taking place in laboratory settings. Scientific in laboratory ambiance and Industry, were the most frequently studied (27 of the 41 studies). Fifteen of the studies (36.5%) used measurements of angular displacement, as well as acceleration. Joint angle kinematics for upper arms, neck and trunk was calculated using various pairs of sensors. For measuring neck posture, pairs of sensors were attached to the forehead and cervical vertebra (Battini et al., 2014).

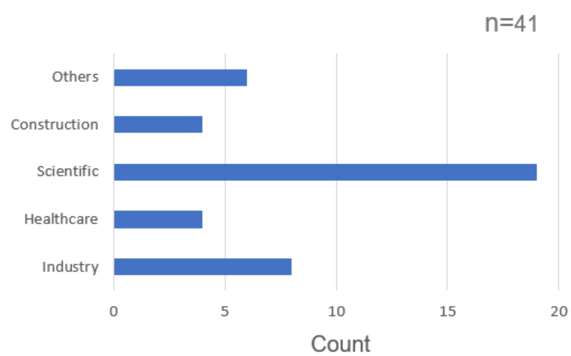
All the studies performed in lab settings validated inertial sensor measurements for accuracy and precision in ergonomics applications. By statistically comparing kinematic measurements obtained using inertial sensing to equivalent measurements obtained from a reference instrumentation system, accuracy was assessed (Xu et al. (2022), Petz et al. (2021), Vikas et al. (2021), Paloschi et al. (2021), Bingcheng et al. (2021), Bingcheng et al. (2021), Lind et al. (2020), Tsao et al. (2020), Su et al. (2020), Vu et al. (2020), Robert-Lachaine et al. (2020), Mokhlespour et al. (2019), Han et al. (2018), Lee et al. (2017), Han et al. (2018), Lee et al. (2017), Dinu et al. (2016), Dahlqvist et al. (2016), Bertrand et al. (2016), Gholipour and Arjmand (2016), Vignais et al. (2013) , Bonnet and Heliot (2007)).

Kinematic measures like joint moments were compared for validation purposes along with segment or joint angular displacement, velocity, acceleration, and range of motion (ROM). Correlation coefficients paired and independent sample t-tests, summary statistics on root mean squared errors (RMSE), and limits of agreement were among the statistical techniques frequently used to evaluate the accuracy of inertial sensor-derived measures in comparison to reference instrumentation measures (Robert-Lachaine et al. (2020), Mokhlespour et al. (2019), Bootsman et al. (2019), Han et al. (2018), Ribeiro et al. (2017),Lee et al. (2017), Bergsten et al. (2017),Heiden et al. (2017)). By measuring inter-rater reliability and intra-rater repeatability, the precision of sensor measurements was evaluated. Multiple examiners alternated attaching sensors to the same participant while they performed the same movement to test inter-rater reliability (Bootsman et al. (2019), Han et al. (2018), Ribeiro et al. (2017)). To compare the measurements obtained after multiple attachments of sensors to the same participant by the same examiner, intra-rater repeatability was typically investigated (Paloschi et al. (2021), Bingcheng et al. (2021), Bingcheng et al. (2021)). Four studies (19.7%) investigated the relationships between subjective workload measures like self-reported questionnaires and direct postural measurements derived from inertial sensors (Fisher et al. (2018), Dinu et al. (2016), Wick et al. (2016), Vignais et al. (2013)). A portion of these studies used commercial software, such as activePAL, Acti4, and ActiLife 6, to categorize various postures from inertial sensor data over time. The lengths of time spent in each posture were compared to results from self-reported surveys like the Occupational Sitting and Physical Activity.

According to the review's findings, over the past ten years, an increasing number of studies have used inertial sensors to evaluate the risk of MD. Over 56.1% of the studies examined (n=23 of 41) were published in the five years prior to the current year (2023); Fig 2 a). Most studies were developed in scientific context (46.3%), a 19.5% took place in industry, 9.7% in construction industry, 9.7% in healthcare, and 14.6% covered other areas (administrative tasks, fishing); fig 2 b).



a)



b)

Fig 2 Summary of the review results in terms of the number of studies by publication year between 2007 and 2022 (a), by field study site where the data collection was performed (b)

When using body-worn inertial sensors for ergonomics applications, the location of the sensors on the body must be carefully considered. Most studies used were focused on the sensor placement on upper body segments (Table 3) (65.8%). The placement decision was related to the study main research question. However, the locations varied according to postural models considered. Most studies reported segment or joint angular displacement in terms of flexion/extension, abduction/adduction, rotation using the sensor frame reference, but they were not standardized making the comparisons undetermined.

Table 3 Sensor placement

Body segment	Quantity	Upper body	Lower body	Study number from table
Head	3	x		3,23,32
Forehead	1	x		4
Cervical	1	x		14
Chest/Sternum	6	x		5,7,19,21,37,39
Scapular	3	x		2,40,41
Thoracic	4	x		15,22,31,38
Upper Arm	7	x		16,20,27,29,30,34, 36
Lumbar	1	x		9
Sacral	1	x		17
Lower Arm	8		x	1,8,10,11,12,24,26,28
Pelvis	1		x	35
Hand	2	x		6,25
Thigh	3		x	5,13,18

A 46.3% of joint angular displacement were calculated for Upper arm-lower arm and lower arm-hand joints (Table 4). It was identified the need to demonstrate the validation process for the sensor attachment placements. The wearability of sensor in terms of user comfort and obtrusiveness was not determined in any study.

The way of expressing extreme postures was using threshold-based ordinal categories. Threshold levels were determined using either study-specific thresholds or previously validated absolute limits. Depending on the task, posture characteristics were either calculated over the entire data collection period or stratified. Studies used data from additional methods, such as direct or video-based observations to annotate and segment sensor data with the start and end of tasks and task type, diaries, or work-logs to record the time and duration of work vs. non-work tasks, especially for data collection sessions spanning multiple days.

Table 4 Joint angle calculation

Joint angle calculation	Quantity n=41
Head-thoracic	3
Forehead-cervical	1
Head-chest	1
Chest/Sternum	6
Upper arm-Lower arm	10
Pelvis-thigh	4
Thoracic-sacral	7
Lower arm-hand	9

In two studies (Bertrand et al. (2016), Wick et al. (2016)), the posture characteristics were separated by task by first determining the length and nature of work tasks using more objective techniques, such as deterministic posture thresholds.

5 CONCLUSIONS

This study investigated the state of the science today regarding inertial sensing technologies for posture assessment. The review was scoped and organized according to biomechanical models used, sensor locations, assessment, and validation processes. The results point to a growing body of information about inertial sensing in ergonomics. The ability of this new technology to improve the quality and quantity of postural data has so far been its primary contribution to ergonomics, making it appealing as a research tool.

Most of the studies under review were either in applied settings for direct measurement of motions and postures in place of observational methods or laboratory evaluations to validate inertial sensor data compared to reference motion capture derived measurements. It seems is still difficult to effectively implement inertial sensing technologies as a tool for online postural assessment and real-time feedback toward proactively identifying and reducing the risk of work-related MD in practical settings.

Sensing and modeling inertial sensing posture analysis techniques must be robust to minor misalignment or use calibration postures or movements that are easy for practitioners to administer because sensor placement misalignments are unavoidable. In addition to the modeling requirements, wearability concerns related to the quantity and placement of body-worn sensors must be considered. It is evident that the trade-offs between the number/location of sensors and wearability are not frequently prioritized because some studies call for up to 17 body-worn inertial sensors (Maxwell et al. (2022), Tsao (2020), Dinu et al. (2016).

Declaration of competing interest

The authors would like to state that they have no known financial or interpersonal conflicts that might have appeared to have an impact on the study presented in this paper.

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ERGONOMIC ANALYSIS FOR WORKERS IN THE CONSTRUCTION PROCESS IN A COMPANY OF GUASAVE, SINALOA.

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Resumen: La empresa se dedica a la construcción de inmuebles en el municipio de Guasave, Sinaloa. En la actualidad, se destaca como una de las principales empresas en términos de calidad en el proceso y resultado final de la construcción de diversas infraestructuras en el municipio de Guasave. Con el objetivo de salvaguardar la salud y bienestar de los trabajadores que laboran en la empresa, se llevó a cabo un minucioso análisis ergonómico centrado en las lesiones musculoesqueléticas y las condiciones ambientales a las que están expuestos. Como resultado de dicho análisis, se determinó la necesidad de realizar un estudio ergonómico exhaustivo para identificar posibles DTA en los operarios que desempeñan funciones en el área de distribución y mezclado de materiales de construcción.

Palabras clave: Método RULA, Corlett and Bishop, Principios Ergonómicos, DTA, Materiales de Construcción.

Relevancia para la Ergonomía: La ergonomía es la interacción entre los seres humanos y otros elementos de un sistema. En este sentido, la investigación se posiciona como un recurso valioso para promover un entorno laboral saludable y productivo en el ámbito de la construcción.

Abstract: The company is dedicated to the construction of real estate in the municipality of Guasave, Sinaloa. At present, it stands out as one of the main companies in terms of quality in the process and final result of the construction of various infrastructures in the municipality of Guasave. In order to safeguard the health and well-being of the workers who work in the company, a thorough ergonomic analysis was carried out, focusing on musculoskeletal injuries and the environmental conditions to which they are exposed. As a result of this analysis, it

was determined that an exhaustive ergonomic study was needed to identify possible ATD in the workers who work in the distribution and mixing of construction materials.

Keywords: RULA Method, Corlett and Bishop, Ergonomic Principles, DTA, Construction Materials.

Relevance to Ergonomics: Ergonomics is the interaction between human beings and other elements of a system. In this sense, the research is positioned as a valuable resource to promote a healthy and productive work environment in the construction field.

1. INTRODUCTION

In Sinaloa, during 2021, the value of the construction industry's production was 9,971 million pesos (mdp), 1,390 million pesos more than in 2020. This represented an increase of 16.2 percent, higher than the national average of 13.4 percent (CODESIN, 2021).

Based on the statistics of the Mexican Institute of Social Security for 2018 of Occupational Risks registered in the IMSS, it shows the accident rate ceiling by economic activity, by occupation, by unsafe act and physical risk, identifying that the construction sector is at number 4 in accidents caused by dangerous postures or actions (SEPRESST, 2019).

2. OBJECTIVE

To perform a detailed analysis of the process of distribution and mixing of materials, specifically the leveling of cement mix, carried out by the construction company, with the purpose of identifying and evaluating possible musculoskeletal injuries that may arise during such activities. It also seeks to evaluate the working conditions existing in the company, considering various aspects related to the work environment.

3. DELIMITATION

The analysis refers to the ergonomic conditions in which the operators of the construction company located in the La Brecha syndicate, in the municipality of Guasave in the state of Sinaloa are found. Evaluating the postures of the workers in the activities they perform, with the RULA and Corlett and Bishop method in a workday of 8 hours a day for 6 days a week. This company has 12 operators and 2 different areas: mixing and casting.

4. METHODOLOGY

The study was conducted in several stages:

1. Diagnosis of the company through tours, identifying the characteristics of the workers, work stations and the situation in which the company finds itself.

2. The workstations were analyzed for a certain period of time, and the activities that present risk factors for the operator were identified in the area of distribution and mixing of construction materials, showing musculoskeletal injuries in the workers.

3. The applicable evaluation methods were RULA (work fatigue test) and Corlett and Bishop (body discomfort), which were used to evaluate the risk run by the worker in his work area, as well as the application of Mexican Official Standards (NOM).

5. RESULTS

After carrying out an exhaustive analysis of the distribution and mixing process of construction materials, an area of opportunity has been identified that has a negative impact on the operators. It has been observed that the movements required to spread the mixture are inadequate, as the process is carried out manually in high temperature conditions, which increases the risk of possible health problems. It is recommended that appropriate measures be implemented to improve the ergonomics of the tasks and reduce the risks associated with exposure to high temperatures, in order to safeguard the health and safety of the operators involved in this process.

5.1 Diagram of operations

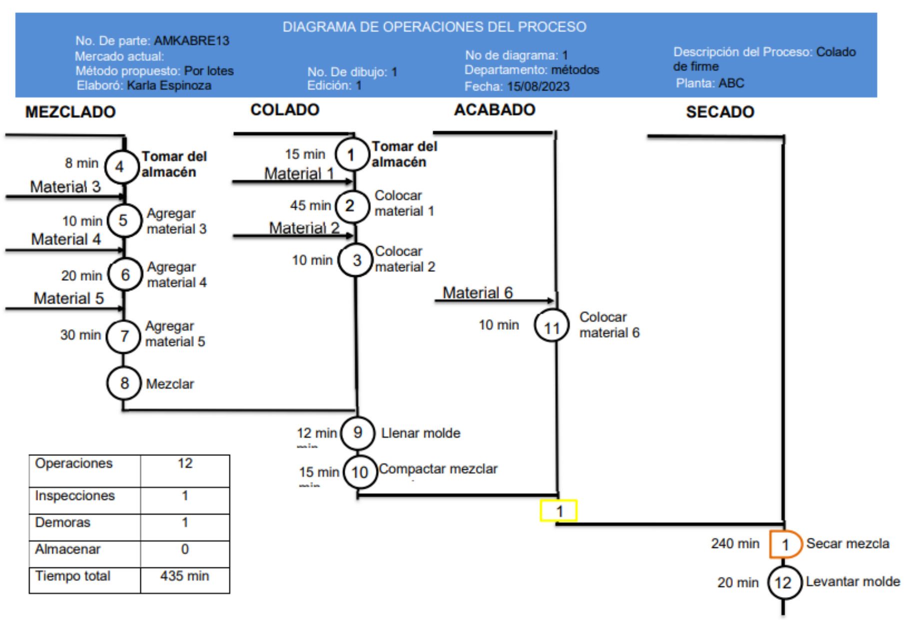
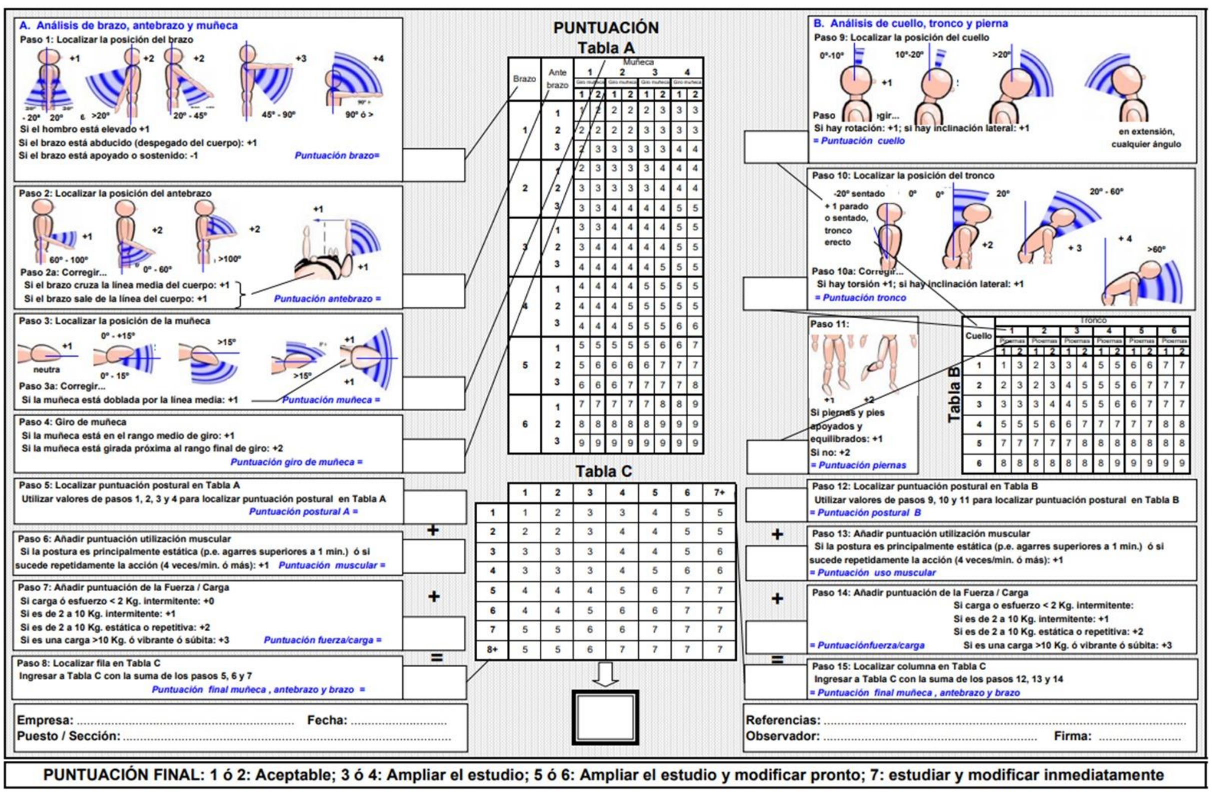


Figure 1. Diagram of operations

Figure 2. Photographs 1 and 2: product development



A. Análisis de brazo, antebrazo y muñeca

Paso 1: Localizar la posición del brazo

Si el hombro está elevado +1
Si el brazo está abducido (despegado del cuerpo): +1
Si el brazo está apoyado o sostenido: -1
Puntuación brazo=

Paso 2: Localizar la posición del antebrazo

Paso 2a: Corregir...
Si el brazo cruza la línea media del cuerpo: +1
Si el brazo sale de la línea del cuerpo: +1
Puntuación antebrazo =

Paso 3: Localizar la posición de la muñeca

Paso 3a: Corregir...
Si la muñeca está doblada por la línea media: +1
Puntuación muñeca =

Paso 4: Giro de muñeca
Si la muñeca está en el rango medio de giro: +1
Si la muñeca está girada próxima al rango final de giro: +2
Puntuación giro de muñeca =

Paso 5: Localizar puntuación postural en Tabla A
Utilizar valores de pasos 1, 2, 3 y 4 para localizar puntuación postural en Tabla A
Puntuación postural A =

+

Paso 6: Añadir puntuación utilización muscular
Si la postura es principalmente estática (p.e. agarres superiores a 1 min.) ó si sucede repetidamente la acción (4 veces/min. ó más): +1 *Puntuación muscular =*

+

Paso 7: Añadir puntuación de la Fuerza / Carga
Si carga ó esfuerzo < 2 Kg. intermitente: +0
Si es de 2 a 10 Kg. intermitente: +1
Si es de 2 a 10 Kg. estática o repetitiva: +2
Si es una carga >10 Kg. ó vibrante ó súbita: +3
Puntuación fuerza/carga =

=

Paso 8: Localizar fila en Tabla C
Ingresar a Tabla C con la suma de los pasos 5, 6 y 7
Puntuación final muñeca , antebrazo y brazo =

Empresa: .... Fecha: ....
Puesto / Sección: ....

PUNTUACIÓN

Tabla A

Brazo	Ante brazo	Muñeca 1		Muñeca 2		Muñeca 3		Muñeca 4	
		Giro muñeca 1	Giro muñeca 2	Giro muñeca 1	Giro muñeca 2	Giro muñeca 1	Giro muñeca 2	Giro muñeca 1	Giro muñeca 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	3	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	5	5	5	5
	2	4	4	4	5	5	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Tabla 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

B. Análisis de cuello, tronco y pierna

Paso 9: Localizar la posición del cuello

Paso ...gir...
Si hay rotación: +1; si hay inclinación lateral: +1
= Puntuación cuello

Paso 10: Localizar la posición del tronco

Paso 10a: Corregir...
Si hay torsión +1; si hay inclinación lateral: +1
= Puntuación tronco

Paso 11:

Si piernas y pies apoyados y equilibrados: +1
Si no: +2
= Puntuación piernas

Tabla B

Cuello	Tronco 1		Tronco 2		Tronco 3		Tronco 4		Tronco 5		Tronco 6	
	Piernas 1	Piernas 2	Piernas 1	Piernas 2	Piernas 1	Piernas 2	Piernas 1	Piernas 2	Piernas 1	Piernas 2	Piernas 1	Piernas 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

Paso 12: Localizar puntuación postural en Tabla B
Utilizar valores de pasos 9, 10 y 11 para localizar puntuación postural en Tabla B
= Puntuación postural B

+

Paso 13: Añadir puntuación utilización muscular
Si la postura es principalmente estática (p.e. agarres superiores a 1 min.) ó si sucede repetidamente la acción (4 veces/min. ó más): +1
= Puntuación uso muscular

+

Paso 14: Añadir puntuación de la Fuerza / Carga
Si carga o esfuerzo < 2 Kg. intermitente:
Si es de 2 a 10 Kg. intermitente: +1
Si es de 2 a 10 Kg. estática o repetitiva: +2
= Puntuaciónfuerza/carga Si es una carga >10 Kg. ó vibrante ó súbita: +3

=

Paso 15: Localizar columna en Tabla C
Ingresar a Tabla C con la suma de los pasos 12, 13 y 14
= Puntuación final muñeca , antebrazo y brazo

Referencias: ....
Observador: .... Firma: ....

PUNTUACIÓN FINAL: 1 ó 2: Aceptable; 3 ó 4: Ampliar el estudio; 5 ó 6: Ampliar el estudio y modificar pronto; 7: estudiar y modificar inmediatamente

Figure 3. Format for application of the Rula method

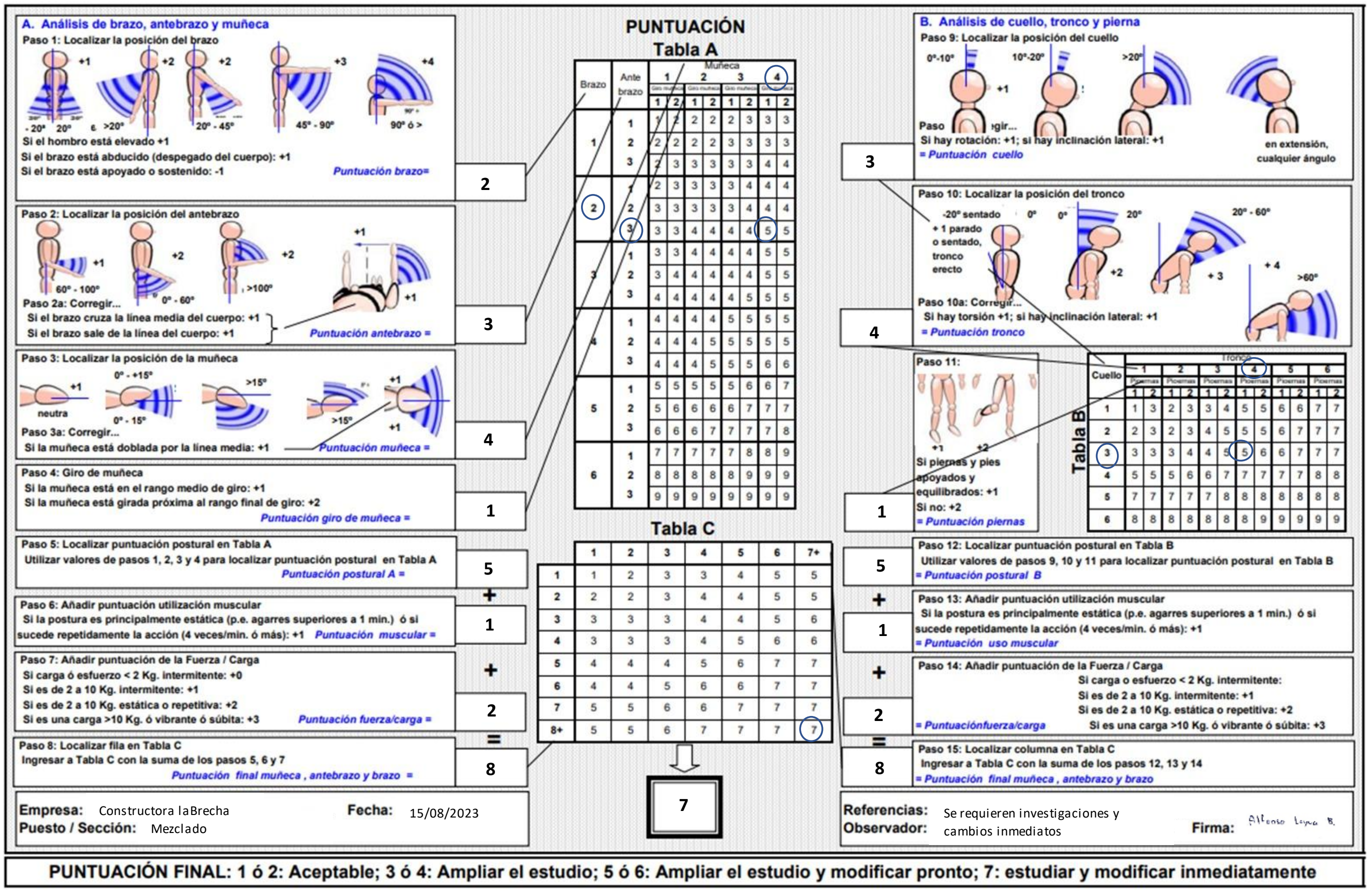


Figure 4. Application of the Rula method to operator

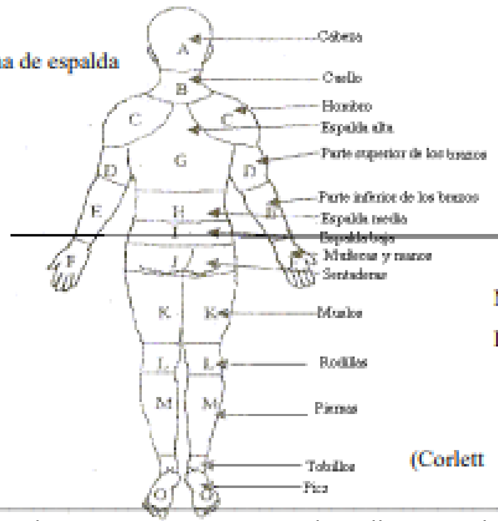
Corlett & Bishop Method

Operador 1

Mapa de molestias para las diferentes partes del cuerpo.

Marque con una cruz las partes del cuerpo donde sienta alguna molestia o dolor y numérelas en orden ascendente según su grado de molestia o dolor

Vista de una persona de espalda



M=Molestia

D=Dolor

(Corlett & Bishop, 1976)

Observaciones: La molestia se concentra en el cuello y espalda.

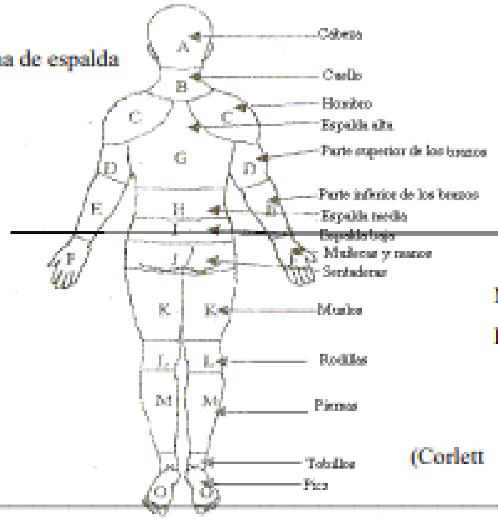
	ENTRADA							SALIDA						
A														
B								M						
C														
D														
E														
F														
G								M						
H								M						
I														
J														
K														
L														
M														
N														
O														

Operador 1

Mapa de molestias para las diferentes partes del cuerpo.

Marque con una cruz las partes del cuerpo donde sienta alguna molestia o dolor y numérelas en orden ascendente según su grado de molestia o dolor

Vista de una persona de espalda



M=Molestia

D=Dolor

(Corlett & Bishop, 1976)

Observaciones:

La molestia se concentra en el cuello y espalda.

	ENTRADA							SALIDA						
A														
B	M							M						
C														
D														
E														
F														
G								M						
H								M						
I														
J														
K														
L														
M														
N														
O														

Fatigue at work

1. Name: Jorge Espinoza Rendón
2. Sex: Male
3. How many days a week do you work?

- 2-4 days
- 5-6 days
- 7 days

4. Do you study in addition to work?
- YES
- NO

5. Do you feel tired when you work?
- YES
- NO

6. How old are you? 25
7. Do you feel that you have become sick from overwork?
- YES
- NO

8. What consequences do you think you have had from working?
- Fatigue
- Accidents at work
- Mental fatigue
- None of the above

9. How many hours do you work a day? 8 hours
10. What is your schedule? 9 am to 5 pm
11. Do you eat to come to work?
- YES
- NO

12. What means of transportation do you use? Public transportation
13. How long does it take you to get to work? 40 minutes

For the first worker evaluated, Jorge Espinoza Rendón, the following results were obtained, showing that he has discomfort at the end of his workday, concentrating in the area from the neck to the lower back, the work has caused fatigue and work-related accidents, so a redesign of his activities should be done to take care of his physical and mental health.

Fatigue at work

1. Name: Adrián Zúñiga López
2. Sex: Male
3. How many days a week do you work?
- 2-4 days
- 5-6 days
- 7 days

4. Do you study in addition to work?
- YES
- NO

5. Do you feel tired when you work?
- YES
- NO

6. How old are you? 22
7. Do you feel that you have become ill from overwork?
- YES

- NO

8. What consequences do you think you have had from working?

- Fatigue
- Accidents at work
- Mental fatigue
- None of the above

9. How many hours do you work a day? 8 hours
10. What is your schedule? 9 am to 5 pm
11. Do you eat to come to work?

- YES
- NO

12. What means of transportation do you use? Car
13. How long does it take you to get to work? 20 minutes

For the second worker evaluated, Adrián Zúñiga López, the following results were obtained, showing that he has discomfort at the end of his workday, concentrating in the area of the arms, from the shoulder to the wrist, the work has generated fatigue and work accidents, so a redesign of his activities should be done to take care of his physical and mental health.

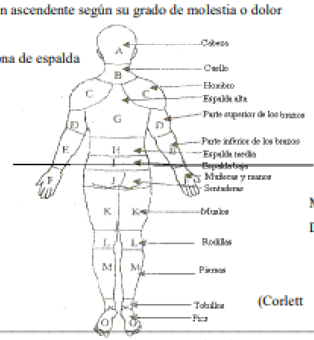
Método Corlett & Bishop

Operador 2

Mapa de molestias para las diferentes partes del cuerpo.

Marque con una cruz las partes del cuerpo donde sienta alguna molestia o dolor y numérelas en orden ascendente según su grado de molestia o dolor

Vista de una persona de espalda



M=Molestia

D=Dolor

(Corlett & Bishop, 1976)

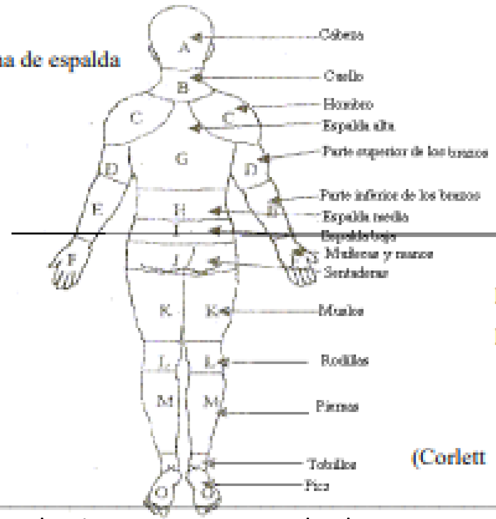
Observaciones: La molestia se concentra en los brazos.

	ENTRADA							SALIDA						
A														
B														
C								M						
D								M						
E								M						
F								M						
G														
H														
I														
J														
K														
L														
M														
N														
O														

Mapa de molestias para las diferentes partes del cuerpo.

Marque con una cruz las partes del cuerpo donde sienta alguna molestia o dolor y numérelas en orden ascendente según su grado de molestia o dolor

Vista de una persona de espalda



M=Molestia

D=Dolor

(Corlett & Bishop, 1976)

Observaciones: La molestia se concentra en los brazos.

	ENTRADA							SALIDA						
A														
B														
C	M							M						
D								M						
E								M						
F								M						
G														
H														
I														
J														
K														
L														
M														
N														
O														

Fatigue at work

1. Name: Adrián Zúñiga López
2. Sex: Male
3. How many days a week do you work?
    - 2-4 days
    - <u>5-6 days</u>
    - 7 days

4. Do you study in addition to work?

- YES
- <u>NO</u>

5. Do you feel tired when you work?
   - <u>YES</u>
   - NO

6. How old are you? 22
7. Do you feel that you have become ill from overwork?
   - <u>YES</u>
   - NO

8. What consequences do you think you have had from working?
   - <u>Fatigue</u>
   - <u>Accidents at work</u>
   - <u>Mental fatigue</u>
   - None of the above

9. How many hours do you work a day? 8 hours
10. What is your schedule? 9 am to 5 pm
11. Do you eat to come to work?
    - YES
    - <u>NO</u>

12. What means of transportation do you use? Car
13. How long does it take you to get to work? 20 minutes

For the second worker evaluated, Adrián Zúñiga López, the following results were obtained, showing that he has discomfort at the end of his workday, concentrating in the area of the arms, from the shoulder to the wrist, the work has generated fatigue and work accidents, so a redesign of his activities should be done to take care of his physical and mental health.

CHECK LIST			
Company name:			
Giro:			
Date:			
Standard	**Yes**	**No**	**Remarks**
Mexican Official Standard NOM-025-STPS-2008, Lighting conditions in workplaces.	**X**		The activities are carried out in a lighted area, and the day ends even with natural light.

Mexican Official Standard NOM-001-STPS-2008, Buildings, premises, facilities and areas in workplaces-Safety conditions.		**X**	The company does not have safety conditions in any of its work areas.
Mexican Official Standard NOM-004-STPS-1999, Protection systems and safety devices for machinery and equipment used in the workplace.		**X**	The operators do not have any protection when using the machinery to carry out their activities.
Mexican Official Standard NOM-017-STPS-2008, Personal protective equipment-Selection, use and handling in the workplace.		**X**	Personnel do not have adequate protection for each of the activities they perform during their workday, and are constantly exposed.
Mexican Official Standard NOM-030-STPS-2009, Preventive occupational safety and health services-Functions and activities.		**X**	Employees do not have preventive health and safety services within the company.
Mexican Official Standard NOM-024-STPS-2001, Vibrations-Safety and hygiene conditions in workplaces.		**X**	Employees are exposed to high levels of vibration without any type of vibration safety.
NOM-016-STPS-1993, Relative to safety and hygiene conditions in workplaces regarding ventilation.		**X**	Personnel are exposed to high levels of humidity with no means of regulating ventilation.

6. DISCUSSION/CONLCUSIONS

The ergonomic analysis allows us to detect the risk factors to which workers are exposed when performing operations. The temperature at which the work is performed ranges from 42 to 48 degrees and a humidity of 70%, which generates low performance in the workers, presenting physical exhaustion, lack of concentration, fatigue from the second day of work, and for operations of mixing can be seen to be performed with improper postures, which could develop cumulative traumatic disorders in the neck, shoulders, arms, upper arms, knees, as well as the lower, middle and upper back.

The application of the RULA Method to the operator indicates that there is a level 7 for each analysis posture. Indicating that a change must be made immediately and that a change in the work method must be made.

One proposal to reduce the effect of environmental conditions is to work at different times of the day when temperatures are not as high. This would also imply a rotation of activities. Regarding the design of the workstation, the workstation should be raised 50 cm so that workers can carry out the operations and not have to be in inadequate postures for a long time.

It is also important to ensure compliance with the Official Mexican Standards, signage of spaces and conditions as required by NOM-001-STPS-2010, the assignment of personal protective equipment to operators, according to NOM-017-STPS-2008, and the identification of ergonomic risks in the workplace.

With the application of the Corlett and Bishop Method, it was detected that physical fatigue is present from the second day of work, as well as discomfort at the end of the workday, and these are concentrated in the neck, upper, middle and lower back, arms, shoulders and wrists. A redesign of the activities is suggested to take care of the physical and mental health of the two workers.

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PROPOSAL OF ERGONOMIC IMPROVEMENTS FOR THE INTERNAL AUDIT WORKSTATION: AN APPROACH BASED ON THE NORDIC QUESTIONNAIRE AND R.O.S.A. METHOD

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Resumen: Esta investigación se enfocó en mejorar las condiciones de salud y bienestar de trabajadores de oficina, a través del análisis de las operaciones realizadas comúnmente en el área de auditoría interna de una empresa agrícola así como de la aplicación de métodos ergonómicos para evaluar y plantear estrategias de mejora que permitan un ambiente laboral seguro reflejado en la reducción de TME (Trastornos Musculo-Esqueléticos), y en un rendimiento óptimo en índices de producción y calidad. En los últimos años, la rápida difusión de las nuevas tecnologías ha introducido progresivamente en el mundo de las oficinas y de los ordenadores personales, en general, toda una serie de equipos que conforman lo que se ha venido a denominar ofimática, que además de suponer una auténtica revolución en el mundo de la oficina, ha traído consigo toda una serie de problemas de salud para los trabajadores derivados de su uso, que se agravan cuando el operario pasa gran parte de su jornada laboral frente a una pantalla de visualización de datos (Mondelo, P.R. 2001). Considerando que la salud ocupacional debe ser preocupación incesante tanto para empresarios como trabajadores, siendo una forma de vida y protección del ser humano y de su medio. Esta genera grandes beneficios a los individuos en cuanto a proteger su salud y brinda a las empresas condiciones de máxima seguridad que indudablemente conducen a una mayor productividad.

Palabras clave: Ergonomía ocupacional, trastornos musculoesqueléticos, estación de trabajo, riesgos ergonómicos, Método R.O.S.A., Cuestionario Nórdico.

Relevancia para la ergonomía: Esta propuesta de mejoras ergonómicas basada en el Cuestionario Nórdico y el Método R.O.S.A. proporciona una guía práctica para evaluar y mejorar las estaciones de trabajo en oficinas. Al abordar los factores de riesgo ergonómico y considerar las necesidades individuales de los trabajadores, se puede lograr una reducción en el riesgo de trastornos musculoesqueléticos y una mejora en la productividad y el bienestar de los empleados. Aplicar este enfoque puede contribuir a promover la ergonomía en el lugar de trabajo y fomentar entornos laborales más saludables y seguros. La ergonomía en la oficina es un elemento indispensable no solo para cuidar la calidad de vida del personal administrativo y relacionado, sino también para garantizar su pleno rendimiento durante su estancia en el lugar de trabajo, basado en condiciones que hagan la tarea cómoda y que no disminuyan la motivación necesaria para llevarla a cabo.

Abstract: This research focused on enhancing the health and well-being conditions of office workers through the analysis of commonly performed tasks in the internal audit department of an agricultural company. Additionally, ergonomic methods were employed to assess and propose improvement strategies aimed at creating a safe work environment. This is reflected in the reduction of MSDs (Musculoskeletal Disorders) and optimal performance in production and quality indices. In recent years, the rapid spread of new technologies has progressively introduced into the world of offices and personal computers in general, a whole series of equipment that makes up what has come to be known as office automation, which in addition to being a real revolution in the office world, has brought with it a whole series of health problems for workers derived from their use, which are aggravated when the operator spends a large part of his working day in front of a data display screen (Mondelo, P.R. 2001). Considering that occupational health should be a constant concern for both employers and workers, being a way of life and protecting human beings and their environment. This generates great benefits to individuals in terms of protecting their health and provides companies with maximum safety conditions that undoubtedly lead to greater productivity.

Keywords: Occupational ergonomics, musculoskeletal disorders, workstation, ergonomic risks, R.O.S.A. Method, Nordic Questionnaire.

Relevance to Ergonomics: This proposal of ergonomic improvements based on the Nordic Questionnaire and the R.O.S.A. Method provides a practical guide for evaluating and improving office workstations. By addressing ergonomic risk factors and considering the individual needs of workers, a reduction in the risk of musculoskeletal disorders and an improvement in productivity and employee well-being can be achieved. Applying this approach can contribute to promoting ergonomics in the workplace and fostering healthier and safer work environments.
Office ergonomics is an indispensable element not only to take care of the quality of life of administrative and related personnel but also to guarantee their full performance during their stay in the workplace, based on conditions that make the task comfortable and that do not diminish the motivation necessary to carry it out.

1. INTRODUCTION

In today's contemporary work environment, here the pervasive use of screens and prolonged sedentary positions has become increasingly commonplace, and the concern surrounding musculoskeletal disorders (MSDs) looms ever larger. Kim, I. (2015) prominently emphasizes that MSDs can exert a profound impact on the health and overall well-being of employees, concurrently influencing the productivity and efficiency of organizations.

A. Shikdar and Mahmoud Al-kindi (2007) identified ergonomic deficiencies in computer workstation design in typical offices. Their study of 40 workstations found major ergonomic issues in physical design, layout, employee postures, work practices, and training. These deficiencies had significant consequences for user health and overall well-being.

It is unequivocally evident that internal audit roles are by no means exempt from this issue. These roles entail extended periods spent before data display screens, coupled with the execution of tasks necessitating repetitive motions. Regrettably, such circumstances engender improper bodily postures, muscular tension, and an array of associated health concerns (Jensen, C. et al. 2002).

Given this urgent concern, a crucial step forward is evident – the necessity to conduct a comprehensive ergonomic assessment of the internal audit workstation. Drawing from the work of Haji Omid Kalte et al. (2014), which emphasizes the identification of ergonomic problems in workplaces through the Finnish method, it becomes apparent that a significant portion of workstations lacked proper ergonomic principles, resulting in incorrect worker positioning. This study underscores the importance of rectifying these ergonomic inadequacies through assessments and methods aimed at enhancing working conditions.

The Rapid Office Strain Assessment (R.O.S.A.) Method is an ergonomic evaluation technique used to quickly identify and assess potential ergonomic risks in office workstations. It focuses on evaluating key factors such as lighting, monitor placement, chair and desk setup, keyboard and mouse arrangement, and other elements that could contribute to discomfort or musculoskeletal issues. The method aims to provide a rapid yet comprehensive evaluation, allowing for timely adjustments and improvements to prevent workplace-related health problems (Sahlabadi, A. et al. 2020).

In this context, the strategic employment of tools such as the initial questionnaire, the Nordic Questionnaire, and the R.O.S.A. Method manifests as a robust approach. These tools, when effectively harnessed, serve as conduits for the collection of germane data, comprehensive scrutiny of ergonomic hazards, and targeted design of enhancements.

The resultant implications of this undertaking are manifold. Through the introduction of ergonomic refinements in the workplace, the specter of MSDs can be appreciably diminished. This, in turn, translates to an amelioration of postural dynamics, enhancement of overall comfort, and cultivation of holistic well-being for the workforce. Moreover, it is pivotal to recognize that an improved workspace design not only mitigates health risks but also acts as a catalyst for elevated productivity and enriched job satisfaction (Chim, J. 2014).

In summation, the evaluative scrutiny and subsequent enhancement of the internal audit workstation are not just commendable but imperative. Such proactive measures are pivotal in mitigating the risks posed by MSDs and nurturing a conducive work environment. The strategic utilization of the initial questionnaire, the Nordic Questionnaire, and the R.O.S.A. Method establishes a resilient foundation, adeptly identifying ergonomic risk factors and propounding tailored solutions in alignment with the unique requirements of each employee.

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COMPREHENSIVE ERGONOMIC EVALUATION TO REDUCE THE POSTURAL LOAD IN OPERATORS IN THE PLASTIC EXTRUSION PROCESS

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Resumen: El estudio se aplicó en una empresa mexicana del giro médico ubicada en Mexicali, Baja California, dedicada a la producción y montaje de tubos de plástico, mediante el proceso de extrusión de plástico. La ergonomía es demandada por los empresarios que se percatan de su utilidad, no solo para mejorar la salud de los empleados; sino porque constituye una herramienta útil para alcanzar mayores niveles productivos, de calidad y competitividad muy necesarios en la actualidad. Para diagnosticar el diseño de la estación de trabajo con respecto a las operadoras se llevó a cabo la aplicación del cuestionario nórdico y un análisis ergonómico previo a través del método RULA en donde se obtuvo un nivel de riesgo muy alto y depués de las mejoras el resultado fue un nivel de riesgo bajo.

Palabras clave: Cuestionario Nórdico, método RULA, carga postural, riesgos ergonómicos, ergonomía ocupacional.

Relevancia para la ergonomía: Fomentar el uso de los métodos ergonómicos para favorecer la salud ocupacional, a través de un análisis y evaluación de un puesto de trabajo, así como el poder plantear propuestas de mejora sencillas y eficaces que impacten en el bienestar de los trabajadores.

Abstract: The study was applied in a Mexican medical company located in Mexicali, Baja California, dedicated to the production and assembly of plastic tubes, through the plastic extrusion process. Ergonomics is demanded by employers who realize its usefulness, not only to improve the health of employees; but because it constitutes a useful tool to achieve higher levels of production, quality and competitiveness that are very necessary today. To diagnose the design of the workstation with respect to the operators, the application of the Nordic questionnaire and a previous ergonomic analysis through the RULA method were carried out, where a very high level of risk was obtained and after the improvements, the result was a low level of risk.

Keywords: Nordic Questionnaire, RULA method, postural load, ergonomic risks, occupational ergonomics.

Relevance for ergonomics: Encourage the use of ergonomic methods to promote occupational health, through an analysis and evaluation of a job, as well as being able to propose simple and effective improvement proposals that impact the well-being of workers.

1. INTRODUCTION

This study is based on a Mexican company located in Mexicali, Baja California. The main business is the production and assembly of plastic tubes, through the "plastic extrusion" process.

This company has been committed to providing its customers with the highest quality products quickly and affordably since March 2019. The true key to success lies in the absolute commitment to quality of each employee. From upper management to all phases of manufacturing and customer service, everyone must be genuinely dedicated to providing the best possible product.

It has developed and implemented the Quality Management System based on the ISO 13485 standard to ensure that its products, standards, and services meet or exceed the rigorous requirements demanded by its customers. The Quality Management System is considered by management as an integral and essential part of all company operations, which is why the quality policy has been implemented.

In the company works 83 operational workers from Monday to Thursday, from 6:00 a.m. to 6:00 p.m. (12 hours) and they have two hours of food.

The Human Factors and Ergonomics Society (HFES) defines ergonomics as human factors that employ knowledge about human abilities and their limitations in the design of systems, organizations, jobs, machinery, tools, and products aimed at human use in a manner safe, efficient, and comfortable. While the French Language Ergonomics Society (SELF) defines that it is the putting into practice of scientific knowledge related to the human being and necessary for the design of tools, machinery and devices that can be used by most individuals with a maximum of comfort, safety, and efficiency" (Torres & Rodríguez, 2020). Both definitions mention the words "design", "tool", "machinery", "comfort", among others. This does not focus special attention on these characteristics when evaluating a job.

Occupational Health is a transdisciplinary activity relatively less known and under-developed in Mexico. Its objective is the well-being of workers: physical, mental, and social spheres. Hygiene, safety, ergonomics, psychology, medicine, physiotherapy, rehabilitation, sociology, anthropology, law, and economics are some examples of the disciplines involved in the field of Occupational Health (Sámano-Rios, 2018).

The Nordic Questionnaire it arises from the difficulty in comparing the results obtained with different methods of analysis and symptom collection. It is a standardized questionnaire for the detection and analysis of musculoskeletal symptoms in nine body regions: neck, shoulders, upper back, elbows, lower back, wrist/hands, hips/thighs, knees, and ankles/feet. Its objective is to confirm or rule out a pathology of occupational origin (Durán-Urón et al., 2020).

The Rapid Upper Limb Assessment (RULA) divides different body segments into two groups. The first group covers the neck, torso, and legs; while the second considers the arm, forearm, and wrist. Through the observation of the studied task, a score is given to each body segment according to the posture taken and with the use of numerical tables two different scores are obtained that represent the degree of musculoskeletal postural load. The A and B scores are obtained by adding the grip, load, and strength considerations to the previous score. Finally, a third table is used to add the C score, which is added to the previous number to obtain the final grade or maximum score. This last amount is within a range of 1 to 15 and is compared against five previously defined action levels and five risk levels (Cuautle Gutiérrez et al., 2021).

2. OBJECTIVES

Improve the occupational health of the operators with respect to their postural load, establishing a favorable design of their work area, taking advantage of the available material resources, to increase safety in the operation, reduce fatigue and increase productivity in the operation.

3. DELIMITATIONS OF THE STUDY

To evaluate the operational area made up of women with respect to the postural load of a medical a medical company dedicated to the extrusion of plastics in Mexicali, Baja California, México.

4.METHODOLOGY

The ergonomic evaluation aims to promote action or change in the workstation, based on a diagnosis appropriate to the characteristics of the workstation that will make it possible to design an intervention program tailored to the results of the diagnosis. Figure 1 shows the methodology for the analysis and ergonomic evaluation of a job, through the RULA method that was carried out in this study.

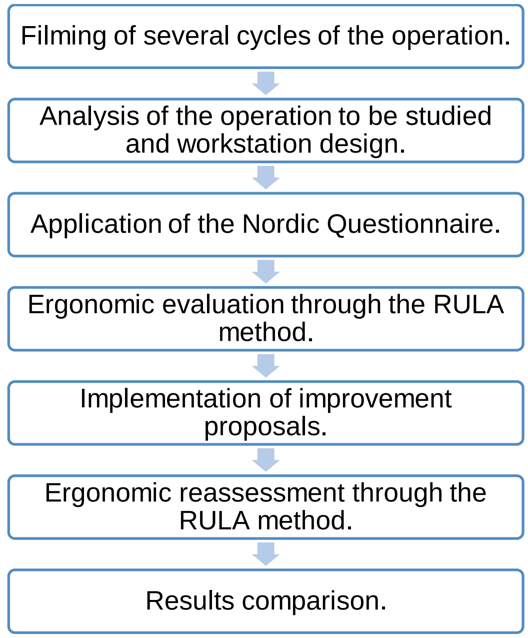

Figure 1. Methodology for the analysis and ergonomic evaluation of a workstation.

5. RESULTS

With the ***filming of several cycles of the operation***, it was possible to analyze and evaluate the workstation, as well as the activities carried out by the operator, which facilitated the application of the RULA method.

Through the ***analysis of the operation***, a flow chart was prepared to show the activities that are carried out, see Figure 2.

The ***design of the workstation*** includes a 1.80m high mobile rack, consisting of 4 floors in which the bins are loaded ready to be transported to the packing area. Figure 3 shows the mobile rack. Each bin weighs 13 kg, as shown in Figure 4.

After applying the ***Nordic Questionnaire*** to the operator, the results showed that she has discomfort in her neck, upper back, right knee, and hip, as shown in Figure 5.

With the previous steps, the application of the ***RULA method*** was facilitated, the results are shown in Figure 6.

The filming of several cycles of the operation and the corresponding analysis reported that the work method is wrong, and the design is inadequate.

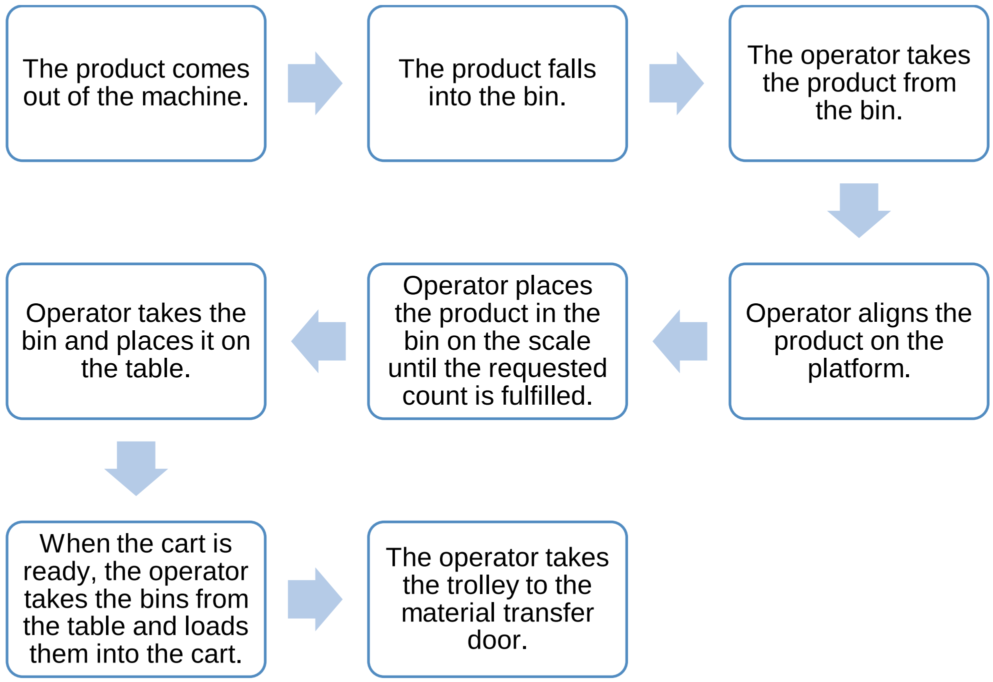

Figure 2. Flowchart of the operation.

Figure 3. Mobile rack.

Figure 4. Bin.

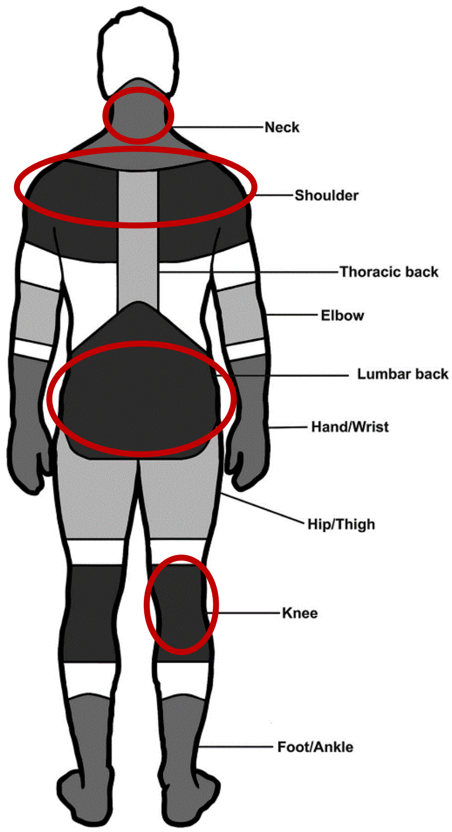

Figure 5. Nordic Questionnaire Results.

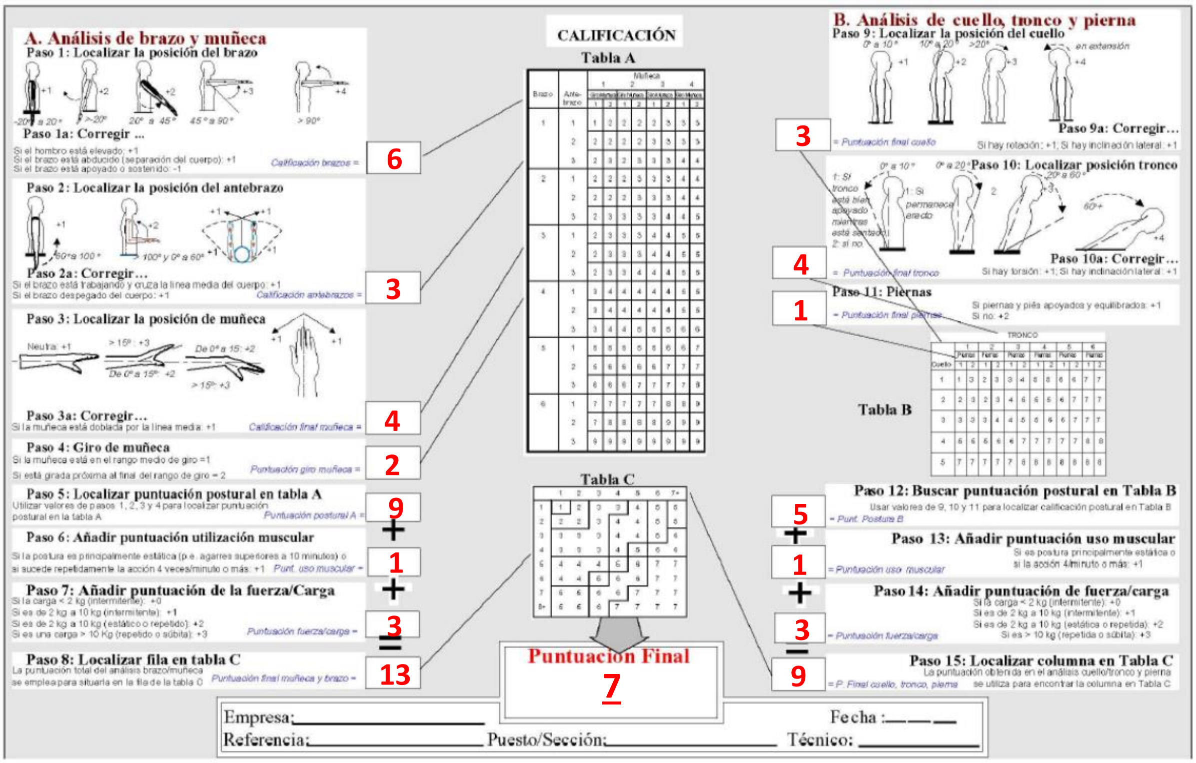

Figure 6. RULA Method.

The problem analyzed in the evaluation is the critical posture when loading bins weighing 13 kg on the 1st and 3rd floors of the cart. Even on floor 2 the optimal posture is interrupted by floor 3, as can be seen in the Figure 7.

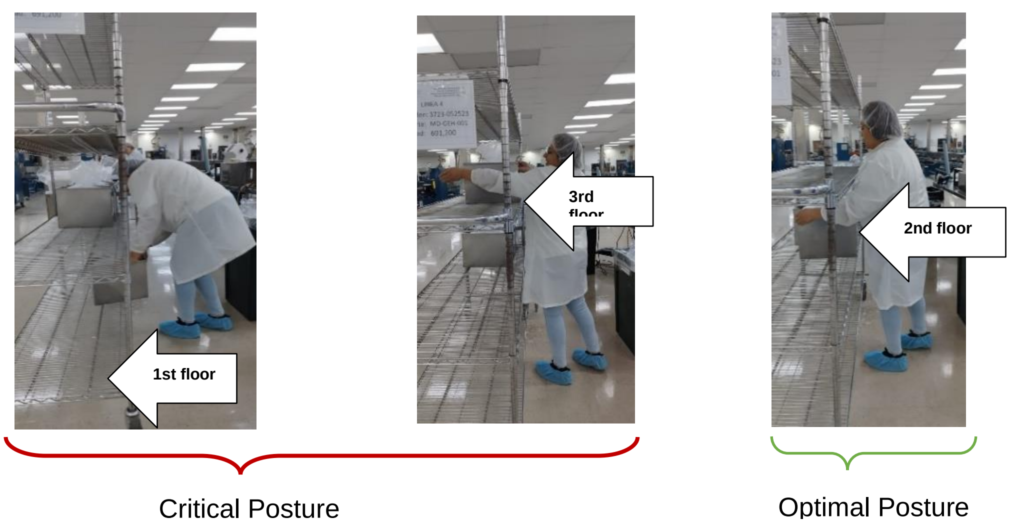

Figure 7. Posture for each floor.

Based on the results obtained from the ergonomic method, it is recommended to implement modifications in the workplace to improve worker postures and reduce the effort and movements that can cause musculoskeletal disorders. The ***proposed improvements*** consist of modifying the mobile rack and the bin.

It was decided to redesign the mobile rack, where only the second floor remains, and all the other floors have disappeared, now a mobile table is used as shown in Figure 8, so that the operator does not have to bend down to use the first floor, nor stretch to reach the upper floors. Since the company has a maintenance department whose function is to carry out all maintenance tasks, including redesign changes of this type, the cost of this modification will be approximately $30 dollars, since only the cost of reinforcing the table legs, the other floors of the current trolley were dismantled, in addition a table that was near the bin will be removed, and replaced by the mobile table, so now 2 mobile tables are required to deposit the bin and thus significantly reduce the effort made by the operator. Table 1 shows the pros and cons of this proposal.

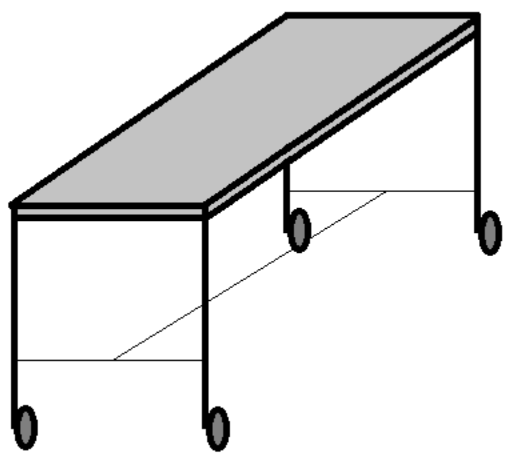

Figure 8. Mobile table.

Table 1. Pros & Cons of the redesign.

PROS	CONS
-Low redesign cost. -Avoidance of extreme and critical positions.	- The period of each transfer would be more frequent, so 2 table mobile are needed.

The bin is made of stainless steel, with a platform used to align the product before placing it in the bag and weighing it. The problem analyzed in the evaluation is the critical position of the wrists when picking up the products and when aligning them on the platform. The proposal in the redesign of the bin is to modify the height/depth and transform it into a wider and shallower bin, as shown in Figure 9, all this to prevent the wrists from reaching the extreme point every time a handful of material needs to be picked up (an activity that is repetitive in the stand). The change includes removing the platform and installing it on the outside of the bin. In this case, the redesign does involve making the new bin from scratch, and according to the price of the current bin, it would cost approximately $350 dollars to manufacture the new one. Table 2 shows the pros and cons of this proposal.

Before After

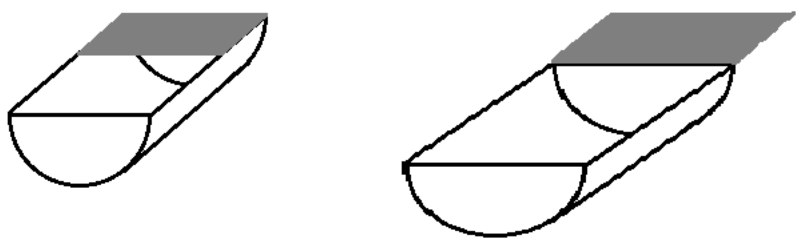

Figure 9. Bin design before and after.

Table 2. Pros & Cons of the bin redesign.

PROS	CONS
-Avoid critical wrist positions.	- The platform is further away than before.

In addition to this, it is planned to add a roller conveyor, like the one shown in Figure 10, to avoid lifting 13kg of load (the bin with product). The roller conveyor will be connected from the scale to the mobile table directly. This attachment is priced at approximately $700 dollars, and the installation will be done by the maintenance department. Some of the benefits of this improvement are shown in Table 3. Figure 11 shows the future flowchart, with the modifications already installed.

Figure 10. Roller conveyor.

Table 3. Pros & Cons of the roller conveyor.

PROS	CONS
- It adapts to the terrain. - It has a great transport capacity. - It allows transporting a great variety of materials. - Loading and unloading is possible at any point along the route. - It can be moved. - It does not damage the transported product.	- The high cost.

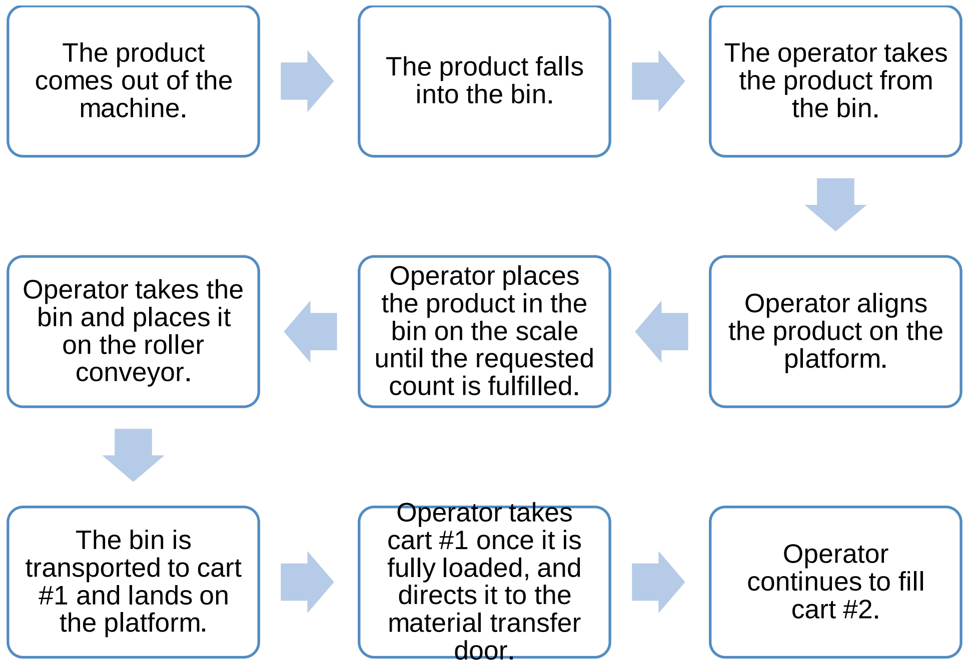

Figure 11. Future flowchart of the operation.

With the new flow of movements, we can see that the operator no longer must carry each 13 kg bin over 2 meters from the scale to the mobile rack, as this activity has been replaced by the conveyor rollers. Considering the three proposals mentioned, the workstation was ***reassessment in the RULA method*** mentioned, and the results are shown in Table 4.

Table 7. Results of the RULA method before and after the proposals.

REBA Method	Result	Description
Before	7	Very high. Immediate action is needed
After	3	Medium level. Expand study.

5. CONCLUSIONS

There are workers in the operational area who have a high-risk postural load, due to critical postures and repetitiveness.

The ergonomic evaluation allowed to carry out a systemic and comprehensive study of the different ergonomic factors that affect the levels of production and the health of the workers in the operational position of the production area. The evaluated method showed a very high level of risk, which suggested acting as soon as possible in the workplace.

However, the results suggest that there is a relationship between the risk levels evaluated by the ergonomic method and the future probability of musculoskeletal disorders in the workers of the medical industry in question. After the ergonomic intervention and the reassessment of the workplace, there is a low risk in terms of the results obtained. The study indicates that the application of the three improvement proposals is convenient, which only require an investment of approximately $1,080 dollars, but that will bring significant improvements in the health and well-being of the operators.

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ERGONOMIC AND PRODUCTIVE IMPROVEMENT IN CNC BENDING MACHINE IN MANUFACTURING COMPANY

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Resumen: En área industrial metalmecánica el presente proyecto buscó mejorar las estaciones de trabajo integradas a un proceso de conformado analizando las estaciones de trabajo donde operan máquinas de corte con Laser, mesa de planos, doblado CNC e inspección que es donde se realizó el estudio

Las mejoras prestablecidas identificaron áreas donde además de mejorar las condiciones de trabajo y operación se puso de manifiesto que el área de oportunidad no solo permitió aumentar la producción del proceso sino además se disminuyeron las probabilidades de riesgos de lesiones musculo esqueléticas, con ello se puso de manifiesto que se pueden aplicar herramientas de mejora industrial y ergonómica como un bienestar.

Al buscar disminuir las condiciones de riesgo ergonómico se pudo tomar la alternativa que mejoro además la productividad del proceso, económicamente la empresa vio el proyecto como una muy buena aportación a su negocio

Palabras clave: Sue Rodgers, RULA, REBA, 5S, SMED

Relevancia para la ergonomía: Los diagramas de ruta permiten mejorar producción y manejo de cargas, así como confirmar cual podría ser la herramienta ergonómica apropiada a aplicar en cada actividad realizada en el proceso

Abstract: In the metalworking industry area, this project sought to improve the workstations integrated into a forming process by analyzing the workstations where laser cutting machines, drawing table, CNC bending and inspection operate, which is where the study was carried out.

The pre-established improvements identified areas where, in addition to improving working and operating conditions, it became clear that the area of opportunity not only allowed to increase the production of the process but also decreased the probability of risks of musculoskeletal injuries. This showed that industrial and ergonomic improvement tools can be applied as a well-being.

In order to reduce the conditions of ergonomic risk it was possible to take the alternative that also improved the productivity of the process, economically the company saw the project as a very good contribution to its business

Keywords. Sue Rodgers, RULA, REBA, 5S, SMED

Relevance to Ergonomics: The route diagrams allow to improve production and load handling, as well as to confirm which could be the appropriate ergonomic tool to apply in each activity carried out in the process

1. INTRODUCTION

The company has experience in industry, specialized in industrial design and manufacture of metal carpentry, material procurement, plant distribution modifications and improvements in work areas. In this project, reengineering, ergonomics and process improvement were applied.

The production of CNC laser cut parts are subsequently bent in CNC Bending Machine, it was required to assess the ergonomic risks and since one of the most common causes of disability in workers are musculoskeletal injuries due to ergonomic risks that are exposed in their work activities, according to the Occupational Health Report issued by the World Health Organization (WHO, 2017) according to (Hernández, 2021). Some risk factors are the generation of internal forces in atrial segments of high intensity or with a significant frequency, the high frequency of repetitive movements and the duration of long exposure according to (Fragoso, 2022).

The main problem detected started in the transfer with 28% priority, followed by inspection with 26.7%, material handling with 23% priority and finally the bending process with 22.3%, so it was necessary to consider the STPS (2018) which was published in the Official Gazette of the DOF Federation, the Official Mexican Standard NOM-036-1-STPS-2018, lto which establishes the elements to identify, analyze, prevent and control ergonomic risk factors in workplaces derived from the manual handling of loads, in order to prevent alterations to the health of workers (DOF, 2018).

The study company aware of the elements that could be improved by reducing the ergonomic risks that may arise in their operations of integrated sheet bending allowed our students to take the necessary data and, in the end, valued the results that allowed to improve the transports, material handling, forming processes and inspection of the parts produced. Taking into account the above, the validation of the safety conditions was carried out, seeking to correct postures, which could improve the health of the workers, as a critical activity to use the methodologies of Mexican standards NOM 011, NOM 015, NOM 025 and NOM-036-1-STPS-2018 and the ergonomic methods Sue Rodgers, REBA, RULA, ARTOOL, QEC, OWAS and WERA among others. and ILO recommendations.

2. OBJECTIVES

Improve operations integrated in the CNC bending process through reducing ergonomic risks and improving their production through ergonomic analysis, process reengineering and some lean manufacturing tools, in accordance with Mexican Standards and recommendations issued by the ILO

3. METHODOLOGY

The process was analyzed, videos, photos and measurements were taken with sound level meters, lux meters and thermometers of the work area integrated into the process of bending sheets in CNC press.

Route and process flow diagrams were made to facilitate decision making of the tool to be used. Official Mexican standards of the Ministry of Labor and Social Welfare (STPS) in verification of risk factors, including the analysis of the activities carried out by operators,an analysis of the area was carried out applying the Official Standards for lighting, noise, to evaluate the work area, in addition to validating the ergonomic risk factors that determine the conditions for the prevention of occupational risks, also the NOM-036-1-STPS-2018, prescribed by the Ministry of Labor and Social Welfare (STPS).

Similarly, ergonomic methods were considered that evaluates the tasks in which load lifting is performed, this is done by applying the equation of the maximum recommended weight according to the conditions of the position with the intention of avoiding the risk of back problems or low back pain.

The Sue Rodgers method (2020), was also applied, which studies the effort, duration and frequency required by each part of the body to perform a certain task, from these parameters a prediction of muscle fatigue of the operator is made.

With the intention of continuing to evaluate the physical risk factors associated with musculoskeletal disorders with work, REBA methods were applied. (Rapid Entire Body Assessment), RULA (Rapid Upper Limb Assessment), ARTOOL (Assessment of Repetitive Tasks of the upper limbs), QEC (quick exposure check), OWAS (Ovako working Analysis System) and WERA (2020) (Workplace Ergonomic Risks Assessment) was applied, which consists of six factors that Rahson mentions posture, repetition, strength effort and strength, vibration, contact stress and the duration of each task involving the five main parts of the body that are: shoulders, wrists, back, neck and legs.

Anthropometry and Workstation Measurement will enable proposed prototype development to decrease risks and improve material flow.
At the same time, it is necessary to plan and improve the area with the application of 5 S Order and SMED that allows to establish an optimal method of ordered and simplified work alternatives.

4. RESULTS

When evaluating the Mexican Standards for safety and hygiene conditions in workspaces, it began by establishing a 4 by 4 mesh to determine the points to be evaluated within the work area.

With reference to NOM-011-STPS-2001 (DOF,2002). The noise inside the office is below 85 dB (A), being within what is allowed by the standard, since the results obtained dB is not necessary to use hearing protection equipment, as shown in Figure 1, the decibels perceived in the company are within the range, but, in the same way they have the protective equipment.

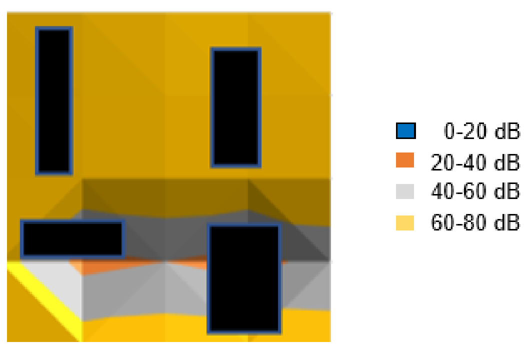


Figure 1. Decibels perceived in work area in noise evaluation.

In the NOM-025-STPS-2008 (DOF,2008) of Lighting within the area of evaluation this standard obtaining the data shown in Figure 2, recommending that it be used with lighting taking care only not to assign equipment or machines in the red zone since the recommended value is 500 lux and, in that area, it does not meet the requirements.

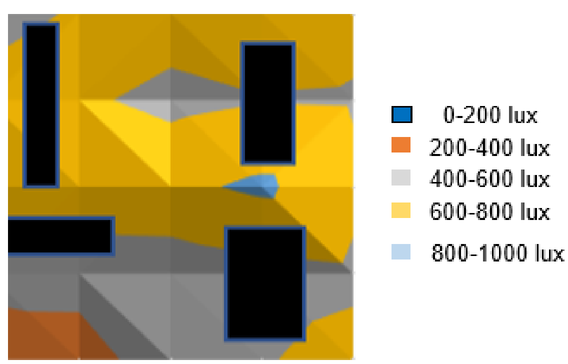
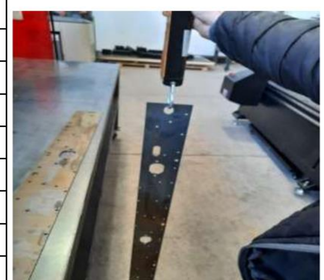


Figure 2. Evaluation of lighting in the work interaction area.

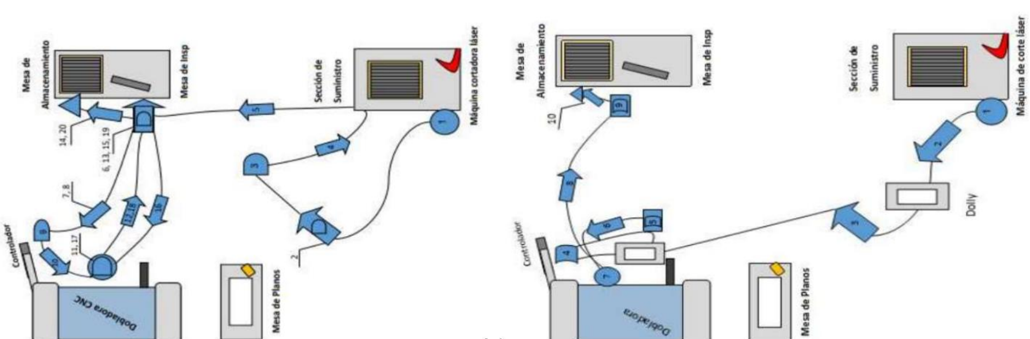
NOM-015-STPS-2001 this standard is based on occupational exposure from high or low thermal conditions in workplaces. The company has temperatures according to the norm, since the highest is at 24 ° C. This means that the workshop is at an ambient temperature of 20 to 24 °C on average. But, in the case of when using the laser cutting machine you should rest for ten minutes

For the NOM-036-1-STPS-2018 the manual annex of loads, when evaluating the activity with this standard it was determined that in the lifting of the load the risk presented is Medium so the tasks must be examined in greater detail, Through the application of a specific evaluation, or implementing control measures through an ergonomics program for manual handling of loads, cargo transport was also evaluated by classifying the activity with medium risk, as shown in Table 1.

Table 1. Results when applying NOM-036-1-STPS-2018.

Factor de Riesgo	Levanta		Transporta		Láminas de 3 Kg
Peso y Carga		4		4	
Distancia horizontal		3		0	
Región vertical		0			
Torsión y flexión del Torso		2		1	
Restricciones de postura		0		0	
Acoplamiento mano-carga		1		1	
Superficie de trabajo		0		0	
Otros factores ambientales		0		0	
Distancia de transporte				1	
Obstáculo de ruta				0	
Puntuación:		10		7	
Nivel de Riesgo:		Medio		Medio	

Each metal sheet has a weight greater than 3 kg. In order to verify this measurement, a figure is attached in table 1 where it was weighed by means of a dynamometer. More than 5 sheets are loaded when transporting it to the inspection table uses lifting of load greater than 15 kilograms, so the Dolly mobile table was proposed



a) b)

Figure 3. Route diagrams; a) before Improvement, b) after improvement

Figure 3 shows the route diagram before and after the proposed improvement, in response to the application of the ergonomic needs analyzed and the methods of industrial improvement resulting in operations using the mobile table (Dolly) which was developed according to the anthropometry of the 2 operators (table 2), In addition to allowing to take the loads of the cut plates to the assigned machines or their inspection as the case may be.

Table 2. Anthropometry of one of the operators for mobile table design

Descripción de Medición	cm	Mesa móvil (Dolly)
Estatura	176.0	
Altura de la vista al suelo	163.8	
Altura hombro al suelo	145	
Altura codo flexionado	107.5	
Altura Rodilla al suelo	51.6	
Extensión brazo doblado	38.8	
Extensión hacia el frente	91.8	
Extensión brazo lateral	94.9	
Ancho de codo a codo	53.2	
Profundidad máxima cuerpo	22.5	
Longitud de la mano	18.7	
Diámetro empuñadura	4.3	

Figure 4 shows: a) Lifting and manual transport of cut sheets of Laser Cutter to assigned work area, b) material handling between press inspection operations and press to inspection, c) sheet handling in pieces folded in CNC press and d) inspection of bent parts and storage.

Figure 4. Sample: a) Material transportation, b) Material handling, c) Bending process and d) inspection

The application of ergonomic methods allowed to assess the ergonomic risk factors as shown in Table 3 to Table 7.

This allowed us to analyze that in some cases before applying improvements the levels of medium to very high existed as a great ergonomic risk. Table 3 shows the ergonomic assessment of the risk factors both before applying the ergonomic and productive improvements and after their application in the manual material transport operation and using the mobile table as an improvement by the sheet cutting operator, no longer by the bending operator, allowed to improve neck postures (average 46.8%), back (average 56.6%), arms (average 40.4%), forearms (average 61.1%) and wrist/hand (average 43.4%) that were from 62.6% to 30.6% and in some methods did not identify changes, We were also able to identify an improvement in the strength factor on average of 62.6%. All improvements on average were 48.8% and obtained according to ergonomic methods s in 87.8% of them for ergonomic risk assessment.

Table 3. Results of ergonomic methods in the transport of sheets cut to bending CNC, "A" (Before), "D" (After) and "%" (percentage of Improvement)

Factor de riesgo	Puntuación en transporte de piezas																				
	S. Rodger			REBA			RULA			ARTOOL			OWAS			WERA			QEC		
	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%
Cuello	3	1	66.6	3	1	66.6	3	2	33.4	1	0	50	-	-	-	4	2	50	H	H	14.3
Espalda	3	1	66.6	5	2	60	5	2	60	2	0	66.6	4	1	70	4	3	24.9	H	M	48
Brazo	3	1	66.6	4	3	24.9	4	2	50	2	0	50	1	1	0	4	3	24.9	V	B	66.7
Antebrazo	3	1	66.6	2	1	50	3	1	66.6	-	-	-	-	-	-	-	-	-	-	-	-
Muñeca	4	1	75	3	2	34	4	1	75	1	0	50	-	-	-	3	3	0	H	H	26.3
Pierna	3	1	66.6	2	2	0	1	1	0	-	-	-	7	2	66.6	5	4	20	-	-	-
Fuerza	-	-	-	2	0	66.6	3	1	50	6	0	80	3	1	66.6	6	3	50	-	-	-

Table 4 shows that the use of a mobile table eliminated the manual transport of the blades, by improving some of the back postures (average 16.7%), arms (average 27.8%), forearms (average 16.7%) and wrist/hand (mean 21.2%) which ranged from 27.8% to 16.7% and in some methods did not identify changes such as neck (mean 0.0%), legs (mean 0.0%) and strength factor on average of 0.0%.All improvements on average were 11.8% and obtained according to ergonomic methods in 22.1% of them for ergonomic risk assessment.

Table 5 shows that there were no significant changes in the bending operation, only postures observed in videos that were subsequently trained by the operators were improved, neck postures with improvements of 8.3%, forearms (average 11.1%) and wrist/hand (average 5.6%) that were 11. 1% to 11.6% and in some methods they did not identify changes such as in average back 0.0%, arms (average 0.0%), legs (average 0.0%) and strength factor on average of 0.0%. All improvements on average were 3.6% and obtained according to ergonomic methods s in 11.9% of them for ergonomic risk assessment.

Table 4. Results of ergonomic methods in handling sheets to bending CNC and from bending CNC to inspection table, "A" (Before), "D" (After) and "%" (percentage of Improvement)

Factor de riesgo	Puntuación en manejo de piezas																				
	S. Rodger			REBA			RULA			ARTOOL			OWAS			WERA			QEC		
	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%
Cuello	1	1	0	3	3	0	3	3	0	1	1	0	-	-	-	3	3	0	H	H	0
Espalda	1	1	0	3	2	33.3	3	2	33.4	1	1	0	2	1	50	4	4	0	M	M	0
Brazo	4	1	70	4	3	24.9	3	3	0	2	0	50	2	1	50	4	4	0	M	M	0
Antebrazo	4	4	0	2	1	50	3	3	0	-	-	-	-	-	-	-	-	-	-	-	-
Muñeca	7	4	42.9	3	2	34	4	2	50	1	1	0	-	-	-	3	3	0	H	H	0
Pierna	1	1	0	2	2	0	1	1	0	-	-	-	7	7	0	4	4	0	-	-	-
Fuerza	-	-	-	0	0	0	2	2	0	4	4	0	1	1	0	3	3	0	-	-	-

Table 5. Results of ergonomic methods in sheet bending process, “A" (Before), "D" (After) and "%" (percentage of Improvement)

Factor de riesgo	Puntuación en proceso doblado de laminas																				
	S. Rodger			REBA			RULA			ARTOOL			OWAS			WERA			QEC		
	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%
Cuello	2	2	0	3	3	0	4	3	24.9	1	1	0	-	-	-	4	3	24.9	H	H	0
Espalda	2	2	0	2	2	0	2	2	0	0	0	0	1	1	0	2	2	0	M	M	0
Brazo	6	6	0	4	4	0	4	4	0	2	2	0	1	1	0	4	4	0	M	M	0
Antebrazo	6	6	0	2	2	0	3	2	33.4	-	-	-	-	-	-	-	-	-	-	-	-
Muñeca	9	6	33.3	2	2	0	4	4	0	1	1	0	-	-	-	3	3	0	H	H	0
Pierna	2	2	0	2	2	0	1	1	0	-	-	-	3	3	0	4	4	0	-	-	-
Fuerza	-	-	-	0	0	0	2	2	0	2	2	0	1	1	0	2	2	0	-	-	-

Table 6 shows how the inspection of bent pieces was improved since another operator was placed to share this task and an adjustable mobile table is used, leaving the results the same as in previous inspection but with fewer inspection operations, by improving neck postures (average 12.2%), back (average 18.1%), arms (average 21.1 %), forearms (average 32.6%), wrist/hand (average 31.1%) and legs (average 12%) which were 32.6% to 12% and in some methods they did not identify changes such as strength factor on average of 0.0%. All improvements on average were 18.1% and obtained according to ergonomic methods s in 50.5% of them for ergonomic risk assessment.

Table 6. Results of ergonomic methods in the inspection of bent parts, "A" (Before), "D" (After) and "%" (percentage of Improvement), "H" (High), "M" (Medium)

Factor de riesgo	Puntuación en inspección de piezas																				
	S. Rodger			REBA			RULA			ARTOOL			OWAS			WERA			QEC		
	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%
Cuello	7	6	14.3	3	2	34	4	3	24.9	1	1	0	-	-	-	4	4	0	H	H	0
Espalda	5	2	60	3	2	33.3	3	2	33.4	1	1	0	2	2	0	3	3	0	M	M	0
Brazo	7	6	14.3	4	4	0	4	4	0	2	0	50	2	1	50	5	4	20	M	M	13.3
Antebrazo	7	6	14.3	2	1	50	3	2	33.4	-	-	-	-	-	-	-	-	-	-	-	-
Muñeca	10	6	40	3	2	34	4	2	50	1	0	50	-	-	-	3	3	0	H	M	12.5
Pierna	5	2	60	1	1	0	1	1	0	-	-	-	2	2	0	4	4	0	-	-	-
Fuerza	-	-	-	0	0	0	2	2	0	2	2	0	1	1	0	3	3	0	-	-	-

Table 7. Concentrate of results of methods showing their risk levels.

Factor de riesgo		Traslado	Manejo	Proceso	Inspección
REBA	Antes	Muy Alto	Alto	Alto	Alto
	Mejora	Bajo	Medio	Alto	Medio
RULA	Antes	Muy Alto	Muy Alto	Muy Alto	Muy Alto
	Mejora	Medio	Alto	Muy Alto	Alto
ARTOOL	Antes	Alto	Alto	Medio	Medio
	Mejora	Bajo	Medio	Medio	Medio
OWAS	Antes	Alto	Medio	Alto	Alto
	Mejora	Bajo	Bajo	Alto	Alto
WERA	Antes	Medio	Medio	Medio	Medio
	Mejora	Medio	Medio	Medio	Medio
QEC	Antes	Muy Alto	Alto	Alto	Alto
	Mejora	Alto	Alto	Alto	Alto
Sue Rodgers	Antes	Bajo	Medio	Alto	Muy Alto
	Mejora	Bajo	Bajo	Medio	Medio

Table 7 shows that 50.0% of cases presented with a decrease in final risk levels, this being an appreciable improvement. In the transfer of cut sheets there were 71.4% of cases with reduction of risk levels, in the handling of parts in stations there were 71.4% of cases with reduction of risk levels, in the process of bending sheets in CNC bending machine there were 14.3% of cases with reduction of risk levels and in the inspection and storage of parts there was 42.9% of cases with reduced risk levels in ergonomic methods submitted for assessment.

Table 8. Concentrate of performance measures after applying industrial improvement.

Medida de Rendimiento	Antes	Después	Unidades	Mejora
Razón de Producción	34.6	60	Piezas/hora	73.4 %
Capacidad Producida	1156	2039	Piezas/día	76.3 %
Utilización	86.5	49.04	%	43.3 %
Disponibilidad	95	95	%	0.0 %
Inventario en Proceso	5.6	3	Piezas	4.6 %

Table 8 shows dafter applying reengineering, 5 S and SMED, the numbers indicate that it stays with pieces the 3 stations including the mobile table (Dolly), concluding that the process was as the lean manufacturing method indicates (one piece at a time), operators are working relaxed since they have more free time between pieces.

Figure 5 shows the distribution proposed in Map 5 "S" in subsection b) shows the route with the mobile table (Dolly), and figure 6 shows how the application described in figure 5 looks with photograph in figure 6

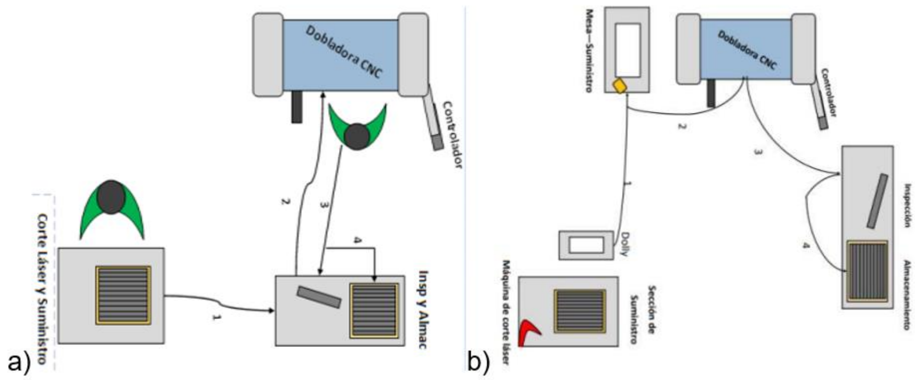


Figure 5. Map 5"S" a) before applying, b) after applying

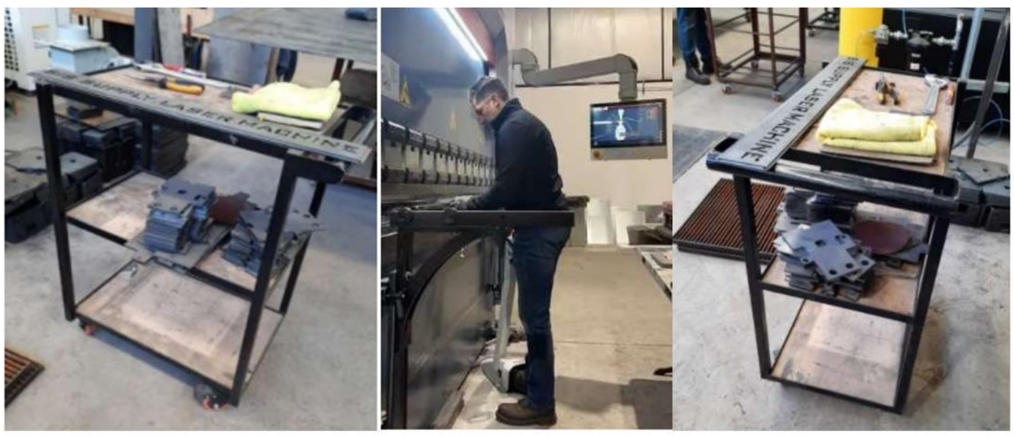


Figure 6. Verification of the mobile table (Dolly) with the proposed and valued changes.

Finally, figure 7 describes the results obtained from the application of SMED in our industry improvement system,30.7% of the time was detected in internal preparations, that is, the machines remained inoperative while preparing the parts or inspecting. Then, as shown in Figure 7 paragraph b this preparation became external preparation, because you have the material and tools in the place where they are going to be used. That is why it is important the mobile table with the tools and materials required in the order and quantity needed.

The methodological assessment of the Mexican standards allowed to identify and reduce the exposed transport conditions and in turn decreased the uncomfortable postures when using the mobile and adapting it to the height of operators was improved in SMED preparation by 77.85% and improving the operation by 60.56% only applying this method

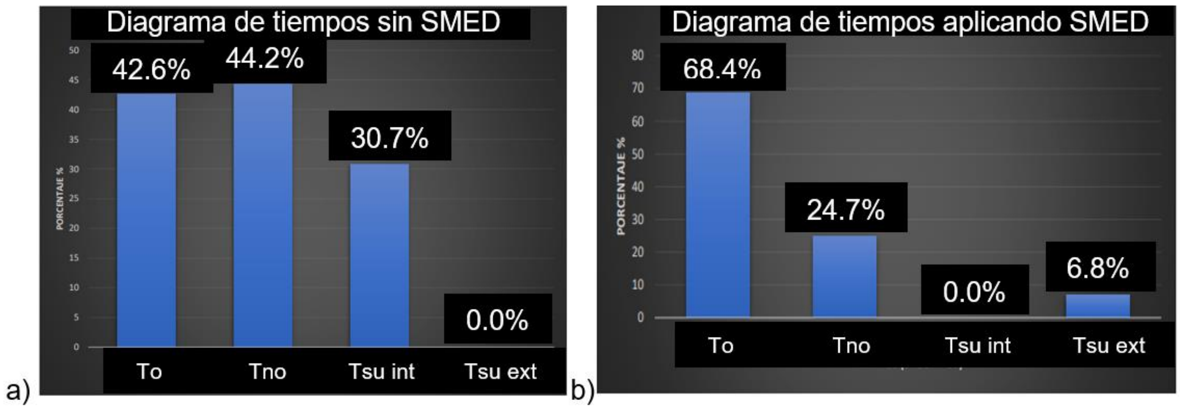


Figure 7. Diagrams show improvement in preparation times a) before and b) after

5. DISCUSSION/CONCLUSIONS

Integrated operations in the CNC bending process were improved by reducing ergonomic risks

Improved operations integrated into the CNC bending process by improving its production with process reengineering analyses and proposals identified by analyzing ergonomic risks

Improving operations by designingload handling equipment is indispensable to radically reduce manual loads that could cause musculoskeletal damage, especially when we consider the selection by anthropometric measurements and validation of results of ergonomic methods.

The Mexican standards allowed to make measurements valued by the methodology that these standards allow to identify the optimal operation of the workstations

Ergonomic methods assessed whether production improvements also reduced ergonomic risks previously assessed by these methods

We can affirm that ergonomic improvement, allows to reduce activities that do not add value, and that risks can be reduced and productivity increased in some proposals such as the one made.

Path diagrams allow you to diagnose processes before and after improvements, as well as what adds and does not add value to the processes analyzed to reduce ergonomic material handling risks

Lean manufacturing tools such as 5 S and SMED allow to give improvement options faster to follow your process improvement methodology that in turn allow you to propose improvements that improve processes by reducing the risks used in the activity

The international recommendations ILO allowed to identify the element of cargo handling that can be used as a support substation to order and reduce the transfers of material with which they decreased the transfers and increased productivity

These assessments will help improve working conditions in the area of transport, handling and inspection of materials, reducing the risk of musculoskeletal injuries and provide information to make the proposal for adaptation of activities and the current work area of operators.

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NOM-036-1-STPS-2018, ERGONOMIC RISK FACTORS AT WORK: MANUAL HANDLING OF LOADS IN WATER BOTTLING PLANT OF AGUA OPOSURA, MOCTEZUMA, SONORA

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Resumen. El presente trabajo se llevó a cabo en Planta Purificadora de Agua Oposura en la localidad de Moctezuma, Sonora donde se trabajó en un proyecto destinado analizar los riesgos ocasionado por el manejo de cargas, esto con la finalidad de establecer cambios de mejora para prevenir alteraciones a la salud del personal ocupacionalmente expuso a dichas actividades dentro de planta, principalmente en el área de llenado, sellado y traslado de expedición de garrafones, para esto se profundizo en la NOM-036-1-STPS-2018, Factores de riesgo ergonómico en el Trabajo, donde se procedió a conocer las instalaciones para identificar y analizar los distintos factores ubicados dentro de las áreas de planta, se conoció al personal de trabajo al cual se le realizaron breves preguntas para recopilar información sobre las distintas actividades realizadas en su trabajo, se profundizo por medio de un análisis o estimación de los riesgos por manejo de cargas anexado a la norma trabajada, con los datos arrojados por la estimación se diseñó una propuesta que disminuyó los riesgos a la cual se le reevaluó para validar la viabilidad de la propuesta, se utilizó el software de diseño Solidworks 2018 para elaborar el diseño de un equipo auxiliar con el cual el trabajo aligero la carga manual de los trabajadores.

Palabras clave: Factores de riesgo ergonómico y manejo de cargas.

Relevancia para la ergonomía: Provee información sobre aplicación de la NOM-036-1-STPS-2018 dentro de un centro de trabajo de embotelladoras de agua purificada.

Abstract The present work was carried out at the Water Bottling Plant Agua Oposura in the town of Moctezuma, Sonora, where work was carried out on a project aimed at analyzing the risks caused by the handling of loads, with the purpose of establishing improvement changes to prevent alterations to the health of the personnel occupationally exposed to these activities within the plant, mainly in the area of filling, sealing and transfer of jugs, for this, interest was deepened on the NOM-036-1-STPS-2018, Ergonomic Risk Factors in the Work, where the facilities were visited to identify and analyze the different factors located within the plant areas, the work personnel were met and brief questions were asked to gather information on the different activities carried out in their work, it was deepen through an analysis or estimation of the risks for handling loads associated with the standard worked, with the data provided by the estimation, a proposal was designed that reduced the risks, whish was reevaluated to validate the feasibility of the proposal. Solidworks 2018 design software was used to develop the design of an auxiliary equipment with whish the work lightened the load handling of the workers.

Keywords: Ergonomic risk factors and load handling.

Relevance for ergonomics: Provides information on the application of NOM-036-1-STPS-2018 within a work center of purified water bottling companies.

1. INTRODUCTION

To start with the project, the way of working, the environment, and the activities carried out by the company, to comply with its operation were first observed, likewise it was observed that areas of opportunity could be developed for the improvement project, and it was decided to opt for the use of NOM-036-1-STPS-2018.

Subsequently, the ergonomic risk factors derived from manual handling of loads are identified and analyzed, and a proposal is developed to prevent alterations to the health of workers; in addition, the activities that entail ergonomic risks are observed, an estimate of the level of risk is carried out, where the information collected is made known, resulting in a proposal to reduce risks and prevent health risks of occupationally exposed personnel.

The methodology used in the development of the project was the application of the MAC and RAPP methods, estimating the risks for lifting, pushing, dragging and transporting loads.

2. OBJECTIVES

Identify the activities involving ergonomic risk factors due to manual handling of loads, based on NOM-036-1-STPS-2018 for the prevention of alterations to the health of workers.

Estimate the level of risk or the assessment of the identified activities, with NOM-036-1-STPS-2018, to determine the actions to improve the workplace.

3. DELIMITATION

Risk estimation for lifting and transporting of loads, and manual loading operations, within the water bottling company, Agua Oposura.

3. METHODOLOGY

3.1 Identification of activities that involve ergonomic risk factors due to manual handling of loads

Based on NOM-036-1-STPS-2018, the area where it was observed that the standard was most applicable was identified due to the manual handling of loads in the work area, proceeding to an identification of the activities based on chapter 7.2 of this standard. The following flow chart was used to indicate the way in which the simple estimation of the level of risk or rapid assessment and/or the specific assessment of the level of risk should be applied.

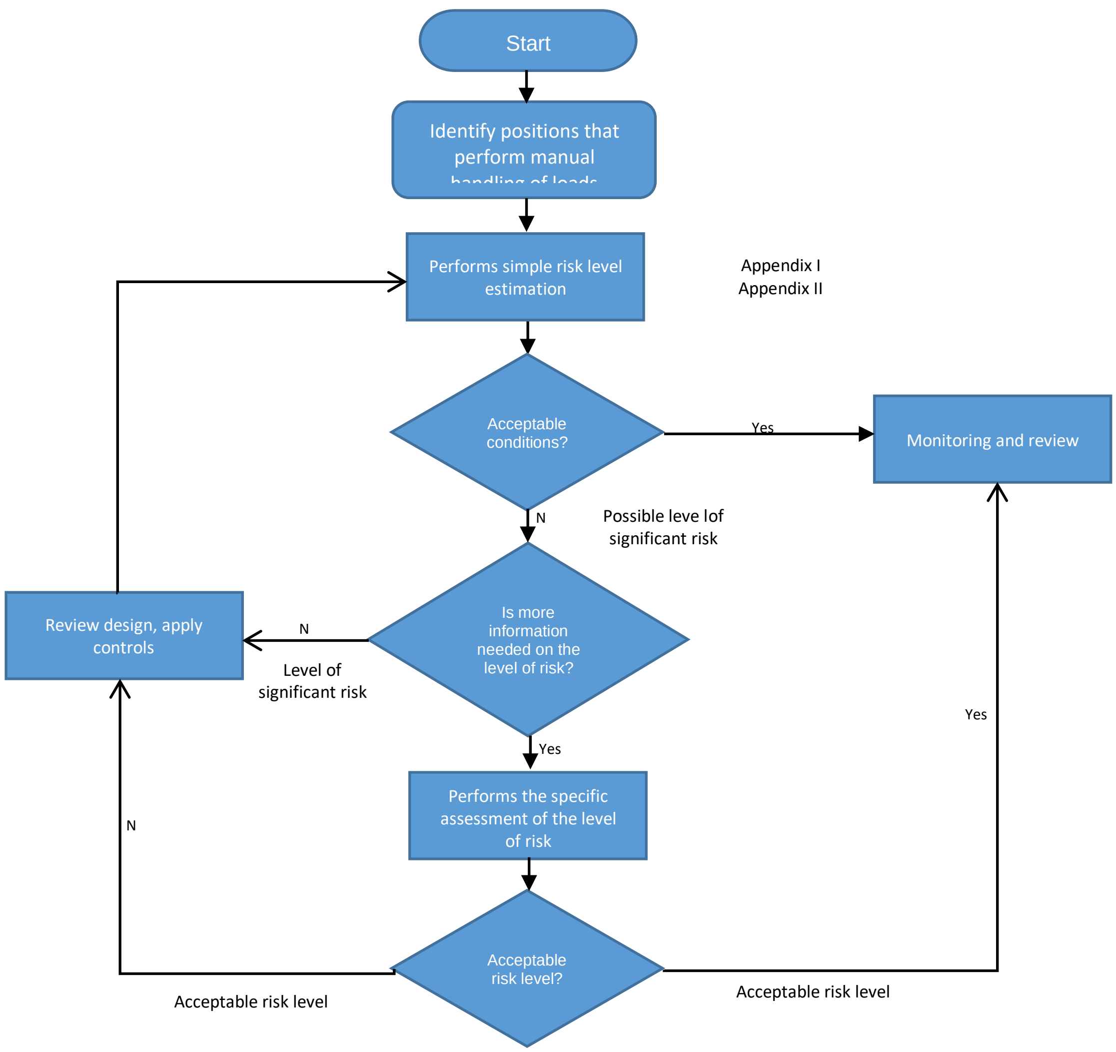

Figure 1. Simple Risk estimation application Flow Chart.

3.2 Simple estimation of the level of risk or rapid evaluation of the identified activities

In accordance with the section appendix I and II of the standard, the estimation of the level of risk was carried out, first the operations were observed for indefinite times until understanding the operation of said activities, the analysis was fulfilled recording the color and the value obtained from each of the analyzed factors for each activity, from which there were three operations that registered a risk to the health of the operators; the complete analysis for each activity is shown in the following tables.

Table1. Determination of risk level.

Risk Level	Priority	Total Score
Low – Acceptable	No corrective actions required	0 a 4
Medium – Possible	Short-term corrective actions are required	5 a 12
High – Significant	Corrective actions are required soon	13 a 20
Very High – Unacceptable	Immediate corrective actions are required	21 a 32

Table 2. Definition of corrective measures

RISK LEVEL	ACTIONS
Low – Acceptable	It is only necessary to monitor the most vulnerable groups such as pregnant women or minor workers.
Medium – Possible	The tasks must be examined in greater detail, through the application of a specific evaluation, or else implement control measures through an Ergonomics Program for the manual handling of loads.
High – Significant	Quick action is required, so control measures must be established through an Ergonomics Program for manual handling of loads.
Very High – Unacceptable	Activities must be stopped, and control measures implemented through an Ergonomics Program for the manual handling of loads.

3.3 Proposal to prevent or control ergonomic risk factors due to manual handling of loads

An improvement proposal was elaborated to prevent future alterations to the health of the workers based on the results obtained from the analysis carried out, a design is created that eliminates or significantly reduces the ergonomic risk factors due to the manual handling of the jugs, this design is thought to be that of an auxiliary equipment that helps transport.

4. RESULTS

4.1 Identification of activities involving ergonomic risk factors due to manual handling of loads

The area where the activities that handle manual loads are located was identified, once the activities were recognized, they were described, as follows in Table 3.

Table 3. Description of Activities

Activity	Descripction de Activity	Required worker	Frecuency of the activity	Duration of the activity
Transfer of water jug to the dispatch area	The jug located on the bar is raised to be lowered to the floor	1	48	7 minutes
Accommodation of the water jug dispatch area	The jug is taken from the neck and slid to its lot location	1	48	4 minutes
Transfer of water jug to transport vehicle	The jug is lifted off the ground to put on the vehicle platform	1	48	4 minutes

4.2 Simple estimation of the level of risk of rapid evaluation of the identified activities

Operation number 1: Transfer of water jug to the dispatch area

Table 4. Registration of color and value of filling transfer to the dispatch

Risk factors	Lifting	
	Color	Value
Weight and ascent of the load / frequency of transport	Orange	4
Horizontal distance between the hands from the lower back	Orange	3
Vertical lifting region	Green	0

Twisting and lateral flexion of the torso; Asymmetric load on the torso (transport)	Green	0
Postural restrictions (uncomfortable, forced, or restricted postures)	Orange	1
Hand-load coupling (clamping elements)	Orange	1
Work Surface	Red	2
Other enviromental factors	Green	0
Score	11	
Level of risk	Medium - Possible	

Operation number 2: Accommodation of the water jug dispatch area

Table 5. Registration of color and value of accommodation of the water jug

Risk factors	**Dragging/pulling or sliding**	
	Color	**Value**
Weight of the load	Blue	0
Posture	Yellow	3
Hand grip	Yellow	1
Work pattern	Yellow	1
Distance per trip	Yellow	1
Work Surface	Yellow	1
Obstacles along the route	Blue	0
Other factors	Yellow	1
Score	8	
Level of risk	Medium - Possible	

Operation number 3: Transfer of water jug to transport vehicle

Table 6. Registration of color and value of water jug to transport vehicle

Risk factors	**Lifting**	
	Color	**Value**
Weight and ascent of the load / frequency of transport	Orange	4
Horizontal distance between the hands from the lower back	Orange	3

Vertical lifting región	Orange	1
Twisting and lateral flexion of the torso; Asymmetric load on the torso (transport)	Orange	1
Postural restrictions (uncomfortable, forced, or restricted postures)	Orange	1
Hand-load coupling (clamping elements)	Orange	1
Work Surface	Red	2
Other environmental factors	Green	0
Score	13	
Leve lof risk	Medium - Possible	

4.3 Design analysis and prevention and/or control of ergonomic risk factors due to manual handling of loads

It was observed that four operations are carried out manually and repetitively, which are performed in the area of filling, sealing and dispatch of water jugs, of which three involve manual load handling and represent a risk of alteration to the health of the workers, in agreement with the actions that must be taken according to NOM-036-1-STPS-2018, it is required to take corrective actions in the short term, for which control measures must be implemented through an ergonomics program for the manual handling of loads.

4.4 Proposal to prevent or control ergonomic risk factors due to manual handling of loads

The elaborated design proposal is presented as an auxiliary equipment that helps prevent alterations in the health of the workers, the auxiliary equipment is the representation of a movable work table, which has a difference in height of the filling bar that with the help of a ramp, the water jug slides from the bar to the table to accommodate, transport and store within it and among of 24 units, which represents half or the units handled in a batch of jugs with an approximate weight of 456 kg.

It was decided that half of the units be the estimation of the level of risk of activities that imply pushing or pulling loads with the use of auxiliary equipment on medium-sized units, with three or more fixed wheels and/or mobile wheels, the optimum weight is from 250 kg to 500 kg, the table does not occupy a larger space than what was already designated for each batch, in the same way to transport the jugs for dispatch to the vehicles that carry the load of batches, the table is moved towards the vehicles and with the help of a platform at the same level as the vehicle, the jugs slide without having to lift the jugs at some point (see figures 2, 3, 4, and 5, created with Solidworks 2018).

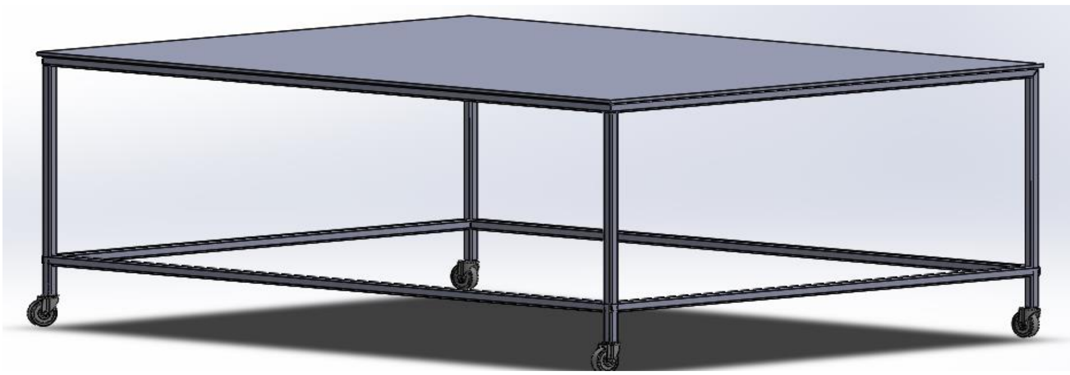

Figure 2. Movable table

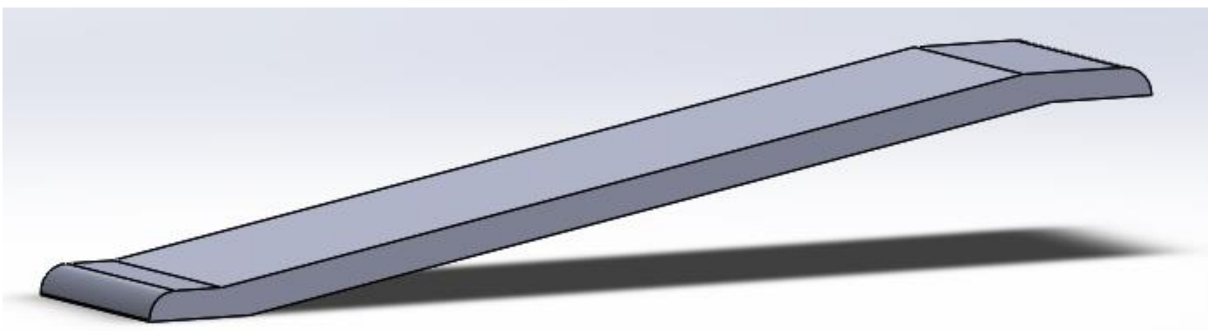

Figure 3. Ramp

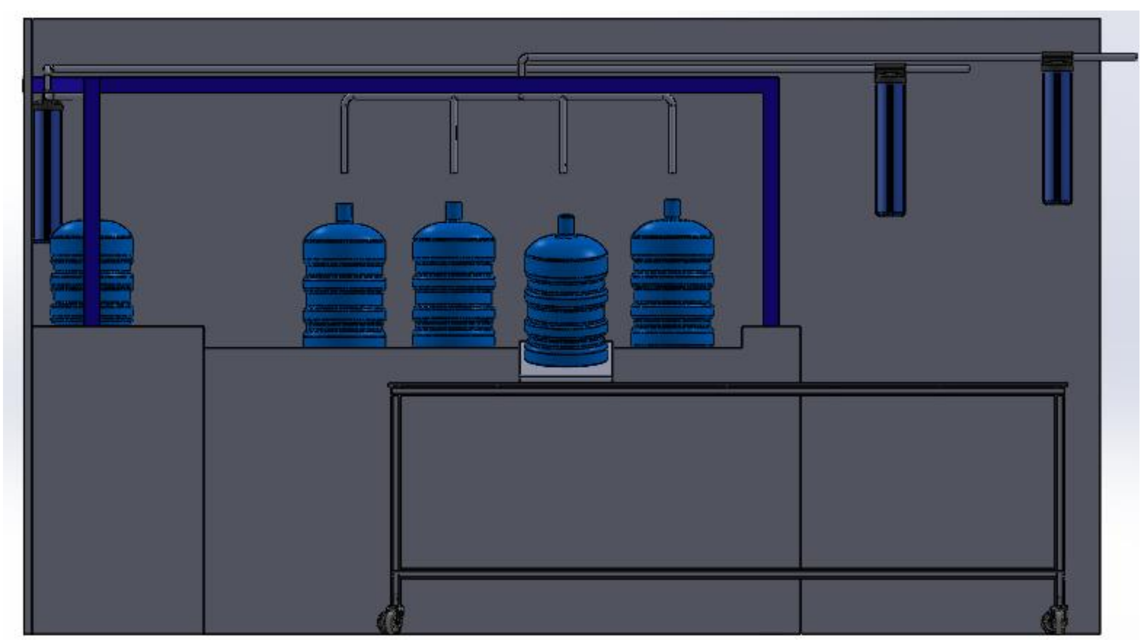

Figure 4. Movable table display, front view

5. CONCLUSIONS

Carrying out this type of research has a great influence within companies, mainly on the health and safety of workers. The company is interested in safeguarding their physical and mental integrity, which is why they improve their performance as employees.

The level of risk was determined with scores of 8, 11, and 13 for the three operations identified respectively, showing these values that the three operations are within the medium – possible risk range. Therefore, short-term corrective actions are required; for this, control measures can be implemented through an ergonomics program for load handling.

A conveyor belt that works with rollers was proposed and thus take advantage of gravity, or also the acquisition of hydraulic tables, which help to descend and ascend the water jugs; supported by a movable work table to transport and store the jugs, this makes it easier for workers with the help of a ramp not to load the jugs, but rather that they slide, reducing the risks due to manual loading.

It is recommended that the company start the preparation and application of transport tables to reduce the risks of workers. It is also recommended to perform warm-up exercises or movements before starting activities, keep transit and work areas free of obstructions, maintain order and cleanliness in the workplace, and ensure that the load has fastening elements.

Finally, it is recommended that once the improvements of the proposals have been implemented, an ergonomic evaluation be carried out again with the NOM-036-1-STPS-2018.

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ERGONOMIC VALIDATION OF STORED FILES HANDLING IN ADMINISTRATIVE OFFICE

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Resumen: Este trabajo trata de identificar actividades de riesgo de lesiones en el trabajo administrativo como archivar documentos, con la evaluación de la NOM-036-1-STPS-2018, condiciones de iluminación y ruido, además de métodos ergonómicos identificando que la trabajadora realiza actividades de cargas que pueden ser de riesgo para su salud, por lo cual, se realizó la validación de las actividades realizadas en el archivo de documentos como cargas, traslado y arrastre de cajas. Esta validación detecta el riesgo de lesiones músculo esquelética mediante esta validación y futura propuesta de mejora de las actividades se puede llegar a disminuir los riesgos de lesiones de la trabajadora realizando el trabajo administrativo de archivar, mejorando la calidad del trabajo.

Palabras clave: NIOSH, WERA, QEC y ARTOOL

Relevancia para la ergonomía: Disminuir los riesgos de lesiones y brindar una mejor calidad de vida en las actividades de un trabajo en su jornada laboral, utilizando los métodos ergonómicos junto con las normas mexicanas de manejo de carga para obtener valoraciones que no afectan al trabajador mediante propuestas de mejora en su entorno laboral.

Abstract: This article tries to identify activities of risk of injuries in administrative work such as filing documents, with the evaluation of NOM-036-1-STPS-2018, lighting and noise conditions, as well as ergonomic methods identifying that the worker performs activities of loads that may be of risk to their health, for which, the validation of the activities carried out in the document file such as loads, transfer and dragging of boxes were carried out. This validation detects the risk of musculoskeletal injuries through this validation and future proposal for improvement of the activities, the risks of injuries to the worker can be reduced by carrying out the administrative work of filing, improving the quality of the work.

Keywords. NIOSH, WERA, QEC y ARTOOL

Relevance to Ergonomics: Reduce the risks of injuries and provide a better quality of life in the activities of a job during their workday, using ergonomic methods together with the Mexican standards of cargo handling to obtain assessments that do not affect the worker through proposals for improvement in their work environment.

1. INTRODUCTION

One of the most common causes of disability in workers are musculoskeletal injuries due to ergonomic risks exposed in their work activities, according to the Occupational Health Report issued by the World Health Organization (WHO, 2017) according to (Hernández, 2021).

Some risk factors are the generation of internal forces in atrial segments of high intensity or with a significant frequency, the high frequency of repetitive movements and the duration of long exposure according to (Fragoso, 2022).

Therefore, in Mexico in 2018, the STPS (2018) published in the Official Gazette of the Federation DOF, the Official Mexican Standard NOM-036-1-STPS-2018, which establishes the elements to identify, analyze, prevent and control ergonomic risk factors in the workplace derived from the manual handling of loads, in order to prevent alterations to the health of workers (DOF, 2018).

A company concerned about the ergonomic risks that may arise from the activities carried out in an administrative office, where documents are filed, boxes are stored and handled through a woman who operates this activity, for which, the validation of the safety conditions was carried out, seeking to correct postures, which could improve the health of the worker. Therefore, the management of dead file boxes was valued as a critical activity to use the methodologies of Mexican standards NOM-036-1-STPS-2018 and the ergonomic methods NIOSH, WERA, QEC and ARTOOL among others. and ILO recommendations.

2. OBJECTIVES:

As main objective, it is to assess the administrative activities of manual handling of files storing them inside boxes and transporting them in an office through analysis tools for the detection of ergonomic risks, such as NOM-036-1-STPS-2018, lighting conditions, noise, the recommendations of the International Labor Organization (ILO) and ergonomic load analysis tools to detect activities of risk conditions of the worker in the area.

3. METHODOLOGY

With the analysis of the activities carried out by the worker, an analysis of the Official Standards for lighting, noise, was carried out to evaluate the work area, in addition to validating the ergonomic risk factors that determine the conditions for the prevention of occupational risks, as well as NOM-036-1-STPS-2018, prescribed by the Ministry of Labor and Social Welfare (STPS).

Similarly, ergonomic methods were considered that evaluates the tasks in which load lifting is performed, this is done by applying the equation of the maximum recommended weight according to the conditions of the position with the intention of avoiding the risk of back problems or low back pain.

The Sue Rodgers method (2020), was also applied, which studies the effort, duration and frequency required by each part of the body to perform a certain task, from these parameters a prediction of muscle fatigue of the operator is made.

With the intention of continuing to evaluate the physical risk factors associated with musculoskeletal disorders with work, the WERA (2020) (Workplace Ergonomic Risks Assessment) was applied, consisting of six factors that Rahson mentions posture, repetition, force effort and strength, vibration, contact stress and duration . of each task that involves the five main parts of the body that are: shoulders, wrists, back, neck and legs.

Finally, also by the (ILO, 2001), the checklist was retaken, with respect to the Mexican Standards of the STPS and another of the relationships to be evaluated are those established by the International Labor Organization (ILO) regarding COVID recommendations. The International Labour Organization seeks to promote productivity-based labour relations; the reconciliation of interests between the factors of production to achieve labor peace, and the legality to enforce the law, especially in the case of social security, labor inclusion and gender equity (International Labor Organization, n.d.).

4. RESULTS

The results of the evaluation of file upload activities with NOM-036-1-STPS-2018 and ergonomic methods coincided with respect to manual loading considering anthropometric height and ILO recommendations.

When evaluating the Mexican Standards for safety and hygiene conditions in workspaces, it began by establishing a 4 by 4 mesh to determine the points to be evaluated within the work area.

With reference to NOM-011-STPS-2001 (DOF,2002). The noise inside the office is below 85 dB (A), being within what is allowed by the standard, since the results obtained dB is not necessary to use hearing protection equipment, as shown in Figure 1, the decibels perceived inside the office at the preset points.

Figure 1. Decibels perceived in work area in noise evaluation.

In the NOM-025-STPS-2008 (DOF,2008) of Lighting within the office, this standard was evaluated, obtaining the data shown in Figure 2, recommending that lighting be improved especially in the lower blue row since according to the standard an office must have a minimum of 300 lux and in that area, it does not meet the requirements, observing that in certain areas the requirements are not met.

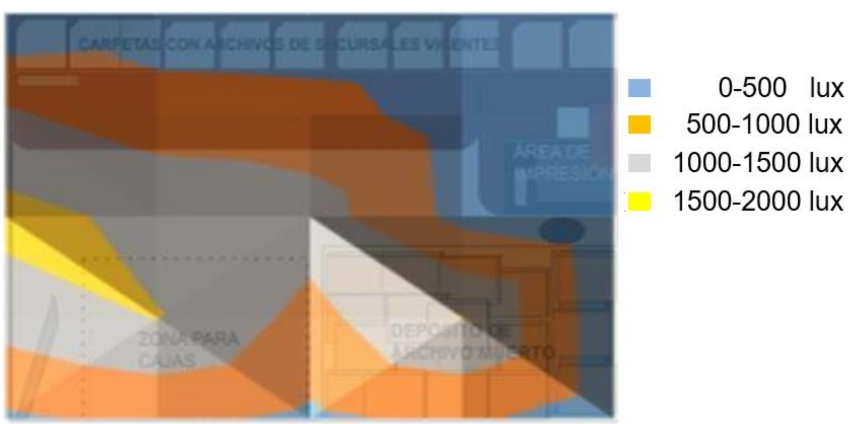

Figure 2. Evaluation of lighting in the work area.

Within this standard is the measurement of the reflection as shown in Figure 3 and according to the percentages of reflection allowed according to the standard, the area is within the allowed range since only at one point exceeds the maximum level and is due to the reflection caused by the window, so the remaining points do not exceed 60% in walls or 50% in work plane.

Figure 3. Evaluation of reflection in the work area.

For the NOM-036-1-STPS-2018 the manual annex of loads, when evaluating the activity with this standard it was determined that in the lifting of the load the risk presented is high so it requires rapid action and establish control measures through an ergonomics program for the manual handling of loads, cargo transport was also evaluated classifying the activity with medium risk, As shown in Table 1 and Figure 4.

Table 1. Results when applying NOM-036-1-STPS-2018.

Factor de Riesgo	Levanta		Transporta	
Peso y Carga		4		4
Distancia horizontal		3		3
Región vertical		0		
Torsión y flexión del Torso		2		1
Restricciones de postura		1		1
Acoplamiento mano-carga		1		1
Superficie de trabajo		2		2
Otros factores ambientales		0		0
Distancia de transporte				0
Obstáculo de ruta				0
Comunicación, coordinación y control				
Puntuación:		13		12
Nivel de Riesgo:		Alto		Medio

Figure 4. Operator in filing, transport and storage of boxes in office.

In these conditions it generates a high exposure of the worker to risk of an occupational musculoskeletal disorder.

When applying the NIOSH method (Diego-Mas, 2015) to determine if the worker performs the activity with the appropriate weight. The corresponding calculations gave a result of IL 3.04 as shown in Table 2, making it an unacceptable task from an ergonomic point of view. The worker is exposed to low back pain because the load handling is not adequate as established in the NIOSH method.

In the application of ergonomic methods are shown from table 3 to table 7, table 4 the evaluations shown in tables 3 are specified, it was determined in some cases before applying improvements levels from medium to very high in their ergonomic risk.

Table 2. Displays the data obtained when applying NIOSH.

Variable	Valor	Coeficiente	Resultado
Carga (Kg)	22	HM	0.63
H (cm)	40	VM	0.94
V (cm)	94.5	DM	1.00
D (cm)	20.5	AM	0.71
A (grados)	90	FM	0.75
F (Lev/min)	8	CM	1
Agarre	BUENO	LPR	7.22
		IL	3.04
		Riesgo	Incremento Acusado

Figure 5. Project of ramp with rotating base for archive boxes.

Table 3. Assessment when applying the QEC method

Factor de riesgo ergonómico	Nivel Riesgo en Paso del proceso								
	Archivo de documentos en caja			Transporte de documentos en caja			Almacenamiento de caja		
	Antes	Después	Mejora	Antes	Después	Mejora	Antes	Después	Mejora
Cuello	Alto	Medio	33.7	Medio	Bajo	60.4	Medio	Bajo	49.5
Espalda	Medio	Bajo	25.3	Alto	Bajo	73.8	Bajo	Bajo	50.4
Hombro/Brazo	Bajo	Bajo	28.6	Alto	Bajo	68.7	Bajo	Bajo	28.6
Muñeca/Mano	Medio	Bajo	21.7	Medio	Bajo	34.7	Bajo	Bajo	21.7

The application of the ergonomic method QEC also allowed to assess the ergonomic risk factors as shown in Table 3. By using a device for adhesive tape, a rotating base for the box and the transport slide ramp figure 5, I improve by decreasing the risk levels in the postures in file, transport and warehouse as follows; in neck (47.9%), back (average 49.8%), arms (average 42%) and wrist / hand (average 46.3%).

Table 4. Results of ergonomic methods in the Boxed Document File, "A" (Before), "D" (After) and "%" (percentage of Improvement)

Factor de riesgo ergonómico	Puntuación en Archivo de documentos en caja																	
	S. Rodger			REBA			RULA			ARTOOL			OWAS			WERA		
	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%
Cuello	6	1	83.3	3	2	33.4	4	3	25.4	2	1	33				5	4	20
Espalda	6	1	83.3	4	2	50	4	2	50.7	2	1	33	4	2	50	5	4	20
Brazo	6	1	83.3	4	3	34.9	3	2	34	2	0	50.7	1	1	0	4	4	0
Antebrazo	6	1	83.3	1	1	0	2	2	0									
Mano/Dedo/Muñeca	6	6	0	2	2	0	3	3	0	1	1	0				5	4	20
Pierna/Tobillo	1	1	0	1	1	0	1	1	0				2	2	0	4	4	0
Fuerza				0	0	0	1	0	50	8	4	17	1	1	0	3	3	0

Table 4 shows how handling an adhesive tape device and a rotating base for the box on a ramp base improved neck postures (mean 33.7%), back (mean 44.6%), arms (mean 33.06%), forearms (mean 41.65%) and wrist/hand (mean 13.04%) which were 88.3% to 20% and in some methods did not identify changes. We were also able to identify an improvement in the strength factor on average of 13.4%. All improvements were obtained according to the ergonomic method of support for ergonomic risk assessment used.

Table 5 shows that using the transport slide ramp eliminated the manual transport of the file boxes, by improving neck postures (average 32.4%), back (average 36.7%), arms (average 33.6%), forearms (average 16.9%), wrist/hand (average 32.1%) and legs (average 24.28%) which were from 73.8% to 33.3% and in some methods did not identify changes. Yes, we could also identify an improvement in the strength factor on average of 56.64%. All improvements were obtained according to the ergonomic method of support for ergonomic risk assessment used.

Table 6 shows that the use of the transport slide ramp allowed to improve the manual storage of the file boxes, by improving neck postures (average 50.1%), back (average 33.4%), arms (average 8.85%), forearms (average 16.9%), wrist/hand (average 11.8%) and legs (average 10%) that were from 66.6% to 28.6% and in some methods did not identify changes. We were also able to identify an improvement in the strength factor on average of 6.68%. All improvements were obtained according to the ergonomic method of support for ergonomic risk assessment used.

Table 7 shows that in 66.67% of cases there was a decrease in final risk levels, this being an appreciable improvement. In the filing of documents in boxes, 60% of cases with reduced risk levels were presented, in the transport of boxes 100% of cases with reduced risk levels were presented and in the storage of boxes with documents, 40% of cases with reduced risk levels were presented in the ergonomic methods presented for valuation.

Table 5. Results of ergonomic methods in the transport of documents in box, "A" (Before), "D" (After) and "%" (percentage of Improvement)

Factor de riesgo ergonómico	Puntuación en transporte de documentos en caja																	
	S. Rodger			REBA			RULA			ARTOOL			OWAS			WERA		
	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%
Cuello	1	1	0	2	1	50	3	2	34	0	0	0				4	2	50
Espalda	1	1	0	3	2	33.3	3	1	66.6	0	0	0	2	1	50	3	2	33.4
Brazo	3	1	66.7	3	2	33.3	3	1	66.6	0	0	0	1	1	0	3	3	0
Antebrazo	1	1	0	1	1	0	2	1	50.7									
Mano/Dedo/Muñeca	3	1	66.7	2	1	50	3	2	33.3	1	1	0				3	3	0
Pierna/Tobillo	1	1	0	2	1	50	1	1	0				7	2	71.4	4	4	0
Fuerza				2	0	66.6	3	1	50	6	1	33.3	3	1	66.6	6	2	66.7

Table 6. Results of ergonomic methods in the checkout warehouse, “A" (Before), "D" (After) and "%" (percentage of Improvement)

Factor de riesgo ergonómico	Puntuación en almacén de documentos en caja																	
	S. Rodger			REBA			RULA			ARTOOL			OWAS			WERA		
	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%	A	D	%
Cuello	3	1	66.6	2	1	50	3	2	34	1	0	50.7				4	2	50
Espalda	1	1	0	3	2	33.3	3	1	66.6	1	0	50.7	1	1	0	3	2	33.4
Brazo	1	1	0	1	1	0	1	1	0	0	0	0	1	1	0	3	2	33.4
Antebrazo	1	1	0	1	1	0	2	1	50.7									
Mano/Dedo/Muñeca	1	1	0	1	1	0	2	2	0	0	0	0				3	2	33.4
Pierna/Tobillo	1	1	0	2	1	50	1	1	0				2	2	0	4	4	0
Fuerza				0	0	0	0	0	0	0	0	0	1	1	0	3	2	33.4

Table 7. Concentrate of results of methods that show their risk levels.

Factor de riesgo ergonómico	Nivel de Riesgo Final									
	REBA		RULA		ARTOOL		OWAS		WERA	
	Antes	Después	Antes	Después	Antes	Después	Antes	Después	Antes	Después
Archivar en caja	Alta	Medio	Muy Alta	Medio	Medio	Baja	Medio	Medio	Medio	Medio
Transporte de cajas	Alta	Muy Baja	Muy Alta	Medio	Medio	Baja	Alta	Baja	Medio	Baja
Almacenado	Medio	Muy Baja	Medio	Medio	Baja	Baja	Baja	Baja	Medio	Baja

According to the ILO, the points that are applicable to the activity were determined Table 8, classified by areas, checkpoints, applicable checkpoints. In this activity they applied all areas except hand tools since it is done in an office.

Table 8. Checklist applied to archiving, transporting, and storing box.

Tema	Puntos de comprobación
Manipulación y almacenamiento	#5 Mejorar la disposición del área de trabajo de forma que sea mínima La necesidad de mover materiales.
	#11 En lugar de transportar cargas pesadas, repartir el peso en paquetes menores y más ligeros, en contenedores o en bandejas.
	#13 Eliminar o reducir las diferencias de altura cuando se muevan a mano los materiales.
Mejora del diseño puesto de trabajo	#57 Ajustar la altura de trabajo a cada trabajador, situándose al nivel de los codos o ligeramente más abajo.
	#66 Dotar, de buenas sillas regulables con respaldo a los trabajadores sentados.
Organización del trabajo	#109 Consultar a los trabajadores sobre cómo mejorar la organización del tiempo de trabajo.
	#110 Resolver los problemas del trabajo implicando a los trabajadores en grupos.
	#111 Consultar a los trabajadores cuando se hagan cambios en la producción y cuando sean necesarias mejoras para que el trabajo sea más seguro, fácil y eficiente.
	#115 Propiciar ocasiones para una fácil comunicación y apoyo mutuo en el lugar de trabajo.
	#116 Dar oportunidades para que los trabajadores aprendan nuevas técnicas.
	#123 Tener en cuenta las habilidades de los trabajadores y sus preferencias en la asignación de los puestos de trabajo.

5. DISCUSSION/CONCLUSIONS:

The methodological assessment of the Mexican standards allowed to identify and reduce the conditions exposed in the office. The validation with ergonomic methods allowed to identify to reduce the conditions exposed by the operator.

With international recommendations, the optimal load handling methods for the operator's load handling were identified faster.

Load handling equipment is indispensable to radically reduce manual load handling, especially when we consider the selection by anthropometric measurements and validation of ergonomic methods.

This analysis showed that the critical activity of handling boxes presented a high level of risk, so the operator is exposed to developing some type of injury based on the results obtained in the ergonomic methods that were not perceived when applying the Mexican Standard.

Generating the implementation of a table with a design so that its height and length can be adjusted according to the anthropological measures of the worker in order to avoid exposing the worker to suffer any musculoskeletal injury, this proposal was validated again by the aforementioned methods and yielding satisfactory results.

These assessments will help improve working conditions in the filing area, reducing the risk of musculoskeletal injuries and provide information to make the proposal to adapt activities and the current work area of the worker.

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JOBS EVALUATIONS BY RULA AND NORDIC KUORINKA ASSESSMENT

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Resumen: Existen actividades en los procesos industriales que por repetición, fuerza, duración y postura pueden generar y desarrollar enfermedades musculoesqueléticas (TME). En este trabajo, las actividades fueron evaluadas utilizando el Rapid Upper Limb Assessment (RULA) y el Cuestionario Nórdico de Kuorinka para evaluar y comparar los resultados entre ellos. El presente estudio fue diseñado bajo el enfoque metodológico mixto, ya que el estudio fue observable y medible. La información fue analizada mediante el programa estadístico SPSS Statistic 22.00. Los resultados de la evaluación RULA fueron que el 33,33% presentó una inclinación mayor a 20° y en el caso de los nórdicos el 53% mencionó una molestia en la espalda al realizar alguna actividad física. Analizando la relación entre las valoraciones, se obtuvo un valor de chi-cuadrado de 6,563 y un valor de P = 0,026. Por este motivo, existe una asociación entre RULA y la valoración nórdica en la posición de atrás. Fue posible el desarrollo y presencia de un TME en la espalda al realizar actividades en procesos industriales.

Palabras clave. Evaluación rápida de miembros superiores, Cuestionario Nórdico de Kuorinka, Enfermedades musculoesqueléticas.

Relevancia para la Ergonomía: La prevención de enfermedades a través de la aplicación de evaluación ergonómica es el primer paso para mejorar las condiciones laborales, por lo que esta investigación ayudará y apoyará para prevenir un TME.

Abstract: There are activities in the industrial processes which, due to repetition, force, duration and posture that can generate and develop a musculoskeletal diseases (MSD). In this paper, activities were evaluated using the Rapid Upper Limb Assessment (RULA) and Kuorinka´s Nordic Questionnaire in order to evaluate and compare the results between them. The present study was designed under the methodological mixed approach, since the study was observable and measurable. The information was analyzed using the SPSS Statistic 22.00 statistical program. The results of RULA assessment were that 33.33% showed an inclination greater than 20° and in the case of Nordic the 53% mentioned a discomfort in the back when doing a physical activity. Analyzing the relationship between the assessments, a chi-square value of 6.563 and a P value = 0.026. For this reason, there is an association between RULA and Nordic assessment in the back position. It was possible the development and presence of a TME in the back when carrying out activities in industrial processes.

Keywords. Rapid Upper Limb Assessment, Kuorinka´s Nordic Questionnaire, Musculoskeletal diseases.

Relevance to Ergonomics: The diseases prevention through the ergonomic assessment application is the first step to improve working conditions, so this research will help and support in order to prevent a MSD.

1. INTRODUCCTION

There are activities in industrial processes which, due to repetition, force, duration and posture, can generate the development of musculoskeletal disorders (MSD).

The Federal Labor Law in its article 475 defines as occupational disease any pathological state derived from the continuous action that has its origin or motive at work or in the environment in which the worker is forced to provide his services. The Mexican Social Security Institute reported 12,622 cases of occupational diseases in 2016, with the highest incidence being occupational diseases that are grouped as TME: carpal tunnel syndrome; shoulder injuries; the Quervain's radial styloid tenosynovitis, so MSDs as a group now represent the first type of occupational disease.

Most of the work-related MSDs develop over time and are caused by the work itself or by the environment; the internal and external conditions of the human being affect the appearance, which increases the predisposition to suffer them (Dimate, Rodríguez and Rocha, 2017).

Widanarko, Legg, Devereux, & Stevenson, (2014) comment that work-related musculoskeletal disorders are very common in a population. Musculoskeletal disorders can be characterized as being multifactorial, which is why they encompass psychosocial, physical, individual, and occupational components (Rasha, Amir, Elsayed, & Dawood, 2019). Those that are work-related occur when there is a mismatch between the human body physical capacity versus the task physical requirements (Orhan, & Memon, 2019).

On the other hand, Bosman, Twisk, Geraedts, and Heymans (2020) mention that MSDs are one of the main causes of occupational diseases, so it is important to modify the practices that are carried out at work that can and are affecting job´s people.

MSDs are disorders that include disorders of the muscles, tendons, tendon sheaths, nerve entrapment syndromes, joint disorders, and generally affect the back, neck, shoulders, and upper extremities (Muñoz, 2021).

On the other hand, Nigudgi, Shrinivas and S.R. Nigudgi (2016) refer that one of the main causes of work absenteeism is TME; for this reason, global models have been proposed, in which it is sought to protect and promote the health, safety and well-being of workers through strategies aimed at improving working conditions.

One of these strategies is the application of work evaluation methods that allow detecting and preventing the presence of a MSD in workers. Bellorín, Sirit, Rincón and Amortegui (2007) mention that in their research work they applied 89 ergonomic evaluations in order to determine the prevalence of musculoskeletal symptoms in occupational activities in workers in the civil construction industry . In Colombia, a study was carried out on the perception of musculoskeletal discomfort in nine body regions using the Nordic Questionnaire, taking a sample of 302 workers (Mendinueta and Herazo 2014).

On the other hand, in Chile, Martinez and Alvarado´s research project (2017) used the Nordic Questionnaire in a sample of 114 workers from 6 economic sectors in order to validate the work carried out in the industry.

Castro, Yandún, Constante and Álvarez (2020) mentioned that the Nordic Kuorinka questionnaire has been widely used internationally in the agriculture, livestock, fishing and forestry industry, as well as in activities related to the treatment of human health and social issues. , for monitoring the development of a TME.

Likewise, Kourinka, Jonsson, Kilbom, Vinterberg, Biering, Andersson and Jørgensen (1987) said that the Nordic instrument together with other functionality and health perception questionnaires are previous steps for the medical evaluation that allows confirming or ruling out the development of a work-related illness.

Dimate, Rodríguez and Rocha (2017) mention that the Nordic Kuorinka questionnaire is a method used to find out the musculoskeletal symptoms in workers who are exposed to risk factors. They comment that the questionnaire provides valuable information to calculate the risk level and thus ultimately have a proactive preventive action. In the same way, they clarify that this tool is self-administered and that it can be used as a complement to the RULA method, since if they are used together it is more feasible to identify potentially critical body segments that can result in a musculoskeletal disease.

On the other hand, Martínez and Alvarado (2017) said that the Kuorinka Nordic Questionnaire is one of the most used ergonomic evaluations worldwide for the diseases detection of the musculoskeletal system. They clarify that it is a tool that allows obtaining data on the symptoms of a disease prior to the appearance of a disease, which helps in decision-making related to preventive actions. They comment that the questionnaire can be used as a survey or as an interview. They also mention that this evaluation is designed mainly to detect problems in the lower back since it includes very specific sections for the lower back. Finally, they mention that reliability and validity data have been presented in various studies where this evaluation has been used, in addition, these studies suggest that these questionnaires can be a useful evaluation to be investigating the MSD development.

Similarly, Namnik, Negahban, Salehi, Shafizadeh, and Tabib (2016) state that the Nordic Kuorinka questionnaire is a widely used evaluation for the analysis and detection of MSD, focused on the management of ergonomic risk prevention. They mention that, although it is a relatively old method, its technical value lies in the information it provides, which allows the level of risk to be estimated proactively, so that the intervention is almost immediate. They comment that it is a questionnaire with eleven questions which, through them, can determine the perception and symptoms of the worker to whom they are exposed in their work activity.

Likewise, Gómez, Díaz, Gutiérrez, Sánchez and Torres (2020) indicate that the Nordic Kuorinka questionnaire consists of two parts, the general part and the specific lumbar neck and shoulder questionnaires. They mention that this ergonomic tool is valid, reliable, and feasible, since it allows comparing musculoskeletal problems between different anatomical areas. They clarify that it should not be used as a tool to confirm the diagnosis of a disorder or pathology, since it has a significant number of false positives. Kuorinka's Nordic Questionnaire, which is a questionnaire that allows examining the scope of a problem and recognizing its importance in the workplace (Gómez, Díaz, Gutiérrez, Sánchez and Torres (2020).

On the other hand, Bermúdez, Patiño and Carmen (2020) mentioned that the Rapid Upper Limb Assessment (RULA) method helps to establish if there is an ergonomic risk and assesses the postures that the personnel adopt during their work of the upper limbs, neck, trunk and the lower limbs; the risk is assessed through the observation of work cycles, taking into account postures, frequency and strength within the scale.

Ansari and Sheikh (2014) pointed out that RULA is a survey method developed for ergonomic investigations of workplaces where work-related upper extremity risks have been reported.

That is why in the present work the process was analyzed at the same time, using the ergonomic evaluation Rapid Upper Limb Assessment (RULA) to determine the presence of movements, postures or efforts that can affect the health of the human body when performing a physical activity. .

2. OBJECTIVES

- Evaluate work activities using the Nordic ergonomic tool and RULA.
- Compare the results of the RULA and Nordic assessments.
- Identify possible musculoskeletal diseases.

3. METODOLOGY

The present study was an experimental design of the pre-experimental type, since it is the one that best adapted to the needs of the study. Considering that the research topic has sufficient theoretical support, a correlational-causal cross-sectional investigation was carried out to determine the risk level in the MSD development.

The present study was designed under the methodological approach of the mixed approach, since the study was observable and measurable. Statistical-based research techniques were used since the facts were considered to be quantified.

From the quantitative approach, the Nordic Questionnaire and RULA assessment were applied to measure the different work postures, movement frequencies, movement efforts and duration of the movement to which the operator is exposed.

The capture of the information was carried out using the Excel 2010 program in which the data taken from the RULA and Nordic Questionnaire evaluations were initially entered.

The information was stored in a spreadsheet, which once it was entered in its entirety was exported to the SPSS Statistic 22.00 software in which the statistical analysis was performed to find out if there is a relationship between the results of both applied ergonomic evaluations.

4. RESULTS

The results of the study show that when applying the RULA ergonomic evaluation, the 15 people surveyed were in a posture with an extra or superior category in 66.66% in the part of the body of the arms. While in the Nordic survey, 40% showed that they do show discomfort or pain in the arms (See Figure 1).

Figure 1. Industrial activity

On the other hand, analyzing the part of the wrists, 60% showed an extreme wrist posture as pronation movements that exceeded 90°. And when applying the Nordic survey, 40% mentioned having discomfort or pain in the part of the wrists when doing physical activities.

In the part of the back or trunk, the RULA survey, 33.33% showed an inclination greater than 20° and in the case of the Nordic, 53% of the people surveyed mentioned that there is discomfort or discomfort in the back when performing your physical activity.

In Table 1 it can be seen that the chi-square value is 1.746 and the P value =0.202, so there is no association between the RULA values and the results of the application of the Nordic survey in the position of the arm.

Table 1. Contingency Table RULA Arm and Nordic Arm

			Nórdico Arm		Total
			No	Yes	
Arm RULA	Normal	Count	4	1	5
		Expected frequency	3.0	2.0	5.0
		% arm RULA	80.0%	20.0%	100.0%
	Superior	Count	4	3	7
		Expected frequency	4.2	2.8	7.0
		% arm RULA	57.1%	42.9%	100.0%
	Extreme	Count	1	2	3
		Expected frequency	1.8	1.2	3.0
		% arm RULA	33.3%	66.7%	100.0%
	Total	Count	9	6	15
		Expected frequency	9.0	6.0	15.0
		% Arm RULA	60.0%	40.0%	100.0%

In Table 2 it can be seen that the chi-square value is 3.542 and the value of P =0.077, so there is no association between the RULA values and the results of the application of the Nordic survey in the position of the wrist

Table 2. Contingency table RULA wrist and Nordic wrist

			Nórdico Wrist		Total
			No	Si	
Wrist RULA	Low	Count	2	0	2
		Expected frequency	1.2	.8	2.0
		% Wrist RULA	100.0%	0.0%	100.0%
	Normal	Count	3	1	4
		Expected frequency	2.4	1.6	4.0
		% Wrist RULA	75.0%	25.0%	100.0%
	Extreme	Count	4	4	8
		Expected frequency	4.8	3.2	8.0
		% Wrist RULA	50.0%	50.0%	100.0%
		Count	0	1	1
		Expected frequency	.6	.4	1.0
		% Wrist RULA	0.0%	100.0%	100.0%
	Total	Count	9	6	15

	Expected frequency	9.0	6.0	15.0
	% Wrist RULA	60.0%	40.0%	100.0%

In Table 3 it can be seen that the chi-square value is 6.563 and the P value =0.026, so there is an association between the RULA values and the results of the application of the Nordic survey in the position of the back.

Table 3. Contingency table RULA Back and Nordic Back

			Nórdico Back		Total
			No	Si	
Back RULA	Normal	Count	7	3	10
		Expected frequency	4.7	5.3	10.0
		% Back RULA	70.0%	30.0%	100.0%
	Superior	Count	0	5	5
		Expected frequency	2.3	2.7	5.0
		% Back RULA	0.0%	100.0%	100.0%
	Total	Count	7	8	15
		Expected frequency	7.0	8.0	15.0
		% Back RULA	46.7%	53.3%	100.0%

5. DISCUSSION / CONCLUSIONS

In the work of Castro, Yandún, Constante and Álvarez (2020) they mentioned that they were able to identify possible musculoskeletal disorders using the Nordic Kuorinka Questionnaire in their research. In his work there were discomforts that occur in the lumbar spine, neck and carpal tunnel syndrome that belongs to the body segment of the right and left wrist hand.

In the same way, in this research work, 40% under the Nordic Questionnaire mentioned that there is pain in the shoulders when carrying out their activity, while in RULA only 20% had an extreme position in the shoulders when working. So there is no relationship between one and another evaluation. We can conclude that people are complaining more than they would see at the time of the operation, but also the RULA evaluation has a poor allocation in the frequency of movements to be able to compare exactly these two evaluations.

In the work of Muñoz (2021) he mentions that the Nordic questionnaire fulfills the role of being an instrument for the detection of workers with discomfort, which serves as a basis for carrying out a more in-depth evaluation. In relation to this, in this study 53% of people reported discomfort with the upper back when performing an activity and when supporting themselves with the RULA evaluation, 33% reported back positions with high risk exposure. Which allows us to conclude the relationship that exists in both evaluations and the possibility of development and the TME presence on the back when carrying out activities in industrial processes.

In the present study, by applying RULA ergonomic evaluations o and Nordic, it was possible to observe that there are positions that can cause the MSD development in the back in workers.

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BIOMECHANICAL ANALYSIS OF THE SHOULDER IN REPETITIVE WORK.

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Resumen: Una de las características importantes de la industria de ensamble, es que a menudo se implican cambios rápidos en la demanda y productos a fabricar, condición que necesariamente se debe cumplir para lograr establecer los niveles competitivos exigentes en los modernos mercados. Las tareas consideradas como repetitivas en esta industria, enmarcan un rol de suma importancia para el sistema de operaciones, ya que logran establecer una alta flexibilidad en las acciones que realizan, debido principalmente a la capacidad del operador de efectuar tareas multifuncionales, extender su tiempo de jornada y de adaptarse rápidamente a los cambios en el tipo y volumen de producto a generar. A su vez, mantienen un conjunto de características que impactan de forma negativa a la estructura anatómica del operador y se hace presente, en un periodo relativamente corto, lo denominado Trastorno Musculoesquelético.

Monotonía, tiempos de ciclo cortos, repetitividad de movimientos, posturas forzadas, estrés por contacto, sobrecarga, compresión, desbalance muscular, son las principales características que implican el trabajo repetitivo. En su conjunto, dichas características impactan de forma negativa la estructura anatómica de los operadores, afectando su funcionalidad y calidad de vida.

El hombro es una de las principales partes anatómicas afectadas por este tipo de tareas, ya que en corto tiempo de accionamiento se presenta acumulación de tensiones y movimientos constantes que afectan los tejidos blandos y las estructuras articulares. Algunas de las patologías del hombro relacionadas con el trabajo repetitivo incluyen: Tendinitis del manguito de los rotadores, bursitis, lesiones del labrum, Tendinopatía bicipital. En función a lo anterior, es de imperiosa necesidad establecer el impacto de las acciones demandantes del trabajo repetitivo, en la articulación del hombro, para con ello estar en condición de implementar medidas ergonómicas en el lugar de trabajo, proporcionar capacitación sobre técnicas de trabajo seguras, fomentar la rotación de tareas para evitar la repetición constante de movimientos y estructurar programas de ejercicios de fortalecimiento y estiramiento específicos que pueden ayudar a mantener la salud y la función del hombro.

Este estudio pone de relieve cómo los diversos movimientos que realiza el hombro en el trabajo repetitivo, pueden contribuir a la aparición de condiciones de riesgo que lesionan o dañan la integridad física del operador. Se analiza la biomecánica del movimiento repetitivo y se indexa con las posibles patologías del hombro.

El trabajo investigativo contempla tres etapas: La primera analiza la biomecánica del movimiento en los diferentes tipos de tareas repetitivas, una segunda parte se desarrolla un instrumento electrónico que mide las ondas eléctricas del estímulo del nervio al realizar la tarea y la última parte que enmarca un método de evaluación ergonómica para el trabajo repetitivo en hombro. El presente trabajo cubre la primera parte de la investigación integral.

La idea fundamental de estructurar un método de evaluación ergonómica es mantener un método de evaluación validado a través de técnicas concurrentes y predictivas, en función al análisis biomecánico y de electromiografía. Esto permitirá a los ergónomos realizar evaluación del potencial de riesgo en las tareas repetitivas que contemplen la funcionalidad del hombro.

Palabras clave: Biomecánica, hombro, trabajo repetitivo.

Relevancia para la ergonomía: El presente trabajo investigativo muestra como los diferentes movimientos desarrollados por el hombro en el trabajo repetitivo, impacta en la conformación de patologías que lesionan o dañan la integridad anatómica del operador. Con ello, la ergonomía cumple su esencial función de mejorar la calidad de vida de los trabajadores, que desarrollan sus actividades en la planta productiva nacional.

Abstract: One of the important characteristics of the assembly industry is that it often involves rapid changes in demand and products to be manufactured, a condition that must necessarily be met in order to establish the demanding competitive levels in modern markets. The tasks considered as repetitive in this industry, play a very important role for the operations system, since they are able to establish a high flexibility in the actions performed, mainly due to the operator's ability to perform multifunctional tasks, to extend his working time and to adapt quickly to changes in the type and volume of product to be produced. In turn, they maintain a set of characteristics that negatively impact the anatomical structure of the operator and the so-called Musculoskeletal Disorder occurs in a relatively short period.

Monotony, short cycle times, repetitiveness of movements, forced postures, contact stress, overload, compression, muscular imbalance, are the main characteristics that involve repetitive work. As a whole, these characteristics negatively impact the anatomical structure of the operators, affecting their functionality and quality of life.

The shoulder is one of the main anatomical parts affected by this type of task, since in a short time of activation there is an accumulation of tensions and constant movements that affect the soft tissues and joint structures. Some of the shoulder pathologies related to repetitive work include: Rotator cuff tendonitis, bursitis, labral injuries, Bicipital tendinopathy. Based on the above, it is imperative to establish the impact of the actions demanding repetitive work, in the shoulder joint, in order to be able to implement ergonomic measures in the workplace, provide training on safe work techniques, encouraging task rotation to avoid constant repetition of

movements, and structuring specific strengthening and stretching exercise programs that can help maintain shoulder health and function.

This study highlights how the various movements carried out by the shoulder in repetitive work can contribute to the appearance of risk conditions that injure or damage the physical integrity of the operator. The biomechanics of the repetitive movement is analyzed and indexed with the possible pathologies of the shoulder.

The investigative work contemplates three stages: The first analyzes the biomechanics of movement in the different types of repetitive tasks, a second part develops an electronic instrument that measures the electrical waves of nerve stimulation when performing the task and the last part that frames an Ergonomic evaluation method for repetitive work on the shoulder. The present work covers the first part of the integral investigation.

The fundamental idea of structuring an ergonomic evaluation method is to maintain a validated evaluation method through concurrent and predictive techniques, based on biomechanical analysis and electromyography. This will allow ergonomists to assess the risk potential of repetitive tasks involving shoulder functionality.

Keywords. Biomechanics, shoulder, repetitive work.

Relevance to Ergonomics: This research work shows how the different movements developed by the shoulder in repetitive work, impacts on the conformation of pathologies that injure or damage the anatomical integrity of the operator. With this, ergonomics fulfills its essential function of improving the quality of life of workers, who develop their activities in the national production plant.

2. OBJECTIVES

2.1 General objective

To design a biomechanical procedure for functional analysis of the shoulder in repetitive work.

2.2 Specific objectives

1. To elaborate the referential theoretical framework of the research, from the study of the epidemiological evidence of Musculoskeletal Disorders and biomechanics in repetitive shoulder work.
2. To structure the procedure for the biomechanical analysis of the shoulder in repetitive work.
3. To evaluate the concurrent validity of the procedure.

2.3 Project boundaries.

The research work is developed in the intermittent production lines with in-line flows of the maquiladora and manufacturing export industry of northeastern Sonora. Due to its own requirements, repetitive shoulder work is necessary.

3. PROJECT METHODOLOGY

The methodology used in the present project is based on a cross-sectional descriptive observational study with a mixed approach. Three stages are framed for its development:

- As a first phase, a study is carried out on the frequency of Musculoskeletal Disorders in the shoulder, developed by repetitive work in the production lines under study.
- The second part of the methodology consists of developing a study of the anatomy and biomechanics of the shoulder in the main movements defined in repetitive work.
- As a third action, the Musculoskeletal Disorder is linked to the biomechanics of shoulder movement in repetitive work.

4. RESULTS

Observational studies were carried out in 20 companies, where the activities required by the production line made repetitive shoulder work necessary. It is important to establish that the lines analyzed are made up of several work stations that contemplate the same need and, in addition to this, they work in two or three shifts, so the population exposed to this high demand for work is considerably large, the study It was carried out on 200 operators who had shoulder pathology.

The works analyzed contemplate the repetitiveness in the actions carried out by the operators, specifically those activities where the shoulder is mainly used.

The shoulder is the joint with the greatest mobility in the human body and, in turn, the one with the least stability, mainly due to its complex anatomical and biomechanical structure. It is one of the five main areas of the upper body and connects the arm to the torso. It consists of two subregions: the thoracic region and the scapular region.

The bones that structure the anatomy of the shoulder are: the clavicle, the scapula and the humerus. The clavicle helps stabilize the joint between the humerus and scapula, which are part of the shoulder girdle. The scapula has a shallow socket called the glenoid fossa, which articulates with the head of the humerus, forming the scapulo-humeral, glenohumeral, or shoulder joint. The humerus is an arm bone that connects proximally to the scapula and distally to the radius and ulna.

The glenohumeral joint is the major shoulder joint and the joint with the greatest range of motion in the human body. It is formed by the junction between the glenoid cavity of the scapula and the head of the humerus. This articulation has three degrees of freedom, allowing the upper limb to be oriented in relation to the three planes of space, in disposition to the three axes. The transversal axis includes the frontal plane, which allows the shoulder flexion-extension movements carried out in the sagittal plane; in the anteroposterior axis, which includes the sagittal plane, abduction and adduction movements are allowed, which are performed in the frontal plane; finally, in the vertical axis, determined by the intersection of the sagittal plane and the frontal plane, the flexion and extension movements are produced in the horizontal plane, with the arm in 90° abduction.

The longitudinal axis of the humerus allows external and internal rotation of the arm in two different ways: voluntary and automatic rotation. The voluntary uses the third degree of freedom and automatic rotation, which is done without any voluntary action on the joints of two or three axes. The upper limb hangs vertically along the body in such a way that the longitudinal axis of the humerus coincides with the vertical axis. In the 90° abduction position, the longitudinal axis coincides with the transverse axis, and in the 90° flexion position it coincides with the axis.

anteroposterior; Therefore, it can be established that the shoulder is a joint that consists of three main axes and three degrees of freedom allowing internal and external rotation movements.

Figure 1 shows the flexion, extension and rotation movements of the shoulder.

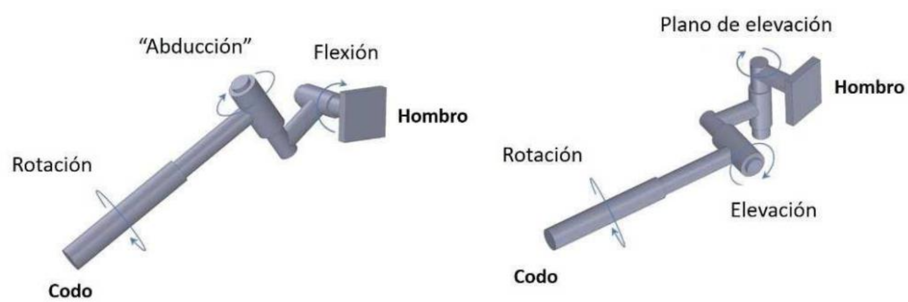


Figure 1: Representation of the movement of the shoulder through the sequence of flexion, abduction, rotation and plane of elevation (Anglin & Wyss, 2000).

Table 1 shows the frequency of Musculoskeletal Disorders that occur in the analyzed workstations, which require repetitive shoulder work. Both the pathology that causes the disorder and the etiology that causes it are described (Vicente-Herrero et al., 2009).

Table 1: Analysis of the prevalence of Shoulder Musculoskeletal Disorders.

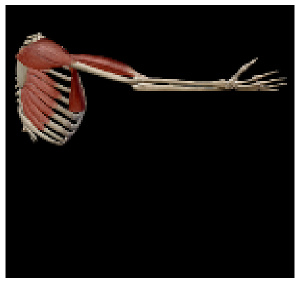
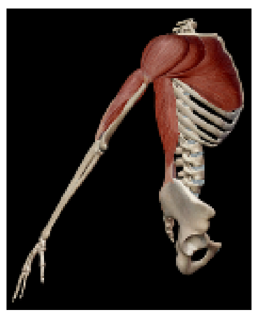
Disorder	Frequency	Pathology	Etiology of the disorder
Rotator cuff tendonitis	64	Injury to the tendons that connect the shoulder muscles to the arm bone.	Repetitive lifting movements of the shoulder, especially overhead.
Bursitis	58	Inflammation of the Bursa, a fluid-filled sac in the shoulder that helps reduce friction between the tendons and bones.	Repetitive and frequent movement of the arms above the head.
Shoulder dislocation	12	An injury that occurs when the arm bone moves out of place in the shoulder joint.	Excessive force on the joint, a hard fall or a violent blow to the shoulder.
Shoulder frostbite	4	A disorder in which there is severe pain and loss of motion in the shoulder joint.	Direct cause unknown, but may be the result of surgery, injury, or health disorder.
Biceps tendonitis	28	Inflammation of the biceps tendon, which connects the biceps muscle to the arm bone.	Activities that involve the repetitive lifting of heavy objects.
Subacromial impingement syndrome	17	Injury that occurs when the rotator cuff tendons are compressed between the shoulder bones.	Activities that involve throwing, swimming, or lifting excessively heavy objects.

In phases two and three of the methodology, a connection is established between Musculoskeletal Disorders, the movements that trigger these disorders and the repetitive tasks that have a greater incidence in the development of these conditions(Balthazard et al., 2015a; Jiménez Lasanta, 2001).

The first Musculoskeletal Disorder that we will analyze is the so-called rotator cuff tendinitis, this pathology occurs mainly in flexion and extension movements. The flexion is structured as the elevation of the upper limb forward of the body, decreasing the angle that is formed between the arm and the body, while the extension establishes a movement that takes the upper limb behind the body, thus reducing the angle that forms between the body and the arm (SUÁREZ-SANABRIA & OSORIO-PATIÑO, 2013).

The main muscles involved in each flexion movement are the deltoid, pectoralis major, coracobrachialis, subscapularis, and biceps. In the case of extension, the muscles are the pectoralis major, latissimus dorsi, teres major, deltoids, and triceps. Table 2 shows the flexion and extension movements and the repetitive task that establishes this type of movement.

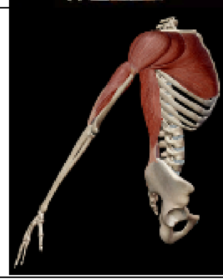
Table 2 – Movements linked to the Musculoskeletal Disorder of rotator cuff tendonitis.

Motion	Image	Repetitive task
Flexion		
Extension		

The second corresponding Musculoskeletal Disorder is Bursitis, a pathology presented when performing abduction and extension movements. Being the case of abduction when executing said movement, the displacement of the upper limb out of the body.

The main muscles involved in the abduction movement are the deltoid, supraspinatus, subscapularis, and biceps (SUÁREZ-SANABRIA & OSORIO-PATIÑO, 2013). Table 3 shows the movements, the repetitive tasks of abduction and extension linked to the present Musculoskeletal Disorder.

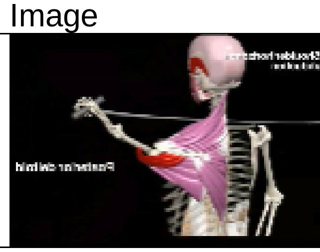
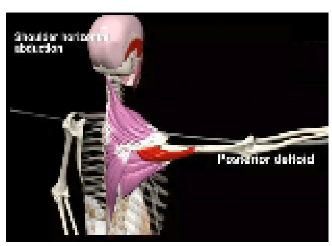
Table 3 – Movements linked to the Musculoskeletal Disorder of bursitis.

Motion	Image	Repetitive task
Abduction		
Extension		

The third labor pathology that we can find arises when performing adduction and abduction movements. Being the following Musculoskeletal Disorder, the so-called bicipital tendinitis, whose pathology develops from the execution of movements where the upper limb of the shoulder is displaced towards the medial line of the body.

The muscles involved in the adduction movement are pectoralis major, subscapularis, latissimus dorsi, coracobrachialis, biceps, and triceps (Guo et al., 2020b). In table 4 the movements and the repetitive task of the described condition are presented.

Table 4 – Movements linked to the Musculoskeletal Disorder of biceps tendonitis.

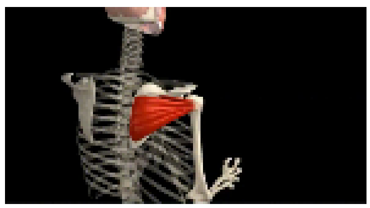
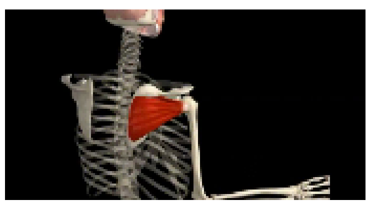
Motion	Image	Repetitive task
Adduction		
Abduction		

The fourth Musculoskeletal Disorder called subacromial impingement syndrome corresponds to movements of internal (or medial) rotation and external (or lateral) rotation. Internal rotation is that which, with the elbow flexed at 90°, brings the upper limb towards the midline, while external rotation, with the elbow flexed at 90°, brings the upper limb outwards (Balthazard et al. , 2015b).

The muscles involved in the execution of the internal rotation movement are the coracobrachialis, latissimus dorsi, teres major, pectoralis major, deltoids, supraspinatus, and biceps muscles. This is the case for external rotation where the muscles used for its execution are the infraspinatus, teres minor and deltoid muscles.

Table 5 presents the movements and repetitive tasks of the present Musculoskeletal Disorders.

Table 5 - Movements related to the Disorder Musculoskeletal subacromial impingement syndrome.

Motion	Image	Repetitive task
Internal (or medial) rotation		
External (or lateral) rotation		

5. CONCLUSIONS

Work-related Musculoskeletal Disorders are one of the main pathologies that occur in jobs that involve high repetitiveness of movements, as is the case of workstations with manual assembly in the maquiladora and manufacturing industry located in the northeast of Sonora.

The research details the set of movements that workers perform when carrying out these activities and links the different movements based on the impact they present in terms of shoulder-related pathologies.

The shoulder is the joint of the human body that maintains the greatest mobility and in turn has great instability in its motor skills. Therefore, the impact of repetitive work, forced postures, inadequate breaks and environmental factors are very high and carry a high probability that the operator will develop irreversible injuries or damage to his anatomy.

Knowledge of the functional biomechanics of the shoulder makes it possible to establish a qualitative assessment of the risk that an operator maintains in his activity and with this, it is possible to generate actions and strategies that allow the productive entity to implement ergonomic measures in the workplace, provide training in safe work techniques, encouraging task rotation to avoid constant repetition of movements, and structuring programs of specific strengthening and stretching exercises that can help maintain shoulder health and function, all of which reduce the impact negative work on the worker, improving their quality of life and the business results of the industry under study.

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USE OF THE 6 SIGMA METHODOLOGY FOR THE REDUCTION OF WORK RISKS ON THE NMV-5000 LINE IN AN AEROSPACE INDUSTRY PLANT IN NORTHWEST MEXICO

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Resumen: Este artículo ilustra como la filosofía seis sigma se puede aplicar para solucionar problemas de ergonomía utilizando la metodología DMAIC. Para tal fin, se solucionara un problema que se presenta en una empresa industrial del giro aeroespacial ubicada en el noroeste de México. Como puntos importantes de esta metodología para problemas de Ergonomía son la definición del problema, establecer la situación actual con medibles que todos puedan entender sin ambigüedades, buscar la causa raíz del problema, proponer soluciones y estimar el costo/beneficio y por ultimo establecer los controles necesarios para sostener la mejora propuesta.

Palabras clave: Seis Sigma, Ergonomia, Solución de problemas

Relevancia para la ergonomía: Se propone una metodología fácil de utilizar para la soluciones de problemas ergonómicos.

Abstract: This article illustrates how the six sigma philosophy can be applied to solve ergonomic problems using the DMAIC methodology. For this purpose, a problem that occurs in an industrial company in the aerospace sector located in the northwest of Mexico will be solved. Important points of this methodology for Ergonomics problems are the definition of the problem, establishing the current situation with measurables that everyone can understand without ambiguities, searching for the root cause of the problem, proposing solutions and estimating the cost/benefit and finally establishing the controls. necessary to sustain the proposed improvement.

Keywords: Six Sigma, Ergonomics, Problem solving

Relevance for ergonomics: An easy-to-use methodology for solving ergonomic problems is proposed.

I. INTRODUCTION

In the NMV-5000 line of the aerospace industry company, there are a total of 21 workers who during their day carry out repetitive activities with dangerous postures that could cause discomfort in the upper extremities (wrists, hands, and fingers). We can visualize repetitive pincer grip movements (with index finger and thumb).

In the same way, operators handle loads greater than three kilograms, which according to the provisions of NOM-036-STPS-2018 must be evaluated with manual handling of loads, since they could trigger injuries in workers that increase the risk premium. IMSS in case they do not meet the requirements. (Standard reference)

With this project, the risks that exist in the workstations will be identified and evaluated using the appropriate ergonomic evaluation methods for each type of work, in addition, improvement proposals will be made that help prevent the appearance of future problems, allowing activities to be carried out. such as repetitive movements or manual handling of loads without these representing a danger to the operators, giving a competitive advantage between companies or avoiding future injuries to their operators.

2. THEORETICAL FRAMEWORK

2.1 Ergonomics.

According to the International Association of Ergonomics, it is defined as the scientific discipline related to the understanding of the interactions between humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design to optimize well-being. human and the general system of operation. Thus, ergonomists contribute to the design and evaluation of tasks, jobs, products, environments, and systems to make them compatible with people's needs, abilities, and limitations. (IEA, October 2011)

2.1.1 Art Tool

The Repetitive Task Assessment Tool (HSE, Health and Safety Executive, 2023) is designed to help assess the risk of tasks that require repetitive movements of the upper extremities (arms and hands). Helps you assess some of the common risk factors in repetitive work that contribute to the development of upper extremity disorders (ULD). It can help identify those tasks that involve significant risks and where to focus risk reduction measures. It will be useful to employers, safety representatives, health and safety professionals, consultants, and ergonomists.

2.1.2 RSI

The Revised Strain Index (Garg, Moore, & Kapellusch, 2017) is a distal upper extremity (DUE) physical exposure assessment model based on: intensity of exertion, frequency of exertion, duration per exertion, hand/wrist posture, and duration of task per day.

2.1.3 Mac Tool

The Manual Handling Assessment Charts (HSE, Health and Safety Executive, 2023) is a tool aimed at employers, health and safety managers, and safety representatives and is used by health and safety inspectors. The tool will help you assess the most common risk factors in lifting (and lowering), carrying, and team handling operations and was developed to identify high-risk manual handling. It will point you toward the factors you need to modify to control these risks.

2.1.4 Rapp Tool

(HSE, Health and Safety Executive, 2023)This tool is designed to help assess the key risks in manual pushing and pulling operations involving whole-body effort, eg moving loaded trolleys or roll cages, or dragging, hauling, sliding, or rolling loads.

2.2 Six Sigma.

"The Six Sigma methodology seeks to identify problems in an organization that may or may not be apparent; which is achieved through research, data collection, and taking appropriate actions to reduce the number of errors that are costing time, opportunities, money, and even clients" (Pavel & Sârbu, 2014).

Here are figures 1.a and 1.b The first one displays the cause-and-effect diagram for repetitive movements , while the second figure shows the cause-and-effect diagram for MMH.

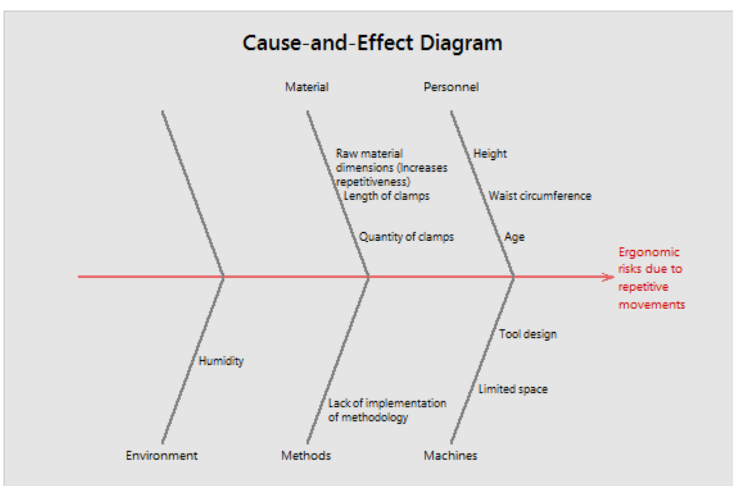


Figure 1.a. cause-and-effect diagram for repetitive movements

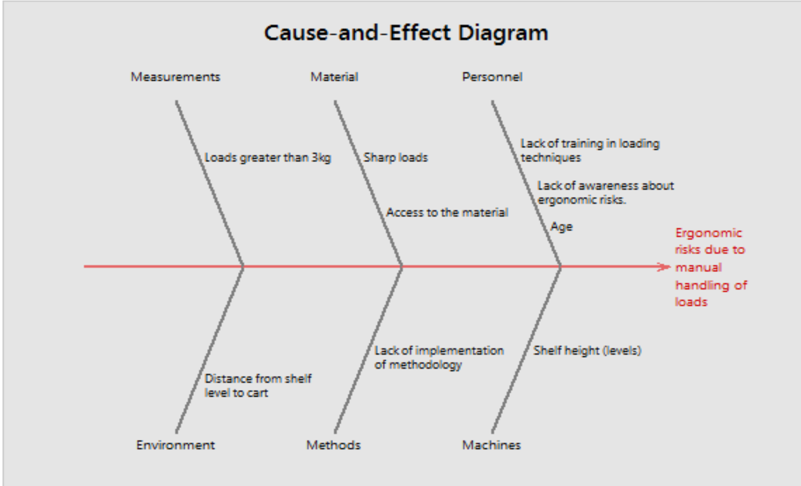


Figure 1.b. cause-and-effect diagram for MMH

3. METHODOLOGY

To know the current situation of the workstations, the transfer function (Y= f(X)) was developed, where:

Y = Annoyances
X1 = Allen keys
X2 = Number of oppressors
X3 = Shelves
X4 = Repeatability
X5 = Carts
X6 = Inadequate methods

Ergonomic evaluations were carried out using the Art tool methods for operations where there is a risk due to repetitive work, RSI for stations with repetitive work exclusively in the hand-wrist area, and Mac Tool in stations where manual handling of loads greater than 3Kgs is present. (Secretaria del Trabajo y Prevension Social, 2023) , as well as the Rapp tool at the station where push or pull activities with a vehicle are presented; For this, the measurement system was first analyzed, carrying out a repeatability and reproducibility study in each method used to validate the data used in this study.

Here are the figures 2 a-q, which indicate the reliability of the evaluators for conducting assessments for repetitive work and manual materials handling

ANALYZE AND VALIDATE THE MEASUREMENT SYSTEM. ART TOOL - RIGHT HAND

Attribute Agreement Analysis for Maria 1, Maria 2, Ricardo 1, Ricardo 2

Within Appraisers

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
Maria	20	20	100.00	(86.09, 100.00)
Ricardo	20	20	100.00	(86.09, 100.00)

Matched: Appraiser agrees with him/herself across trials.

Each Appraiser vs Standard

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
Maria	20	20	100.00	(86.09, 100.00)
Ricardo	20	20	100.00	(86.09, 100.00)

Matched: Appraiser's assessment across trials agrees with the known standard.

Between Appraisers

Assessment Agreement

# Inspected	# Matched	Percent	95% CI
20	20	100.00	(86.09, 100.00)

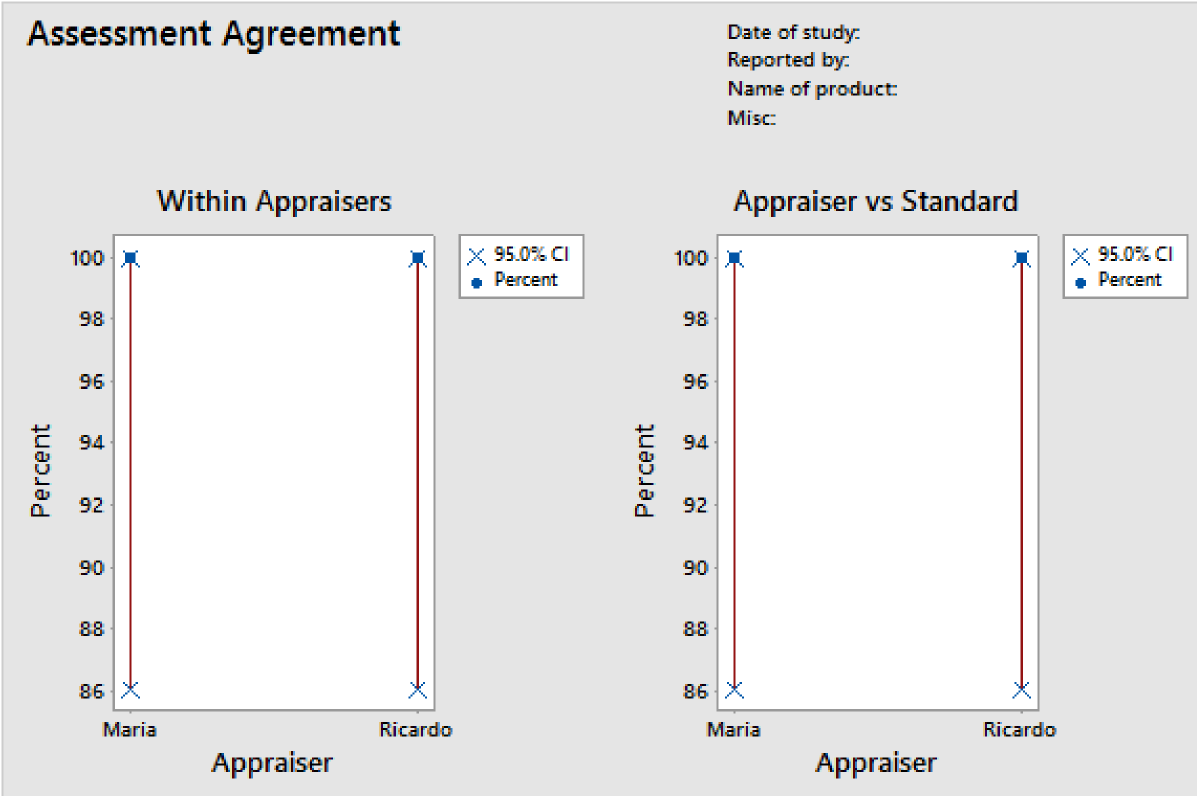
Matched: All appraisers' assessments agree with each other.

All Appraisers vs Standard

Assessment Agreement

# Inspected	# Matched	Percent	95% CI
20	20	100.00	(86.09, 100.00)

Matched: All appraisers' assessments agree with the known standard.



Figures 2 a-e, which indicate the reliability of the evaluators for conducting assessments for repetitive work. (ART TOOL)

ANALYZE AND VALIDATE THE MEASUREMENT SYSTEM.
RSI - RIGHT HAND

Attribute Agreement Analysis for Maria 1, Maria 2, Ricardo 1, Ricardo 2

Within Appraisers

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
Maria	20	20	100.00	(86.09, 100.00)
Ricardo	20	20	100.00	(86.09, 100.00)

Matched: Appraiser agrees with him/herself across trials.

Between Appraisers

Assessment Agreement

# Inspected	# Matched	Percent	95% CI
20	20	100.00	(86.09, 100.00)

Matched: All appraisers' assessments agree with each other.

Each Appraiser vs Standard

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
Maria	20	20	100.00	(86.09, 100.00)
Ricardo	20	20	100.00	(86.09, 100.00)

Matched: Appraiser's assessment across trials agrees with the known standard.

Between Appraisers

Assessment Agreement

# Inspected	# Matched	Percent	95% CI
20	20	100.00	(86.09, 100.00)

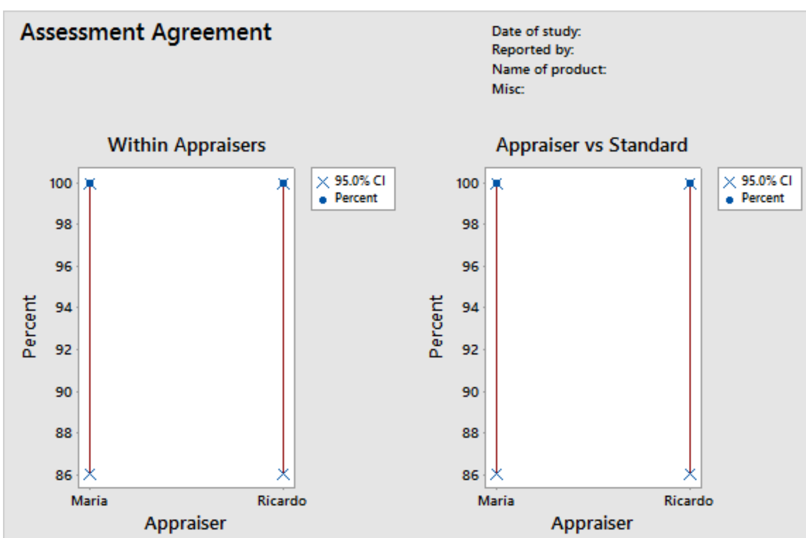
Matched: All appraisers' assessments agree with each other.

All Appraisers vs Standard

Assessment Agreement

# Inspected	# Matched	Percent	95% CI
20	20	100.00	(86.09, 100.00)

Matched: All appraisers' assessments agree with the known standard.



Figures 2 f-j, indicate the reliability of the evaluators for conducting assessments for repetitive work. (RSI)

ANALYZE AND VALIDATE THE MEASUREMENT SYSTEM. MAC TOOL

Attribute Agreement Analysis for Maria 1, Maria 2, Ricardo 1, Ricardo 2

Within Appraisers

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
1	10	10	100.00	(74.11, 100.00)
2	10	10	100.00	(74.11, 100.00)

Matched: Appraiser agrees with him/herself across trials.

Each Appraiser vs Standard

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
1	10	10	100.00	(74.11, 100.00)
2	10	10	100.00	(74.11, 100.00)

Matched: Appraiser's assessment across trials agrees with the known standard.

Between Appraisers

Assessment Agreement

# Inspected	# Matched	Percent	95% CI
10	10	100.00	(74.11, 100.00)

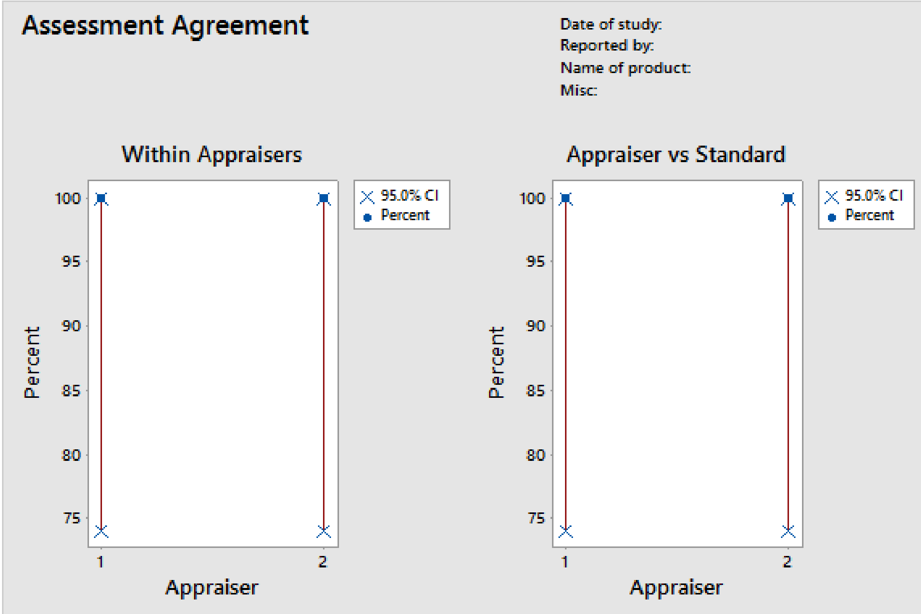
Matched: All appraisers' assessments agree with each other.

All Appraisers vs Standard

Assessment Agreement

# Inspected	# Matched	Percent	95% CI
10	10	100.00	(74.11, 100.00)

Matched: All appraisers' assessments agree with the known standard.



Figures 2 h-l, indicate the reliability of the evaluators for conducting assessments for MMH. (MAC TOOL)

ANALYZE AND VALIDATE THE MEASUREMENT SYSTEM.

RAPP TOOL

Attribute Agreement Analysis for Maria 1, Maria 2, Ricardo 1, Ricardo 2

Within Appraisers

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
1	10	10	100.00	(74.11, 100.00)
2	10	10	100.00	(74.11, 100.00)

Matched: Appraiser agrees with him/herself across trials.

Each Appraiser vs Standard

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
1	10	10	100.00	(74.11, 100.00)
2	10	10	100.00	(74.11, 100.00)

Matched: Appraiser's assessment across trials agrees with the known standard.

Between Appraisers

```
Assessment Agreement

# Inspected  # Matched  Percent        95% CI
       10          10   100.00  (74.11, 100.00)

# Matched: All appraisers' assessments agree with each other.
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All Appraisers vs Standard

```
Assessment Agreement

# Inspected  # Matched  Percent        95% CI
       10          10   100.00  (74.11, 100.00)

# Matched: All appraisers' assessments agree with the known standard.
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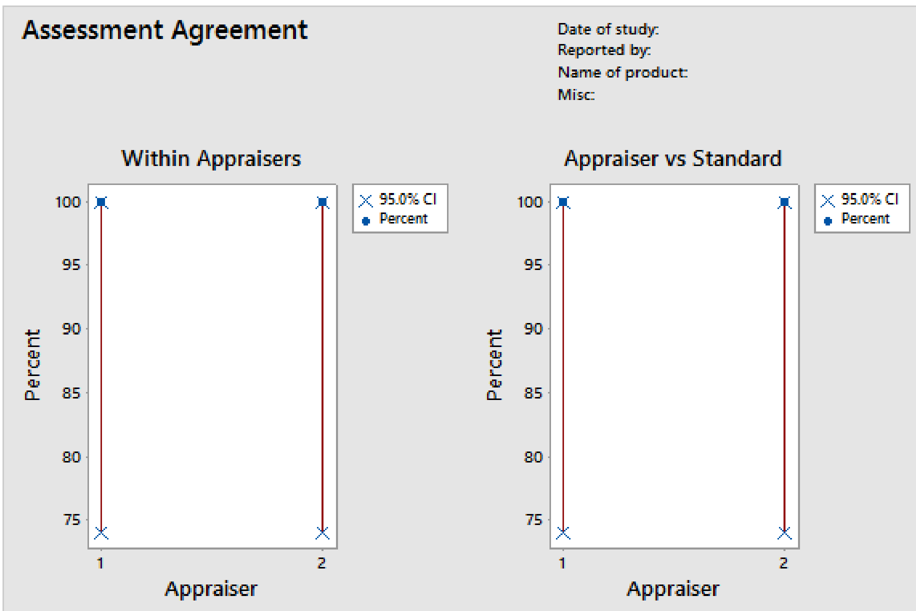


Figures 2 m-q, indicate the reliability of the evaluators for conducting assessments for repetitive work. (RAPP TOOL)

After approving the Measurement System and demonstrating that the evaluators provide us with reliable information in their studies, all the jobs were evaluated, obtaining the following results already transformed into Defects per million opportunities. Table 1.

Table 1. DPMO

Part	DPMO	Approximate Six Sigma
ART tool	65,000,000	-0.39
RSI	66,666.67	1.5
MAC tool	650,000.00	-0.39
RAPP tool	244,444.44	0.69

Once the workstations were evaluated, a Pareto diagram was made where the root causes of the defects for the repeatability problem were quantified. Figure 3.

2.- Arm/Wrist Posture - Arm Movement:
Bad Habit
1.- Head/Neck Posture - Back Posture:
Fixture base heigth (110 cm)
4.- Repeatability:
Number of opressors per operator
3.- Hand-finger grip:
Tool (Allen Wrench)

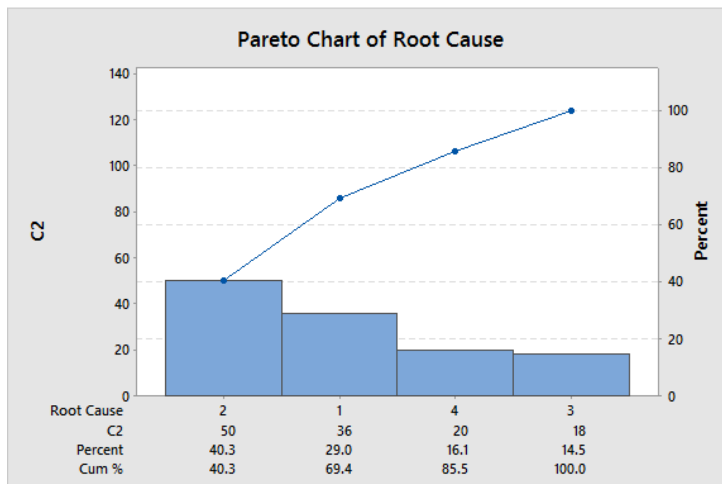


Figure 3. Pareto diagram

Each cause was studied until the root for every problem was found. Cause by cause was studied until the root of each problem was found. For cause number 2 arm/wrist posture - Arm movement, it was found that the bad postures presented at the station are due to misuse of the machine, which DOES allow the operator to carry out his task without having to force the wrist and arm posture, which present a risk to the health of the worker. Here you can see how the arm moves away from the body and remains in that position for 2 minutes and 45 seconds, which is the duration of the work cycle. The bad habit occurs in 7 of the 10 operators evaluated at the station.

Currently, there is no established method to perform the task, workers carry out the operation in the way that seems most comfortable or easy to perform, without considering that there are bad postures and the possibility of long-term injury. A photograph of evidence of the problem is attached: Figure 4.

After the head-neck posture problem was analyzed: back posture because it is a precision job, workers need to observe their work in detail, we observed that the height of the fixture base (110cm) causes the neck posture to remain at a 15° inclination for more than half the cycle time, regardless of the worker's height.

Additionally, a back inclination greater than 20° is observed during 90% of the cycle, which lasts 2 minutes and 45 seconds. A photograph of evidence of the problem is attached:

The study was carried out on cause number 4, repetitiveness; which refers to the number of oppressors each operator adjusts. Each piece requires a total of 36 oppressors, and for its adjustment, the workers make a total of 308 movements during the cycle, which is higher than the 20 movements per minute that penalize the "art tool" ergonomic evaluation method. A photograph of evidence of the cause is attached:

BAD HABIT **GOOD HABIT**

Figure 4. Bad and good postures

Subsequently, cause number 3 which refers to the hand-finger grip that is made with the Tool (Allen key) was studied. This tool forces the worker to hold it in a pincer grip with the index finger and thumb for approximately 95% of the cycle. A photograph of the obligatory posture is attached.

Figure 5. Hand-Whist posture

The tool (Allen key) is small and without any grip adaptation. Dimensions are attached:

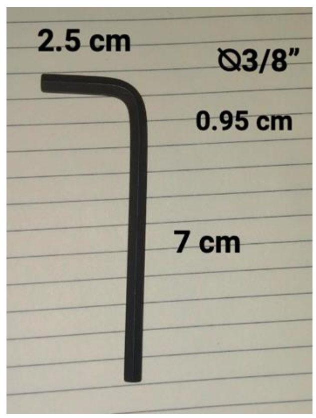
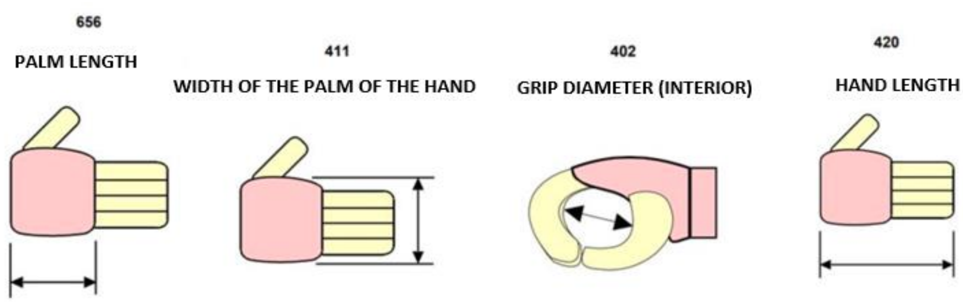


Figure 6. Allen key dimensions

Anthropometric data representative of the population were obtained, showing the dimensions of the body involved in the grip:

Representative anthropometric data of the population were obtained, illustrating the body dimensions involved in the grip, Figure 7.



MEN				
	420	656	411	402
Average	18.8189	10.7672	8.7667	47.9342
Std. Deviation	0.8745	0.6756	0.5077	3.8414
5 Percentile	17.4	9.8	8	42
50 Percentile	18.8	10.7	8.7	48
95 Percentile	20.2	11.7	9.6	54
Min	15.5	8.2	4.8	36
Max	28.8	19.2	10.7	60

Figure 7. Hand anthropometric data

It can be seen that the tool is even small for the 5th percentile. Additionally, the analysis of the root causes was carried out for the problems of manual handling of loads; for this, the corresponding Pareto was made:

2.- Weight: The piece weighs over 25 kg and is lifted by a single person.
3.- Grip: The piece does not have grips to hold it correctly (there is no way to hold it from below)
4.- Bad habit: There's no proper lifting method, and the worker has developed a bad habit for lifting pieces.
1.- Location: The piece is placed on the lowest level of the shelf, 20 cm from the ground.

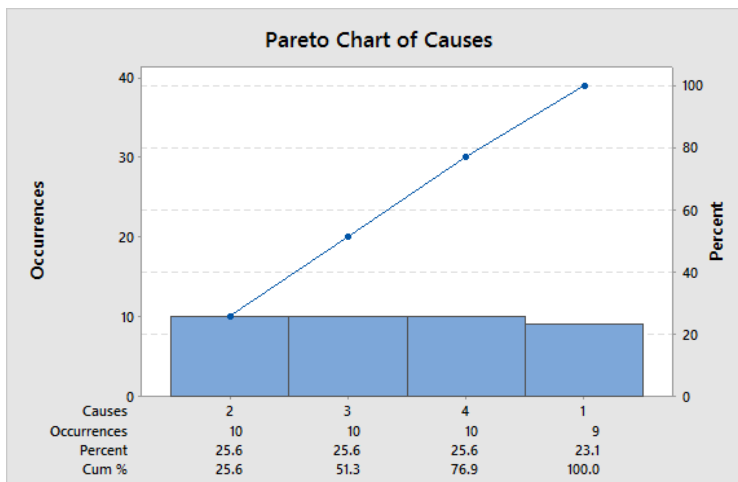


Figure 8. Pareto Diagram for root cause

Root cause number 2, which refers to the weight of the product, was analyzed; at the station, we find:

That the Fixture weighs 47 kg and is carried by a single person. Based on NOM-036-STPS-2018-1 8.3 b) 2) The actual maximum mass that workers can lift and/or lower loads must be determined based on the values indicated in Table 1, considering factors such as frequency, distance, position of the load, grip, accumulated mass, among others, but it must not exceed the limit indicated in this Table 2 (Social S. d., 2018).

Table 2.

Maximum mass a worker can lift or lower by age and gender

Maximum mass kg	Gender	Age (Years)
7	Female	Under 18
	Male	
15	Female	Over 45*
20	Female	Between 18 and 45
	Male	Over 45*
25	Male	Between 18 and 45

A photograph of the operation at the workstation is attached. Figure 9.

Figure 9. operation at the workstation

Afterward, cause number 3 regarding grip was studied. At the station, we find that: Due to the design of the piece, the load does not have grips or a way to hold it correctly, since the Mac tool method tells us that the type of grip on the piece that the operators have is not adequate.

Additionally, we study the cause of number 3 bad habits. At the station, we find: There is no method of loading and they do not receive training on how to perform lifting tasks, thus they have a bad habit in their procedure to performing these tasks. Photograph evidence of the posture presented at the workstation is attached:

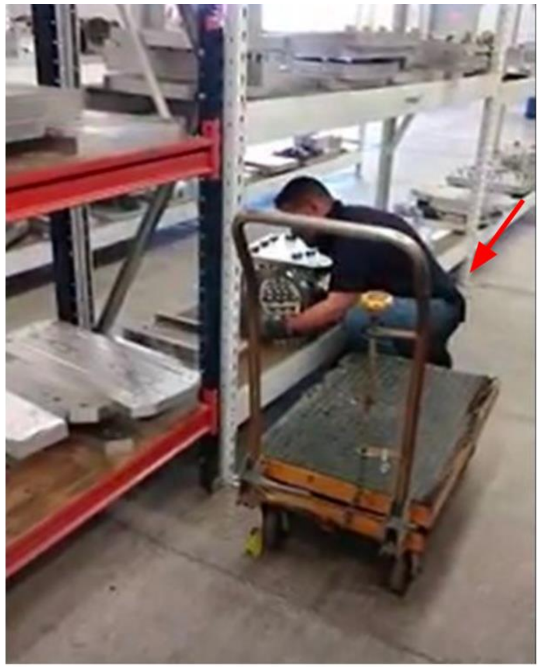


Figure 10. Posture presented at the workstation

We continue to study the cause number 1 location. At the station, we find: The piece is placed at the lowest level of the shelf, 20 cm from the ground, causing the worker to bend his knees and back to reach it There isn´t a system that designates specific places for different fixtures based on weight.

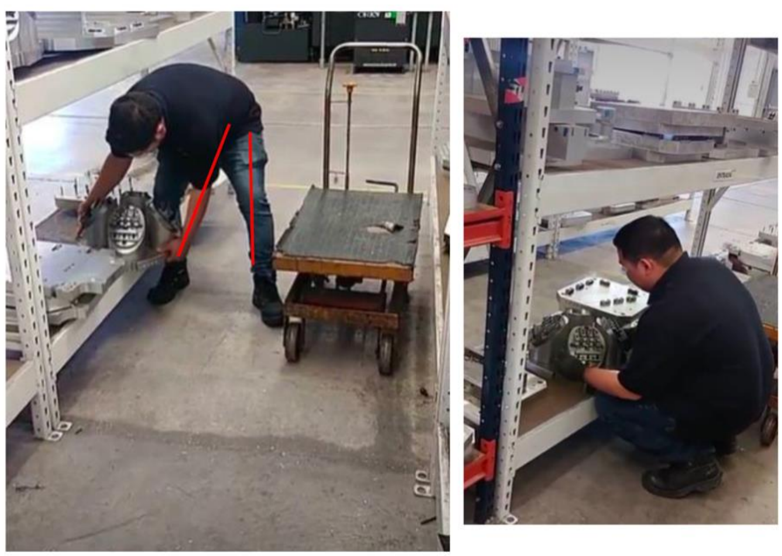


Figure 11. Posture presented at the workstation

After an extensive review of the root causes of the problems, opportunities for improvement were studied.

The Implementation of a pneumatic ratchet is proposed. which will eliminate repetitive movement of the wrists. A photograph of the position of the hand when using the tool and a photograph of the proposed tool is attached.

Figure 11. Posture and tool

The rattle would help us:

- Reduce time on adjusting oppressors so you save money.
- Modify the evaluation of the station by changing to green. Prevent disabilities from appearing.

2 . **Training to eliminate bad habits.** Ergonomics Education: Start by educating yourself on the basic principles of ergonomics and how it affects your body. Learn about proper posture when sitting, standing, and lifting, as well as the risks associated with poor ergonomic habits.

Self-awareness: Develop self-awareness of your current posture and habits. Observe how you sit, how you use your electronic devices, how you stand, etc. Identify the bad habits you want to correct and be aware of them throughout the day.

Set up your work environment: Make sure your work environment is set up ergonomically.

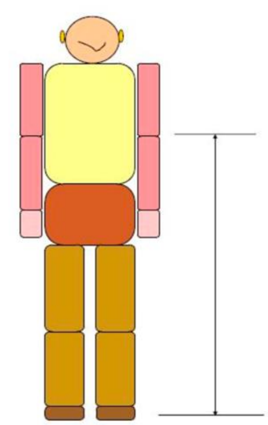
Stretches and exercises: Perform specific stretches and exercises to strengthen key muscles and maintain good posture. These may include stretching exercises for the neck, shoulders, back, and legs, as well as strengthening exercises for the abdominal and back muscles.

Visual Reminders: Place visual reminders in your workspace to remind you to maintain good posture. These can be sticky notes with messages like "Straighten your back" or pictures that represent proper posture.

Gradually correct bad habits: Don't try to correct all your bad habits at once. Pick one or two habits at a time and gradually work on correcting them. Once you've made progress, move on to the next habit.

For MMH problems, we propose

1. Implement a sorting system on the shelves. According to this system, fixtures weighing 25 kg or more will be placed at elbow height (104.1 cm for the 5th percentile), while those weighing less than 25 kg will be placed at the lowest level of the shelving. In addition, it is suggested to use an established method that includes labels or names of the fixtures on each shelf, to facilitate their correct arrangement systematically. A representative anthropometric study of the population is attached:



MEN SAMPLE SIZE: 2613

	Age	920	805	328	23	309
Average	32.9958	81.1341	173.4076	162.4964	144.7112	111.6579
Std. Deviation	8.2021	12.3767	6.5184	6.6652	6.486	4.9266
5 Percentile	21	62.5	162.75	152.4	135.6	104.1
50 Percentile	33	80	173.3	162.35	144.6	111.5
95 Percentile	46	103	184	173.4	154.155	119.5
Min	18	50.5	150.4	100.7	20.6	89
Max	61	156.4	194.6	185.4	169.4	146.6

Figure 12. Anthropometric data

2. Reposition the levels of the shelves to the optimum height, which is 100 cm for the upper one and 20 cm for the lower one.

3. Incorporate another cart with adjustable height to the exact measurement of the levels of the shelf, getting rid of the only cart that does not have height adjustment.

4. Apply a preventive and corrective maintenance program to the trolleys, where the lifting pistons, the trolley platforms where the bases are placed, and the wheels are checked.

5. Use of Neoprene Gloves These gloves are specifically designed to provide a strong grip on slippery or oily surfaces. Annex photo of the proposal:

Figure 13. Gloves proposed

These gloves would help us:
• Improve the grip of the fixtures without the risk of slipping and an accident.
• Avoid the risk of cutting operators since the edges of the fixtures are sharp.
• Prevent the appearance of disabilities.

Ergonomic evaluations were carried out after the implementation of the improvements and the following results were obtained:

Measurement phase									
Process	Stations	Opportunities per station		Total number of defects		DPMO	Improved DPMO	Difference in DPMO´s	% Improvement
Art Tool		Before	Improvement	Before	Improvement				
Workstations	10.00	22.00	22.00	143.00	80.00	65000.00	363636.36	286363.64	56%
RSI									
Workstations	10.00	6.00	0.00	4.00	0.00	66666.67	0.00	66666.67	100%
Mac tool									
Workstations	10.00	8.00	0.00	52.00	0.00	650000.00	0.00	650000.00	100%
Rapp tool									
Workstations	10.00	9.00	9.00	22.00	2.00	244444.44	22222.22	222222.22	91%
			Average Improvement Percentage				86.71%		

Figure 14. Results for evaluation

To prevent the root causes from returning once the problem is corrected, the following control plan is proposed. Figure 15

CONTROL PLAN

Department:	HSE	Prepared by:		Page:	1 of 1
Process:	NMV-500 line	Approved by:		Document No:	1
Location:	LMX-D Plant	Approved by:		Revision Date:	
Others:		Approved by:		Supersedes:	

Characteristics/Parameters	CTS/CL	Specifications/Requirements	Measure method	Sample size	Frequency	Measurer	Where it is recorded	Decision rule/Corrective action	Reference number
Fixture Location	The fixtures are systematically placed.	Fixtures weighing 25 kg or more are placed on the upper shelf, while fixtures weighing less than 25 kg are placed on lower shelves.	Check list	21 operators	Every two weeks	To be designated by the company.	Information board	Notify the worker about the bad habits, and if the issue persists after two instances, redirect to HR.	UF-001
MMH method for upper shelves	The fixtures are not lifted; they are dragged onto the cart.	Use an adjustable cart.	Check list	21 operators	Every six months	To be designated by the company.	Information board	In case of not following the method, the worker is sent for retraining. If there's a recurrence, they are directed to HR.	MM5-005
MMH method for lower shelves	The cart is lowered to the shelf level, and the fixture is dragged onto it.	Use an adjustable cart.	Check list	21 operators	Every six months	To be designated by the company.	Information board	In case of not following the method, the worker is sent for retraining. If there's a recurrence, they are directed to HR.	MM5-001

Figurer 15. Control Plan

Additionally, in the event of an out-of-control point, the following reaction plan is proposed:

1. Verify if it is a special cause or if it is a trend, a special cause is if it happens 1 time in at least 1 month, if it is a trend it would be if it happens with several fixtures and at least 2 times a week.
2. The right time to react is if you start to see a trend in the process
3. The actions to be taken will be to retrain the operators
4. Human resources will be in charge of applying the actions taken
5. The person responsible for verifying whether the trends occur will be assigned by the company.
6. If the failures continue to be presented, it is recommended that Human Resources take action.

4. CONCLUSIONS

After presenting the DMAIC methodology, it becomes clear that it is easy to apply, although it is not suitable for urgent or emergency situations. However, it can be applied to any other situation. To apply the methodology, it is necessary to undergo training and certification, at least as a Green Belt.

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EFFECTS OF THE CONTINUOUS USE OF MOBILE DEVICES IN POSTURE DISORDERS: A REVIEW

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Resumen: Hoy en día, la comunicación de manera rápida es esencial para llevar a cabo múltiples actividades, como realizar compras, pagar gastos, consultar el clima, pagar servicios, acceder a noticias y resultados deportivos, así como también para fines recreativos mediante el uso de juegos en línea y redes sociales entre otras, haciéndonos cada vez más dependientes de ellos, y esto es posible debido a la rápida evolución y disponibilidad de la tecnología móvil. Mientras esto ocurre, día con día novedosos y sofisticados dispositivos móviles son fabricados y comercializados haciendo más fácil la vida de los usuarios. Sin embargo, el uso prolongado de estos dispositivos conduce a posturas que provocan síntomas de fatiga muscular y malestar visual en los usuarios y pueden generar además trastornos musculares que se manifiestan generalmente como dolor de espalda o cuello, atribuidos a la postura de la cabeza hacia adelante y hacia abajo mientras se observan las pantallas. Dado lo anterior el objetivo de esta revisión fue identificar el conocimiento actual respecto a los riesgos a la salud específicamente relacionados con la postura asociados al uso excesivo de dispositivos móviles, así como también identificar a las poblaciones más susceptibles. Para lograr este objetivo se llevó a cabo una búsqueda exhaustiva en diversos buscadores científicos a fin de lograr recopilar información actual y novedosa que nos condujera a obtener la información pertinente. Derivado de esta búsqueda se logró determinar que el uso continuo y frecuente de los diferentes dispositivos móviles pueden contribuir a lesiones en diferentes partes del cuerpo, especialmente en el cuello y espalda, todo esto asociado a diferentes trastornos que pueden sufrir los nervios, huesos, articulaciones y músculos dirigidos por el cerebro y la médula espinal.

Palabras clave: Salud humana, riesgos, celular, computadora, tableta.

Relevancia para la Ergonomía: La importancia que aporta esta investigación respecto a la ergonomía es brindar información referente a los daños musculares asociados al uso continuo y prolongado de los dispositivos móviles.

Abstract: Nowadays, fast communication is essential to carry out multiple activities, such as making purchases, paying expenses, checking the weather, paying for services, accessing news and sports results, as well as for recreational purposes through the use of games. online and social networks among others, making us increasingly dependent on them, and this is possible due to the rapid evolution and availability of mobile technology. While this is happening, everyday new and sophisticated mobile devices are manufactured and marketed, making life easier for users. However, prolonged use of these devices leads to postures that cause symptoms of muscle fatigue and visual discomfort in users and can also generate muscle disorders that generally manifest as back or neck pain, attributed to forward head posture and down while viewing the screens. Given the above, the objective of this review was to identify the current knowledge regarding the health risks specifically related to posture associated with the excessive use of mobile devices, as well as to identify the most susceptible populations. To achieve this objective, an exhaustive search was carried out in various scientific search engines to collect current and new information that would lead us to obtain relevant information. Derived from this search, it was possible to determine that the continuous and frequent use of different mobile devices can contribute to injuries in different parts of the body, especially in the neck and back, all associated with different disorders that nerves, bones, and joints can suffer. and muscles directed by the brain and spinal cord.

Keywords: Human health, risks, cell phone, computer, tablet

Relevance to Ergonomics: The importance of this research regarding ergonomics is to provide information regarding muscle damage associated with the continuous and prolonged use of mobile devices.

1. INTRODUCTION

The use of mobile devices, cell phones, and tablet computers, is predominant in the workplace, homes, and schools (Pope-Ford, 2019). Musculoskeletal complaints and posture disorders are caused by the intensive use of instruments commonly used for communication and entertainment affects a large number of people (Xie *et al.*, 2017). The use of mobile touchscreen devices, namely smartphones and tablet computers, has increased rapidly in recent years worldwide (Toh *et al.*, 2020). Mobile devices use cause certain postures that result in muscle loading in upper extremity regions mainly in the neck, arms, upper and low back, and shoulder. However, the physical demands of mobile devices are often overlooked, and more time is spent discussing some of the other hazards of cell phone use, like distraction and addiction (Pope-Ford, 2019).

2. OBJECTIVE

Carry out an exhaustive search that allows determining the current knowledge regarding the risks that arise in health focused on posture due to the indiscriminate use of mobile devices and determine the most susceptible populations.

3. DELIMITATION

To delimit the present work, the bibliographic search that was carried out focused on the health risks referring specifically to those related to posture, leaving aside other risks that are commonly associated, among which vision problems stand out.

4. METHODOLOGY

In order to identify the risks associated with the posture and the susceptible population by the use of mobile devices, a bibliographic review was carried out in scientific databases such as Google Scholar and PubMed. The review of scientific documents was carried out in Spanish and English of the literature published between 2003 and 2023. In the search used the keywords: "posture, mobile devices, health risks, ergonomics". The literature search terms were identified and combined to search the databases to carry out the selection of the documents, the abstracts and keywords of the same were reviewed and analyzed in order to evaluate those of greatest importance. Of the articles found, 10 articles per section were selected to demonstrate the effects regarding the use of tablets, laptops and computers as well as for the use of cell phones.

5. RESULTS

Nowadays, various studies have been carried out to find the relationship between the use of mobile devices and the possible effects on health, for which the studies carried out have been carried out on groups of people of certain ages because they are considered to be the most susceptible to the constant use of these technological devices. The main effects of the continuous use of mobile devices in posture disorders are presented in Figure 1.

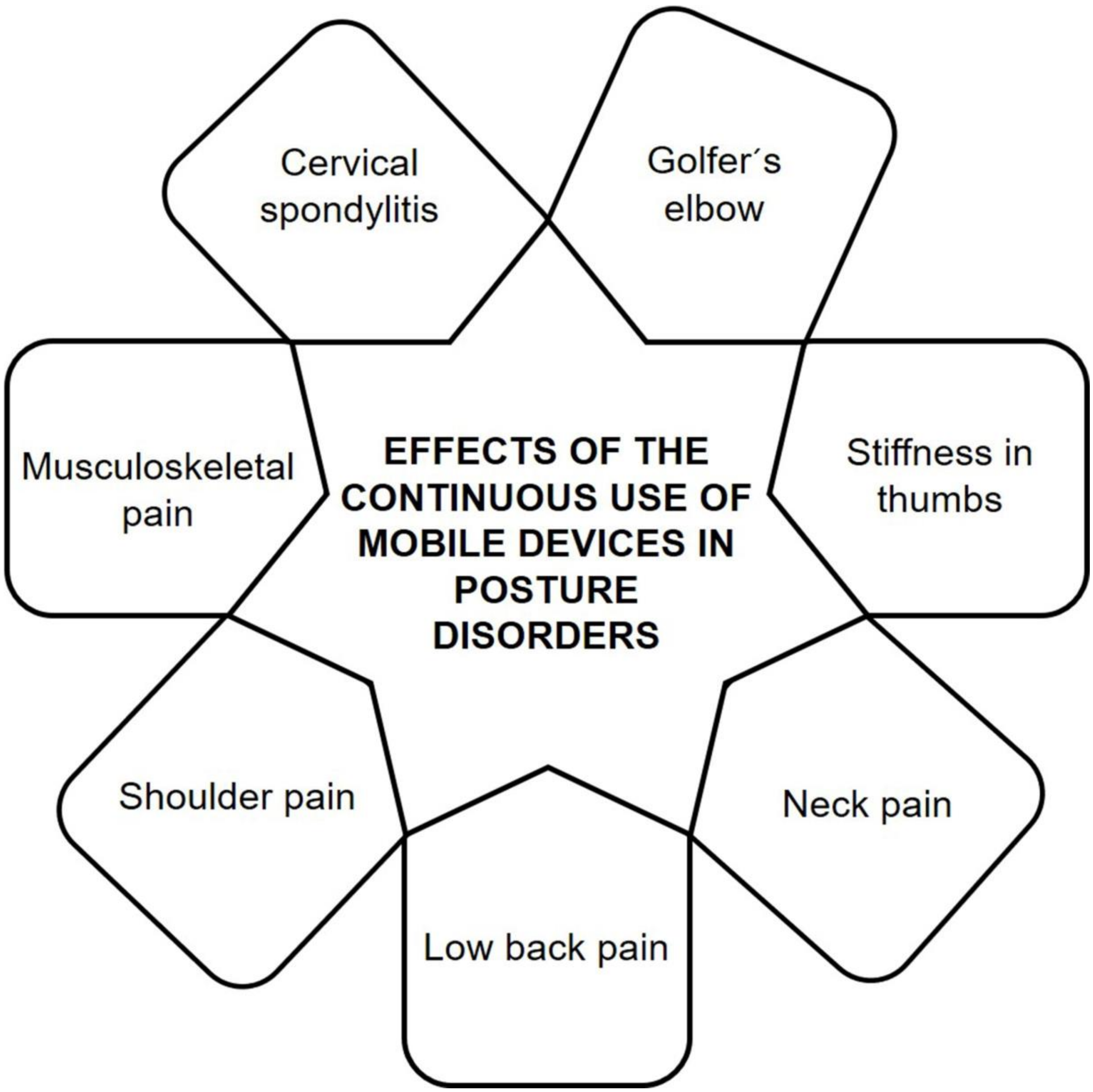

Figure 1. Effect of the continuous use of Mobil devices in posture disorders.

5.1 Effect on posture and muscle by use of the tablet, laptop and desktop computers

Computers are tools essential in the office, school, and the house worldwide, however, their effects on health are analyzed, due to prolonged time to use could cause musculoskeletal complaints and cause posture disorders. The increasing use of computers across younger age groups has led to concern that children and adolescents may be at risk of computer-related health problems, due to most people adopting a wide range of postures, especially during tablet and laptop use (Straker *et al.*, 2008). In this sense, it has been revealed that the usage of portable computers can increase musculoskeletal symptoms in the neck and it has also been reported that using a tablet computer can induce significant biomechanical stress on the upper extremities (Chiu *et al.*, 2015).

Likewise, it is considered that potential or injury or illness may be elevated when working on smaller, portable computers (Werth & Babski-Reeves, 2014). Gracia *et al.* (2015), carried out a study with 400 workers from the administrative area of 20 medium-sized companies, where they managed to find that due to the prolonged use of computer equipment and not having the ideal conditions or adequate ergonomic environments such as the work equipment, the work environment and lighting, among others the workers had health problems, including damage to muscles, nerves and bones, due to poor posture.

Straker *et al.* (2008), showing that the tablet computers use was associated with a more flexed and asymmetrical spine, a more flexed upper spine is likely to be associated with a greater gravitational moment, and maybe this higher gravitational load imposes greater musculoskeletal demands on the body and is therefore likely to pose a greater risk of injury or discomfort.

In this sense, Young *et al.* (2013), suggest tablets should be placed in cases or stands that adjust the tilt of the screen rather than supporting and tilting the tablet with only one hand.

Chiu *et al.* (2015), conducted a study with thirty individuals, who were assigned two task types were employed in this experiment (movie watching and game playing on a tablet), because of the different impacts on muscle activity, largely just postural maintenance in the former, and greater demands for movement in the latter, showing that the tilt angle of a tablet computer to done some task mainly affected the musculoskeletal stress in the upper trapezius and anterior deltoid and that it also increased stress during neck flexion/extension and shoulder forward flexion.

In the same way, Juraida (2016), investigated the effects of tablets compared to laptop usage postures on the development of fatigue, discomfort, and pain, the results indicated that the effect of portable device placement was significant, and no effect of portable computer type was found, showing the presence of negative effects like fatigue, discomfort, and pain while using a tablet in public places that may lead to a higher risk of musculoskeletal disorders.

Correct posture while mobile devices are used result critical to avoid disorders, and having a support surface is fundamental Lee *et al.* (2018), investigated the prevalence of neck and shoulder symptoms during the use of a tablet computer and identified the risk factors associated with these symptoms in 412 participants in a school setting, significant risk factors associated with symptoms were sitting without back support, sitting with the device in lap, and lying on the side and on the back during tablet computer use, among all postural factors, sitting without back support was identified as the most important risk factor for having musculoskeletal symptoms.

Shan *et al.* (2013), investigated the neck/shoulder pain (NSP) and low back pain (LBP) among high school students in Shanghai and explored the relationship between these pains and their possible influences, found that laptop PC users showed a higher prevalence of NSP and LBP compared to desktop PC users, and the use of a tablet significantly increased the incidence of NSP. Lin *et al.* (2015) claim that prolonged use of tablets in non-traditional office environments may result in awkward postures that may expose users to greater risks of developing musculoskeletal symptoms. So they suggest adequate virtual keyboard designs show the potential to alleviate some postural effects. Szucs *et al.* (2018), carried out a study in which the purpose was to compare the posture of the upper body and extremities while performing standard tasks with 3 devices (mobile phone, tablet, laptop, noting that all mobile devices had effects on posture. However, the tablet may produce greater harmful effects than regular use of other devices.

5.2 Effect on posture and muscle by use of cell phone

Cell phones have become a fundamental tool for many people. Through various studies it has been observed that the use of cell phones can cause various effects on muscles, nerves and bones. In the results found by Gustafsson *et al.* (2010), it was shown that postures (sitting or standing) as well as the type of mobile phone task (holding the phone vs. texting) affected muscle activity and thumb positions, this study was carried out with sixty young adults between 19-25 years old. These same authors Gustafsson *et al.* (2017), examined whether texting on a mobile phone is a risk factor for musculoskeletal disorders in the neck and upper extremities in a population of young adults, and founded that the results implicated effects on musculoskeletal disorders in neck and upper extremities.

Chany *et al.* (2007), discovered that the phone design and anthropometry influenced the development of discomfort and fatigue during phone use and the use of small clamshell phones may contribute to a lack of rest. In a study realized by Park *et al.* (2017), founded that smartphone use induced more flexed posture on the neck and trunk than other visual display terminal (VDT) work, and they recommended that clinicians should consider the influences of smartphone use in posture and muscle activity.

In the same way Aliberti *et al.* (2020), mentioned that the widespread abuse of cell phones can be translated into a physical condition harmful to the human body, known as "Text Neck", the incorrect posture due to incorrect use of these devices, flexing the head to send messages and excessive time spent in this position, over time can lead to the presence of musculoskeletal pain in the neck region, besides, mentioned that when the neck curves by 30 and 45 degrees exerts a pressure of 40 and 49 pounds to the dorsal spine, respectively (Figure 2), where, the loss of the natural curvature of the cervical brings an increase in tension on the neck and shoulders and this weight over time results in pain, stiffness and back pain.

Children and young adolescents are no strangers to trouble from excessive use of cell phones, these groups have present a set of musculoskeletal symptoms that have not been seen before in these ages, these symptoms are diverse and can range from neck and shoulder discomfort to pain, peripheral neurological symptoms of the upper extremity, and long-term complications such as disk prolapse and degenerative disk disease of the cervical spine (Warda *et al.*, 2023).

Prolonged cell phone use can cause various musculoskeletal problems, in particular, smartphone use can encourage awkward postures, these postures can affect soft tissues, like strain muscles and ligaments, irritate tendons, and compress nerves leading to musculoskeletal discomfort (Namwongsa *et al.*, 2018). In this sense, In *et al.* (2021), agree when mentioning that using a smartphone during prolonged sitting may lead to a slumped posture. In agreement, Kim & Koo (2016), showed that the pain and fatigue worsen with longer cell phone use, and to avoid these inconveniences mentioned that is important the correct posture and breaks of at least 20 minutes are recommended when using smartphones, since, pain and fatigue worsened with longer smartphone use. Finally, cell phone time use must be intermittent and not prolongated, continuous smart phone usage causes faulty posture such as forward neck posture, slouched posture, or rounded shoulders, sustained forward neck posture can cause injury to the structure of the cervical and lumbar spine, as well as ligaments (Jung *et al.*, 2016).

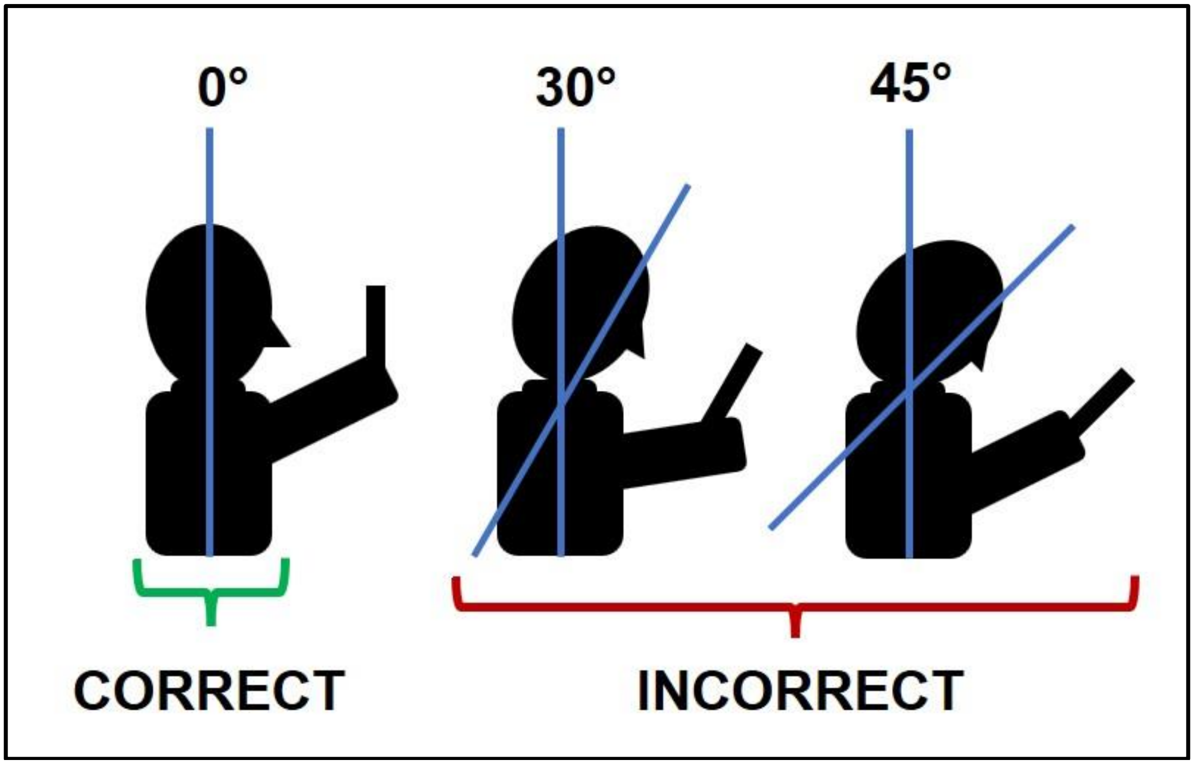

Figure 2. Cell phone posture disorders.

6. CONCLUSIONS

In this work, relations were found between the prolonged use of mobile devices and different posture disorders. The search results showed negative effects on posture in people of different ages and activities that use continuously mobile devices, especially tablet computers and cell phones.

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IMPLEMENTATION OF AN ERGONOMIC PROGRAM IN THE TORTILLA PRODUCTION PROCESS OF HERMOSILLO, SONORA

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Resumen: El siguiente trabajo consiste en la aplicación de un programa de gestión ergonómico en la empresa dedicada a la producción de tortillas, con el objetivo de identificar y reducir los niveles de riesgo en las cinco estaciones que del proceso de elaboración de tortillas de harina. Se realizaron visitas al establecimiento para obtener información sobre el proceso de producción de tortillas y se registraron imágenes y vídeos que permitieran observar con claridad los movimientos de cada uno de los trabajadores. Se llevaron a cabo evaluaciones ergonómicas como son los métodos Art, Mac y Rapp Tool, así como el método postural RULA y el método para obtener el gasto metabólico de energía de todas las estaciones, esto con el fin de identificar los factores de riesgo presentes en cada una de las estaciones para proponer mejoras que permitan reducir el nivel de riesgo de las tareas. Las evaluaciones para las estaciones 3,4 y 5 se tomaron en cuenta al trabajador más alto y el más pequeño, con la finalidad de identificar el nivel de riesgo para ambos casos. Como resultados se obtuvieron que la estación 1 en función de RULA y Mac indica un riesgo alto (rojo) en la posición de amasado y Mac riesgo medio (naranja) en el transporte y carga de la cubeta de agua y un riesgo alto (rojo) para la carga y transporte del costal, la estación 2 se categoriza en riesgo bajo (verde) para ambos brazos. La estación 3 cuenta con riesgo bajo (verde) mientras que el transporte de charola muestra un riesgo medio (naranja) según Mac. La estación 4 en base Art indico un riesgo medio (naranja) para el lado derecho y riesgo bajo (verde) para el lado izquierdo, por último, la estación 5 en función del método Art indico un riesgo medio en sus labores a excepción del brazo izquierdo del trabajador de estatura baja. En base los resultados, se plantearon propuestas de mejora con ayuda de una simulación para el rediseño y apoyo de cada una de las estaciones de trabajo.

Palabras clave: Ergonomía, evaluación ergonómica, salud, lesiones, riesgo.

Aportación a la Ergonomía: Aplicación de un programa ergonómico demostrando la importancia y la presencia de la ergonomía en empresas como es una tortillería, analizando y midiendo los niveles de riesgo que se presentan en el proceso de fabricación. De esta manera los trabajadores puedan desenvolverse en un ambiente cómodo que les permite ser eficientes en sus labores.

Abstract: The present study consists of the application of an ergonomic risk management program in the company dedicated to the production of tortillas, with the aim of identifying and reducing ergonomic risk levels in the five workstations of the flour tortilla production process. Visits were made to the establishment to obtain information on the production process and images and videos were recorded to clearly observe the movements of each of the workers. Ergonomic evaluations were carried out such as the British Art, Mac and Rapp Tool methods, as well as the RULA postural method and the method to obtain the metabolic expenditure of energy of all the stations, this in order to identify the risk factors present in each of the stations to propose improvements that allow reducing the level of risk of the tasks. The evaluations for stations 3,4 and 5 were considered the tallest and smallest worker, to identify the level of risk for both cases. As results, it was obtained that station 1 based on RULA and Mac indicates a high risk (red) in the kneading position and Mac medium risk (orange) in the transport and loading and loading of the water bucket and a high risk (red) for loading and transporting the sack, station 2 is categorized as low risk (green) for both arms. Station 3 has a low risk (green) while the transport of tray shows a medium risk (orange) according to Mac. Station 4 in Art base indicated a medium risk (orange) for the right side and low risk (green) for the left side, finally, station 5 according to the Art method has a medium risk in their work except for the left arm of the short worker. Based on the results, proposals for improvement were proposed with the help of a simulation for the redesign and support of each of the workstations.

Keywords: Ergonomics, ergonomic evaluation, health, injuries, risk.

Relevance to Ergonomics: Application of an ergonomic program demonstrating the importance and presence of ergonomics in companies such as a tortilla shop, analyzing and measuring the levels of risk that arise in the manufacturing process. In this way, workers can function in a comfortable environment that allows them to be efficient in their work.

1. INTRODUCTION

1.1. Background

According to the International Ergonomics Association (IEA, 2015), ergonomics is the application of scientific knowledge to design work, systems, products, and environments that fit the physical and mental capabilities and limitations of individuals. Its presence in companies has been increasing due to the prevalence of musculoskeletal injuries caused by poor posture, repetitive movements, among

other factors. Its application aims to ensure that workers do not suffer injuries from the postures, movements, or forces exerted during their workday.
An ergonomic risk assessment becomes highly important, as it allows for the identification and control of risks associated with tasks involving repetitive motions, uncomfortable postures, and excessive strain on the human body. When evaluating ergonomic risks in the process, we can pinpoint problematic areas and take measures to reduce or even eliminate risks. In addition to safeguarding the health and well-being of workers, it can also contribute to enhancing worker efficiency and productivity.

The Tortilleria is a microenterprise dedicated to the production and sale of corn and flour tortillas, founded in January 2003. It started as a small establishment operating from a private residence with only one employee.

The objective of this study is to conduct an ergonomic evaluation of the various workstations within the company, identifying and analyzing working conditions in order to detect, prevent, and mitigate potential occupational hazards that could impact both the well-being of the workers and the efficiency of the workplace.

1.2. Process Description

This study focuses on the process of making homemade-style flour tortillas, which consists of the steps illustrated in Figure 1.

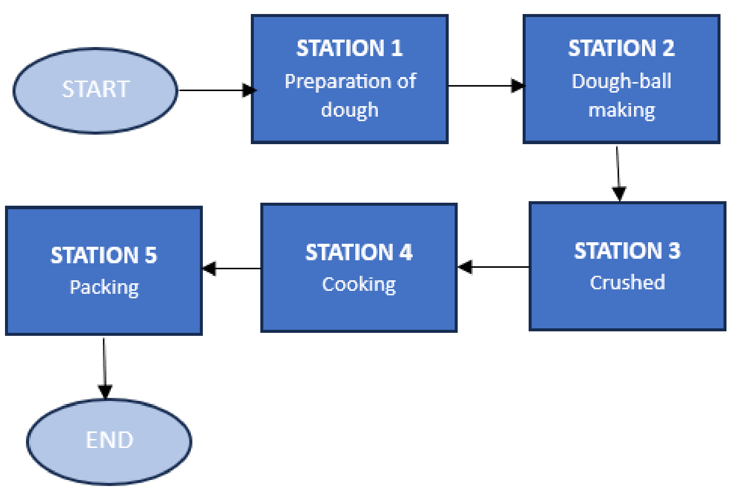

Figure 1. Block diagram: tortilla production process

1. Dough Preparation: Wheat flour, water, salt, and shortening are mixed, and a kneading machine is responsible for thoroughle blending the mixture until the desired consistency is achieved (Figure 2).

Figure 2. Station 1: dough preparation

2. Dough-ball making. With the assistance of a rounding machine, the dough is placed into the hopper to form small, equally sized dough balls, which are then place onto trays. During this step, the dough is loaded into the machine in specific quantities base on its capacity (Figure 3).

Figure 3. Station 2: dough-ball making

3. Ball Flattening: The trays are taken to a machine where each dough ball is flattened. The dough ball is placed in the flattening machine, which automatically presses it just once, resulting in the shape of a tortilla (Figure 4).

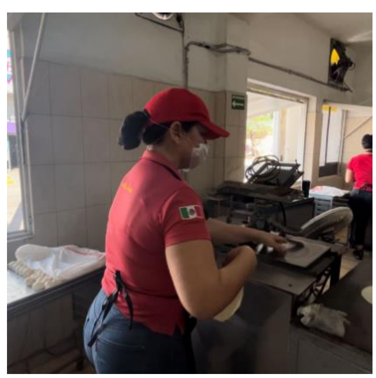

Figure 4. Station 3: crushed

4. Cooking: The tortillas are transferred to a griddle, where they are flipped approximately 3 times each using a spatula to ensure thorough cooking (Figure 5).

Figure 5. Station 4: cooking

5. Cooling and Packaging: Once cooked, the tortillas are transferred to a cooling table, where they rest for a few minutes under direct air. Once they have cooled completely, they are packed in sets of 12 pieces in a clear plastic bag. It is important to note that Tortilleria has no prior history of implementing ergonomic risk management programs in the company, making this the first time such a program is being introduced (Figure 6).

Figure 6. Station 5: packing and cooling

2. THEORETICAL FRAMEWORK

2.1. Ergonomic Evaluation Method

Ergonomic evaluation methods allow for the assessment and analysis of ergonomic risks in workplaces. These methods focus on the relationship between the worker and their work environment, aiming to identify factors that can lead to musculoskeletal injuries, fatigue, stress, discomfort, and other work-related health issues. This is achieved through direct observation of work postures, body movements, physical task requirements, worker-environment interactions, and other relevant factors. Subsequently, redesign options are proposed to mitigate the level of risk (Diego-Mas & Jose Antonio, n.d.).

2.2. Related Works

Researching works with some similarity to the ergonomic risk management project within Tortillería, a compilation of research and applications by the Ergonomists Society of Mexico, A.C was found, focusing on occupational ergonomics. Among its content is the "Analysis and Ergonomic Evaluation of Tortilla Cutting Activity in a Corn Products Factory" in the city of Tijuana, B.C. The objective of this study is to determine the risk level of developing musculoskeletal disorders within the corn products factory. For evaluation, ergonomic assessments like REBA and Suzanne Rodgers are implemented. For the REBA assessment, Ergonautas software is used, while Suzanne Rodgers' method employs an Excel-based evaluation.

The results obtained (Vol, 2022) using REBA indicate a high risk with a score of 10 for the left side and a very high risk with a score of 11 for the right side. This assessment suggests that immediate actions are necessary to reduce the high level of risk. On the other hand, the evaluation conducted using Suzanne Rodgers' method identifies body areas with a high level of muscular fatigue and high priority for modifications, such as shoulders and back. Neck, arms, and elbows are at a medium risk level, while the remaining areas are at a low risk level.

Finally, the team recommends machinery redesign to accommodate the measurements and reach of the majority of the male workforce in this case. Additionally, they propose establishing schedules for machinery use, indicating breaks for workers, and even considering alternating with other operators to reduce task repetitiveness and associated fatigue.

3. METHODOLOGY

The necessary steps were followed for the implementation of an ergonomic program.

During the diagnostic phase, the OSHA (Occupational Safety and Health Administration, 2018) checklist was utilized. The conducted diagnosis revealed that all 5 workstations exhibit ergonomic risk factors related to posture, while the first and third workstations present risks associated with manual material handling.

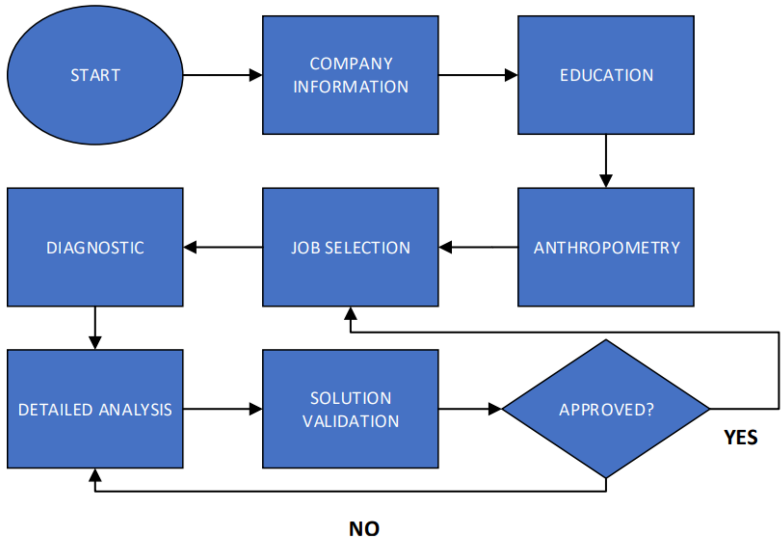

Figure 7. Diagram: ergonomic evaluation process

Regarding the level of risk obtained for each workstation, the results are presented in Table 1:

Table 1. Risk level stations 1-5

No. De estación	**Nivel de riesgo**		
	Bajo	**Medio**	**Alto**
1			
2			
3			
4			
5			

3.1. Ergonomic Evaluation Procedures.

Table 2 outlines the methods employed to conduct the ergonomic evaluation for each workstation.

Table 2. Selection of ergonomic evaluation methods.

No. de estación	**Operación**	**Tipo de evaluación**	**Método**
1	Preparación de la masa	DTA, MMM y GME	Mac Tools y RULA

2	Boleado	DTA y GME	Art Tools
3	Prensado	DTA, MMM y GME	Art Tools y Mac Tools
4	Cocción	DTA y GME	Art Tools
5	Enfriado y empaque	DTA y GME	Art Tools

4. RESULTS

Stations 3, 4, and 5 were analyzed for two specific cases: the tallest and the smallest workers, with the intention of identifying the risk level for both scenarios. To determine the risk level, the worst-case scenario was considered, which is the evaluation indicating the highest risk level.

4.1. Ergonomic evaluation

4.1.1 Station 1: Dough Preparation

For the postural aspect (right side), RULA (McAtamney, 1993) was used, resulting in a score of 5, suggesting the need for further study and prompt modifications.

Regarding Manual Material Handling (MMM), utilizing MAC Tools (HSE (Health and Safety Executive), 2003), it is divided into two parts: the first involves lifting a bucket of water (17 kg), transporting it, and lifting it again. The first lift for transport yielded a score of 6, while the transportation scored 9, and the final lift to deposit the bucket scored 8. Although all three activities are of low-risk category, corrective actions are required based on the MAC scores.

The second part involves lifting and transporting a flour sack (44 kg). Like the bucket, this also involves two lifts and one transportation. The first lift for transport yielded a score of 18, transportation scored 21, and the final lift to deposit the flour yielded a score of 14. For the first and second flour sack lifts, scores of 18 and 14 respectively were obtained, warranting prompt corrective actions. The transportation of the flour sack obtained a score of 21, demanding immediate corrective actions.

4.1.2 Station 2: Dough Rounding

In this station, both arms were evaluated for the postural aspect using ART Tools (HSE (Health and Safety Executive), 2010), resulting in a score of 9.5 for both arms. This indicates a low risk level according to the method's scale, but with some factors that could be improved, such as repetition.

4.1.3 Station 3: Pressing

For both ends, both arms were evaluated for the postural aspect using ART Tools (HSE (Health and Safety Executive), 2010), resulting in a score of 6.5. This signifies a low risk level according to the method's scale, but with certain areas for improvement, such as repetition.
For MMM in this station, evaluated using MAC Tools (HSE (Health and Safety Executive), 2003), two types of actions were considered: lowering when picking up a tray from the rack where the dough rests, and transportation to the workstation. The first activity scored 8, and transportation scored 7. Both are considered lower-risk activities, but they require corrective actions.

4.1.4 Station 4: Cooking

Similarly, we evaluated both ends of the operators and both arms for the postural aspect using ART Tools (HSE (Health and Safety Executive), 2010). For the taller operator, the left arm scored 8.25, and the right arm scored 15.75. For the shorter operator, the left arm scored 9, and the right arm scored 16.5.
For both the taller and shorter operators, a low exposure level was obtained for the left side, while the right side had a high level of exposure. Therefore, immediate further investigation is required for Station 4.

4.1.5 Station 5: Cooling and Packaging

For Station 5, there are three tasks: arranging, gathering, and packaging. ART Tools (HSE (Health and Safety Executive), 2010) were used for evaluation, considering both ends and both the left and right arms.
The first activity, arranging the tortillas, resulted in scores of 14 for both arms of the taller operator, and scores of 13 for the left arm and 18 for the right arm of the shorter operator.
The gathering activity yielded scores of 8 for the left arm and 16 for the right arm of the taller operator, and scores of 9 for the left arm and 18 for the right arm of the shorter operator.
Lastly, the packaging activity for the taller operator resulted in scores of 15 for both arms, while the shorter operator obtained scores of 14 for both arms.
Consequently, all evaluations presented a medium exposure level, indicating that Station 5 has a medium risk level and requires further investigation.
Below is a table summarizing the results obtained, with "I" denote the left side and "D" denoting the right side.

Table 3. Results of the ergonomic evaluations

No. de estación	Evaluación		Puntuación final
1	RULA	D	5
	MAC Tools (cubeta)		5-12
	MAC Tools (costal)		13-21
2	ART Tools	I	9.5
		D	9.5
3	ART Tools (estatura alta)	I	6.5
		D	6.5
	ART Tools (estatura baja)	I	6.5
		D	6.5
	MAC Tools (charola)		5-12
4	ART Tools (estatura alta)	I	8.25
		D	15.75
	ART Tools (estatura baja)	I	9
		D	16.5
5	ART Tools (Acomodar-estatura alta)	I	14
		D	14
	ART Tools (Acomodar-estatura baja)	I	13
		D	18
	ART Tools (Juntar- estatura alta)	I	8
		D	16
	ART Tools (Juntar- estatura baja)	I	9
		D	18
	ART Tools (Empacar- estatura alta)	I	15
		D	15
	ART Tools (Empacar- estatura baja)	I	14
		D	14

4.2. Metabolic Energy Expenditure

The results of the application of the AMMA method (SEMAC, n.d.) are presented in Table 4.

Table 4. Results of the AMMA method.

No. de estación	Edad	CTF	GME	Método
Estación 1	30	6.33	3.24	CTF > GME
Estación 2	30	9.11	3.09	CTF > GME
Estación 3	40	5.94	3.1	CTF > GME
	50	5.69	3.1	CTF > GME
Estación 4	40	5.94	2.475	CTF > GME
	50	5.69	2.965	CTF > GME
Estación 5	40	5.94	3.02	CTF > GME
	50	5.69	3.02	CTF > GME

In all workstations, the total metabolic energy expenditure is lower than the physical work capacity, indicating that the work falls within the limits of the workers' physical capacity.

5. PROPOSED IMPROVEMENTS

5.1. Engineering Controls

- Anthropometric redesign of all workstations.
- Step stool for shorter individuals to reach the worktable.
- Footrest mats for all workstations, as operators remain standing throughout their shift.
- Relocate the sink, placing it at 4 meters or less from the dough preparation station.
- Move the sacks closer to the station, reducing the distance traveled to transport the load.
- Use of a shovel at the kneading station to prevent excessive back bending when moving the dough.
- Implementation of the 5S tool to maintain a clean and well-organized workspace.

5.2. Administrative Controls

- At Station 1, where a load equivalent to a 44 kg sack is handled, it's necessary for this sack to be manipulated by two individuals.

- Hire a second person for Station 4, so that between the two workers, they can flip the tortillas for proper cooking, thereby reducing repetitions by a single worker.
- Employ a second person for Station 5. One person would be responsible for receiving and distributing tortillas on the cooling table, while the second person would handle the packaging.

5.3. Personal Protective Equipment

Proper use of the following personal protective equipment to maintain personal hygiene and ensure a manufacturing process free from contaminants:

- Hairnet.
- Cap.
- Face mask.
- Apron.

6. EVALUATION OF IMPROVEMENTS

The evaluation of improvements was carried out through a simulation of the new workstations.

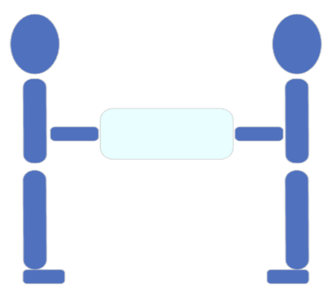

Figure 8a. Simulation station 1 MMM flour bag as a team

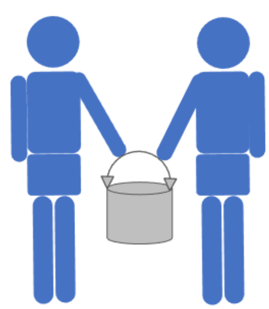

Figura 8b. Simulation station 1 MMM Bucket Loading as a team

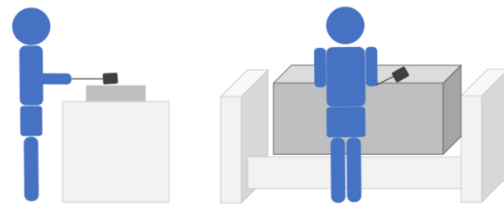

Figure 8c. Simulation station 1: kneading

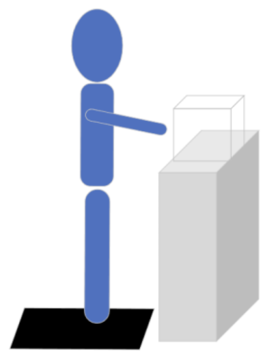

Figure 9. Simulation station 3: pressing

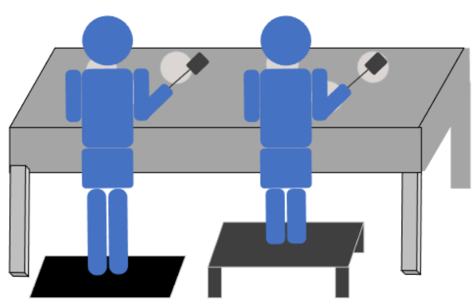

Figure 10a. Station 4 simulation: cooking

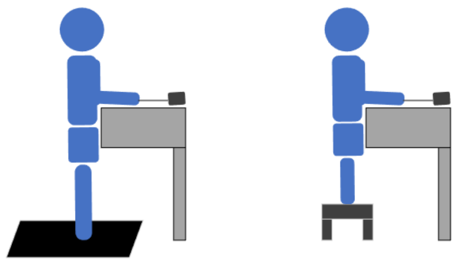

Figure 10b. Station 4 simulation: cooking

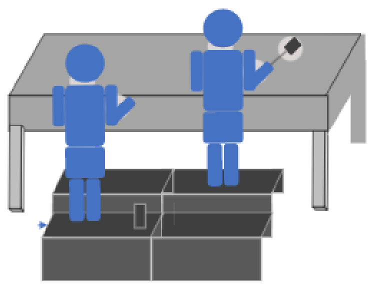

Figure 11. Simulation station 5: packing and cooling

The evaluations for each station were conducted once again, considering the proposed improvements (Table 5). A new method, RAPP Tools (HSE (Health and Safety Executive), 2016), was used.

Table 5. Results of ergonomic evaluations after improvements

No. de estación	**Evaluación**		**Puntuación final**
1	RULA	D	3
	MAC Tools (cubeta)		4
	MAC Tools (costal)		10
	RAPP Tools (charola)		4
4	ART Tools (estatura alta)	I	8.25
		D	9.75
		I	8.25

	ART Tools (estatura baja)	D	9.75
5	ART Tools (Acomodar-estatura alta)	I	7
		D	8
	ART Tools (Acomodar-estatura baja)	I	7
		D	8
	ART Tools (Juntar-estatura alta)	I	5
		D	9
	ART Tools (Juntar-estatura baja)	I	5
		D	9
	ART Tools (Empacar-estatura alta)	I	6
		D	7
	ART Tools (Empacar-estatura baja)	I	6
		D	7

7. DISCUSSIONS

This evaluation focused on the process of making homemade-style flour tortillas, which is divided into 5 subprocesses: dough preparation, rounding, ball flattening, cooking, and cooling and packaging. The assessment was carried out for ergonomic risk factors such as repetition, postures, and efforts. While improvements were proposed to achieve low risk levels in the workstations, there are still opportunities for further enhancement.

8. CONCLUSIONS

The implementation of the ergonomic program within Tortilleria allowed for the identification of risk factors present in each workstation involved in the flour tortilla-making process. This was accomplished through evaluations using various ergonomic methods, including postural assessments, manual material handling, and metabolic energy expenditure. This process facilitated the identification of workstations with higher risk levels. Thanks to the proposed engineering and administrative control measures, workstations were redesigned with elements that provided operators with more comfortable working conditions, ultimately reducing the level of risk they were exposed to. However, there are still opportunities for improvement in body parts that continue to have a moderate to high risk level.

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INCIDENCE OF THE ORGANIZATIONAL CLIMATE AND WORK PERFORMANCE: PRACTICAL CASE

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Resumen El Clima Organizacional adecuado en las empresas permite que estas sean competitivas en un entorno cambiante y de calidad, el trabajador genera un desempeño laboral adecuado por las condiciones favorables presentes. Las empresas de transporte no son la excepción por lo que el objetivo: es determinar los niveles de cada una de las variables investigadas y cómo estás se correlacionan. La metodología usada es la aplicación del test de Clima Organizacional y de desempeño Laboral con variables sociodemográficas en un grupo de trabajadores. Se determina: el Alpha de Cronbach y KMO para ver la fiabilidad y confiabilidad de los test aplicados. Los resultados permiten determinar la incidencia y correlación entre las variables de estudio para luego plantear medidas que generen impacto en las condiciones laborales como: incremento de productividad, disminuir índices de accidentabilidad, absentismo, mejorar las relaciones interpersonales, comunicación, entre otros aspectos. El Clima Organizacional es de: 45.5 % bajo y 54.5 % medio, el desempeño laboral: 4.5 % medio y 95.5 % medio. Se concluye que a pesar de un resultado medio-bajo en Clima no incide en el desempeño del trabajador.

Palabras clave: Clima Organizacional, desempeño laboral, trabajadores

Relevancia para la ergonomía: El Clima Organizacional y desempeño laboral es importante para la ergonomía debido a que el trabajador es la parte fundamental de la empresa, si no funciona el trabajador de manera adecuada en todos los aspectos empresariales, no se siente comprometido con la misma su desempeño laboral tampoco es adecuado, por lo que es importante su publicación por la data y la evaluación de la incidencia de las variables sociodemográficas y las objeto de estudio.

Abstract: The adequate Organizational Climate in companies allows them to be competitive in a changing and quality environment, the worker generates an adequate work performance due to the favorable conditions present. Transport companies are not the exception so the objective is to determine the levels of each of the variables investigated and how they correlate. The methodology used is the application of the Organizational Climate and Work Performance test with sociodemographic variables in a group of workers. It is determined: The Cronbach's

Alpha and KMO to see the reliability and reliability of the tests applied. The results allow us to determine the incidence and correlation between the study variables and then propose measures that generate impact on working conditions such as: increased productivity, decrease accident rates, absenteeism, improve interpersonal relationships, communication, among other aspects. The Organizational Climate is: 45.5% low and 54.5% average, work performance: 4.5% medium and 95.5% average. It is concluded that despite a medium-low result in Climate does not affect the performance of the worker.

Keywords. Organizational Climate, work performance, workers.

Relevance to Ergonomics: The Organizational Climate and work performance is important for ergonomics because the worker is the fundamental part of the company, if the worker does not work properly in all business aspects, he does not feel committed to it, his work performance is not adequate either, so it is important to publish it for the data and the evaluation of the incidence of the sociodemographic variables and the object of study.

1. INTRODUCTION

The present research was developed in a transportation company in the city of Quito, the objective is to determine the levels of Organizational Climate and work performance as a work discipline, which allows determining the state of how the institution is in its structure and what In this way, these conditions affect the performance of the worker when performing the task, and thus be able to contribute to the improvement of unfavorable conditions.

The search of companies to be competitive in a world globalized by constant changes, industry 5.0, the use of information technologies, artificial intelligence, etc.; That is why today attention must be paid to systemic productivity approaches based on the human component for continuous improvement, through the study of the behavior of people in companies and thus be able to change and improve.

The working conditions in which the worker performs the task must be improved and generate comfort with motivated, committed and high-performance personnel to achieve the goals set in the organization that allow achieving profitability without leaving aside the human aspect.

Companies have begun to study the components of the human being. Improvements in working conditions are observed in several areas because of this analysis, which seeks to generate an adequate work environment with motivated, committed and high-performing work teams, capable of achieving planned goals with profitability levels. The organizational climate as a key factor positively or negatively affects job performance.

The organizational climate is an important factor that positively or negatively affects the work performance of workers and has an impact on the company's productivity indices. All organizations have an organizational structure and a set of people that interrelate with each other to generate people's behavior; these component relationships produce the so-called Organizational Climate (Caligiore and Díaz, 2003). The organizational climate in the world has generated expectations and importance as a topic of analysis due to global competitiveness and globalization, so the aspects of this topic generate factors that make the difference between a company being successful in relation to the competition. (Gan, F. and Berbel, G. 2007, 180) considers climate: “conglomerate of attitudes and behaviors that characterize life in the organization; "It originates and develops in the interactions between individuals and the environment of the organization," it reflects culture. (Chiang et al. 2010, 36) state that: “climate is a property of the organization, a set of variables that describe it. The objective aspects of the context are: the degree of formalization, centralization, technology, size, physical location, etc.”

Companies seeking to improve their environments have implemented strategies to generate an adequate organizational climate in which those involved can develop cognitive abilities and communication skills, interpersonal relationships that allow them to achieve intellectual capabilities to achieve the goals planned by the company.

For (Arizmendi Diaz,2015), I investigated the relationship of Organizational Climate in the Motivation of Mexican workers, at UNAM, in which a motivational relationship and climate factors were identified, there was support among colleagues and good communication, which causes leadership. According to (Tushman and Nadler 1980 cited in (Chiang et al. 2010, 74), “the organizational model is the interaction between the individual and the organization, indicating the existing relationships between the organizational structure and processes and the attitudes, behaviors of the individuals of the same organization, and between the climate that emerges from the interaction and its organizational and human environment.” Job performance, according to (Chiavenato, 2000), is how the worker reaches the set objectives, through an individual strategy. Authors such as (Milkovich and Boudrem, 1994), mention individual characteristics such as: that are related to the work and the company that generates behavior with results that can benefit or affect the organization. For (Bohórquez, cited in Araujo and Guerra, 2007, 140) job performance is the level of execution that the worker achieves in achieving the goals within the organization in a given time. For (Stoner 1994, cited in (Araujo, M. and Guerra, Martin 2007, 140) he states that job performance is: “the way in which the members of the organization work effectively, to achieve common goals, subject to the established basic rules. in advance.” Therefore, executing tasks efficiently allows the fulfillment of organizational objectives. Service companies as the case study to offer adequate attention to their clients consider correlated factors that directly affect the performance of workers: worker satisfaction, self-esteem, work. For (Quintero, Africano, and Faría 2008, 40).

Company managers have made an analysis of the importance of the organizational climate to achieve the company's objectives. In the past it was secondary, today it is fundamental, in which the human talent areas were dedicated only to keeping payrolls for their personnel, today in Today they operate under this traditional approach, but with the addition that the worker needs a suitable and appropriate place to perform the task. Its success or failure depends on this, it depends on the degree of perception that the worker has with the functions he performs and if these give him a meaning in life, so it is necessary to improve workplaces in all their aspects to guarantee your comfort. For this research, the following question is raised: Does the organizational climate affect the work performance of the workers of the transportation services company?

2. METHODOLOGY

The research was descriptive, observing the phenomenon as it is presented, deductive and inductive, starting from the particular to the general and vice versa, correlational, establishing the relationship between variables and transversal in a single instant of time to obtain results. The investigation started from a situational analysis to establish the root causes of the problem, then the evaluation of the dimensions of the Organizational Climate and Work performance in the company was proposed through the respective tests, its application was done in the Google Drive where the survey through Google forms, the link created was disseminated to the company's workers who voluntarily and anonymously proceeded to fill it out. The data collected in the form is reflected in an Excel sheet that can be downloaded to be programmed. Once this stage is completed, it is exported to SPSS V26 to carry out a new programming and obtain the results of the analyzed data. To evaluate the Organizational Climate, the corresponding test was applied, which consists of 24 questions and consists of 5 dimensions, with a scale of lickers: 1 = never; 2 = very rarely; 3 = sometimes; 4 = almost always; 5 = always. The corresponding dimensions by questions are presented in the following table:

Table No. 1. Dimensions and questions of the Organizational Climate test

DIMENSIONS	**QUESTIONS**
LEADERSHIP	P3, P6, P11,P24
PARTICIPATION	P4, P9,P10, P13, P14
RECOGNITION	P5, P19, P20,P23
RELATIONSHIPS	P7,P8, P12, P21, P22
COMMUNICATION	P1,P2,P15,P16, P17,P18

Recovered: Organizational climate survey: What it is, types and examples (questionpro.com)

The Organizational Climate score is presented in the following table:

Table No. 2. Score of the Organizational Climate test

Denomination	Score
Low	De 0 a 67

Medium	De 68 a 134
High	De 135 a 200

To evaluate Job Performance, the corresponding test was applied, which consists of 20 questions and consists of 6 dimensions, with a scale of lickers: 1 = very low; 2 = low; 3 = moderate; 4 = High; 5 = very high. The corresponding dimensions by questions are presented in the following table:

Table No. 3. Dimensions and questions of the Job Performance test

DIMENSIONES	**PREGUNTAS**
RESULTS GUIDANCE	P1, P2,P3
QUALITY	P4,P5,P6,P7,P8
RELATIONSHIPS	P9,P10,P11
INITIATIVE	P12,P13,P14,P15
TEAMWORK	P16,P17
ORGANIZATION	P18,P19,P20

The Job Performance score is presented in the following table:

Table No. 4. Score of the Job Performance test

Job Performance	**Score**
High	De 67 a 100
Medium	De 34 a 66
Low	De 0 a 33

3. RESULTS

The sociodemographic variables are presented in the following table:

Table No. 5. Sociodemographic variables

Gender (%)	**Status**	**(%)**	**Personal Action (%)**
MALE 68,2	Single	36,4	Definitive Contract 50,0
FEMALE 31,8	Married	31,8	Occasional contract 50,0
	Divorced	4,5	
	Free Unión	27,3	

There are more men than women in the company under study, the majority have committed marital status and the same exists between appointments and contracts. The following tables present the reliability and reliability of the organizational climate and work performance tests.

Table No. 6. Reliability of the Organizational Climate test

Reliability statistics	
Cronbach´s Alpha	Number of elements
0,952	40

Table No. 7. Reliability of the Organizational Climate test

KMO and Bartlett test	
Kaiser-Meyer-Olkin measure of sampling adequacy	0,910

The values of Cronbach's alpha of 0.952 and KMO of 0.910 are high, which determines the reliability and trustworthiness of the test so it can be applied in this work environment.

Tabla No. 8. Reliability of the Job Performance test

Reliability statistics	
Cronbach´s Alpha	N elements
0,891	20

Table No. 9. Reliability of the Job Performance test

KMO and Bartlett test	
Kaiser-Meyer-Olkin measure of sampling adequacy	0,937

The values of Cronbach's alpha of 0.891 and KMO of 0.937 are high, which determines the reliability and trustworthiness of the test so it can be applied in this work environment.

The following table presents the results of the applied Organizational Climate and work performance..

Tabla No. 10. Organizational Climate

Organizational Climate	(%)
Low	45,5
Medium	54,5
Total	100,0

The Organizational Climate in the transportation company analyzed is 54.5% average, which reflects that it is not adequate, it must be improved to meet the goals set that reflect in production rates, always prioritizing the worker.

Table No. 11. Job Performance

Job Performance	(%)
Medium	4,5
High	95,5
Total	100,0

The Work Performance in the transportation company analyzed is 4.5% medium and 95.5% high, which reflects that the worker feels committed to the objectives and goals set by the company.

The verification of the research premise on the incidence of Organizational Climate and work performance through Pearson's Chi-square.

Table No. 12. Chi-square test

	Valor	df	Significación asintótica (bilateral)
Chi-cuadrado de Pearson	848,352[a]	360	,000
Razón de verosimilitud	290,100	360	,997
Asociación lineal por lineal	80,884	1	,000
N de casos válidos	106		

a. 398 casillas (99,7%) han esperado un recuento menor que 5. El recuento mínimo esperado es ,01.

As the significance value or critical value observed is 0.000 and is < 0.05, the Null Hypothesis (Ho) was rejected and the Alternative Hypothesis (H1) was accepted, that is, the organizational climate did affect job performance.

4. CONCLUSIONS AND RECOMMENDATIONS

It was determined that the organizational climate affects the work performance of the collaborators of the transportation company under study, this was determined by the results that the descriptive statistics showed on the variables and their dimensions, and the statement was consolidated by the statistical inference tests that later If applied, they completely discarded the idea of independence between the indicated variables.

Through the corresponding tests of each variable analyzed, the following aspects were found: 45.5% with low Organizational Climate and 54.5% with medium, it is concluded that the Climate must be improved to obtain better results in the company in all its indicators and goals, referring to performance. labor we have: 4.5% medium and 95.5% high, this implies that on the part of the workers there is an adequate task with active participation to satisfy their needs and business commitment.

The reliability and reliability of the Organizational Climate test was analyzed in which Cronbach's Alpha is 0.952 and KMO is 0.91, being reliable and reliable for the applied environment. Additionally, it was determined in the job performance test in which Crombach's Alpha is 0.891 and the KMO is 0.937, being very good, acceptable and reliable for the research, it can be concluded that its values can be increased by reducing the number of questions and increasing the number of respondents, which generates a new construct.

Strategies were implemented to improve the Organizational Climate and Work Performance in the company's workers through the implementation of a positive Psychology plan that generated adequate results through games, training, group integration that allows improving communication between colleagues, working in team with clear objectives and goals that contribute to improving the company's production and worker performance, so it is recommended to continue promoting it.

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