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Prefacio

Este año, al parecer, vemos una luz al final del camino. Al parecer la pandemia está cediendo en nuestro país y son buenas noticias debido a que podemos regresar a las aulas maestros y alumnos y seguir con nuestras investigaciones.

Este año, la pandemia nos afecto en cuanto al numero de trabajos publicados, afortunadamente los trabajos publicados, como cada año, han subido en calidad y se muestra como se ha ayudado a nuestros compañeros operadores de línea y alumnos.

Otra buena noticia es que ya se iniciaron los trabajos, por parte de la Secretaria del Trabajo y Previsión Social, con la continuación de la Norma Oficial Mexicana 036-2, que corresponde a los trabajos repetitivos y han sido convocados a trabajar en dicha norma nuestros colegas y amigos los doctores Carlos Espejo y Octavio Lopez, y estamos seguros que será en beneficio de la Sociedad Mexicana.

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

Enrique de la Vega Bustillos

Presidente SEMAC 2002 – 2004

SOCIEDAD DE ERGONOMISTAS DE MÉXICO A.C.

“Trabajo para optimizar el trabajo”

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STUDY OF HUMAN ERROR IN PRODUCT DESIGN FOR ADDITIVE MANUFACTURING: A SYSTEMATIC LITERATURE REVIEW

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Resumen: Actualmente, el sector industrial crece constantemente respondiendo a la demanda de procesos de diseño de productos para la manufactura aditiva (MA). El desarrollo del diseño de un producto se considera importante en la gestión de proyectos de MA, ya que diversas acciones son llevadas a cabo por los diseñadores, los gestores del diseño del software y los operadores de los equipos. Sin embargo, las malas prácticas en el proceso contribuyen a los errores humanos. Éstos pueden generar problemas mayores como el desperdicio de material y energía, pérdidas económicas entre otros efectos (Song y Telenko, 2017).

La Ergonomía Cognitiva es la rama de la Ergonomía que estudia los procesos por los que el ser humano procesa y analiza información sobre todos los aspectos del trabajo humano, teniendo como componentes esenciales la toma de decisiones, el aspecto perceptivo, el análisis de la información y la motricidad (Cañas, 2001). Su propósito es estudiar las actividades y proceso mentales sobre el desempeño del ser humano en situaciones rutinarias, tareas cognitivas, interacciones hombre máquina, entre otras y tiene métodos para estudiar estos procesos (Benito, 2008). Entre ellos están los métodos de análisis, identificación y evaluación del error humano (Marchito, 2011).

Así, el error humano es uno de los aspectos más importantes a estudiar dentro de la Ergonomía Cognitiva. Se define conceptualmente como "cualquier conjunto de acciones o actividades humanas que exceden algún límite de aceptabilidad, es decir, una acción fuera de tolerancia en la que los límites de rendimiento son definidos por el sistema" (Di Pasquale et al., 2015).

Palabras clave: Error humano, Manufactura aditiva, Conducta Humana, Procesos de diseño, Producto.

Relevancias para la ergonomía: A través de este trabajo abre la puerta a futuras investigaciones para determinar los problemas que existen, causados por el manufacturador dentro del área de Manufactura aditiva.

Abstract: Currently, the industrial sector is constantly growing in response to the demand for product design processes for additive manufacturing (AM). Developments of a product design is considered important in the management of AM projects, as various actions are carried out by designers, software design managers and equipment operators. However, poor practices in the process contribute to human errors. These can generate major problems such as material and energy waste, economic losses among other effects (Song and Telenko, 2017).

Cognitive Ergonomics is the branch of Ergonomics that studies the processes by which human beings process and analyze information about all aspects of human work, having as essential components decision-making, perceptual aspect, information analysis and motor skills (Cañas, 2001). Its purpose is to study the activities and mental processes on human performance in routine situations, cognitive tasks, human-machine interactions, among others, and has methods to study these processes (Benito, 2008). Among them are the methods of analysis, identification and evaluation of human error (Marchito, 2011).

Thus, human error is one of the most important aspects to study within Cognitive Ergonomics. It is conceptually defined as "any set of human actions or activities that exceed some limit of acceptability, i.e., an out-of-tolerance action in which performance limits are defined by the system" (Di Pasquale et al., 2015).

Keywords: Human Error, Additive manufacturing, Human behavior, Design processes, Product.

Relevance to Ergonomics: Through this work, it opens the door to future research to determine the problems that exist, caused by the manufacturer within the Additive Manufacturing area.

1. INTRODUCTION

In their eagerness to obtain more accurate results, decision makers have to look for alternatives that propose better solutions to the presentation of a problem. Thus, engineers, designers and managers are given the task of obtaining and processing information that can give them the opportunity to exercise clear and objective judgments in situations involving multifactorial phenomena or low objectivity. To this end, Cognitive Ergonomics is the branch of Ergonomics that studies the processes by which the human being processes and analyzes all aspects of human work, having as essential components decision-making, the perceptual aspect, the analysis of information and motricity. The purpose of which is to prevail in mental activities on the performance of professionals in routine situations (Benito, 2008), and has methods to study these processes. Among them are the methods of analysis, identification and evaluation of human error. Marchito (2011) defines that the approach to human error was influenced by Cognitive Ergonomics since it arose from addressing the phenomenon of human behavioral failure, defining a taxonomy that helps to identify and interpret the error itself. Thus, human error is one of the most important aspects to be studied within Cognitive Ergonomics. It is defined conceptually as "any set of human actions or activities that exceeds some limit of acceptability, i.e., an out-of-tolerance action in which performance limits are defined by the system" (Swain, 1986). Similarly, Hollnagel, (2005) proposes to consider human error as "an identifiable human action that, in retrospect, is considered to be the cause of an undesirable outcome". In either case, a human error implies a deviation from an expected result. In other words, the deviation generally manifests itself in manufacturing as a quality problem (Torres, 2020).

In The historical evolution of industrial systems, technology, and automation for the design and elaboration of products, Marchitto (2011) reports on the substitution of the human operator in risky, tedious, physically demanding activities, transforming said operator into a key participant in automatic process monitoring. In addition, this author points out that as a consequence of the above, the reduction of execution errors in many cases, such as additive manufacturing, has inevitably been replaced by an increase in other types of errors such as those of evaluation, forecasting, and maintenance of automatic systems. In such a way that with the human factor, it continues to be identified as responsible for 70% of product problems and accidents. He also states that the reasons most likely lie in the fact that it is not so much the level of automation of a system that determines the presence and absence of erroneous or incorrect behaviors, but rather the set of factors that affect and regulate human performance. In certain systems: these factors are related to the organization, its culture, its policies, its procedures, and its practices. Other authors such as Turjanski (2016) mention that responsibility goes beyond the operator's failure. Thus, the operator's "human error" would no longer be treated as the key factor to explain the facts, but rather as the supervisor's "human error". , or the manager, who can explain what happened in a greater degree of "depth." In other words, the error of the first-line operator is no longer associated with a psychological precursor, nor with another error within the hierarchical chain, but with the design of the nearby work context and, upstream, with the problems of “organizational design”.

Human error is here to stay (Taylor et al., 1995) this perhaps obvious statement has a deeper implication if we consider how common human errors are in everyday life and in the work environment. The vast majority of today's catastrophes arise from a combination of small events, system failures, and human errors that would be irrelevant individually, but when combined in a special time sequence of circumstances and actions, can lead to unrecoverable situations (Di Pasquale et al., 2015). Several researchers have focused on the concept of human error in order to understand, evaluate and identify possible actions to limit it. The evidence that human actions are a source of vulnerability for industrial systems gave rise to human reliability analysis (HRA), which aims at a closer examination of the human factor by predicting when an operator is most likely to fail (Di Pasquale et al., 2015).

The selection of a suitable process within additive manufacturing to manufacture a product design in its final phase is an important issue in MA design. One of the many types of approaches to AM process selection is based on user criteria decision making. Most user decision-based approaches have the advantage of taking into account the relative importance of types of product design performance parameters. However, they are not entirely satisfactory, since they do not have the ability to reduce the influence of the deviation of the values in the performance parameters on the result of the final product, these risks are usually visible according to the attitudes of the users in decision making (Yuchu Qin, Qunfen Qi et al., 2020).

That is, an important factor in user decision making for the product in the use phase of additive manufacturing is often a trigger for environmental impacts in the life of products due to energy and material consumption. These inappropriate human behaviors could increase environmental impacts during the use stage of the product design life cycle (Song and Talenko, 2019).

On the other hand, additive manufacturing is defined by building a volume layer by layer, from a CAD file, and has the advantage of producing parts of high complexity, good dimensionality and with a wide range of materials. The Origin of MA has presented several benefits the increasing demand for manufacturing components with complex designs has caused a revolution in manufacturing methods. Additive manufacturing stands out as a promising technology when it comes to prototyping multi-functional and multi-material designs (Jin, Z et al., 2020). However, it also has certain drawbacks.

Among them are the low production volumes, small dimensions, cost and low manufacturing speed (León et al., 2020). Other factors being different variations in the parameters of 3D printed design samples due to damage properties and deformation behavior, this is a matter of considerable importance that is often overlooked (Webbe Kerekes et al. , 2019). Its beginnings began in 1984, Charles Hull invented the method of Stereolithography (SLA), it was a printing process aimed at making models to test prototypes before taking them to the assembly line, That same year he created the company 3DSystems, from this mode allowed the industrial use of the 3D printing process. Later in 1990, Scott Crump founded Stratasys developing a new 3D printing technology, FDM (Fused Deposition Modeling), with which it was possible to create three-dimensional objects thanks to the superposition of layers of material, which were fused with each other to, as it cools, the joint solidifies. Over time, this technology reduced costs and managed to reach smaller companies or even some users (Pascual, 2018).

Today companies are thinking of using additive manufacturing in their design production processes. Mainly to replace subtractive production processes. This to give companies a clearer idea of the benefits of using additive manufacturing in the industrial sector, the approach results in the visualization of impact on the market, therefore helping companies in the orientation phase. (Zimmermann et al., 2019). That is why Additive Manufacturing is now moving towards the direct production of functional parts, parts that fulfill one or more functions, such as medical implants or aircraft engine parts, which are ready for distribution.

The term human error has not been defined as such within additive manufacturing and opens the door to research by exploring the possible causes that define errors in the operator-machine interaction.

1.1. Objetives

The objective of this research is to develop a systematic review of the literature to determine the state of the art of the study of human error in product design with additive manufacturing, using the most recognized databases.

1.2. Delimitation

The present study aims to conduct a comprehensive literature search for human error in the industrial sector within the additive area in product process management.

2. METHODOLOGY

To develop the literature review, it consisted of PRISMA that incorporates several conceptual and methodological aspects, which consists of various successive steps that must be explicit and reproducible, known as a systematic review.

3. EVIDENCE OF HUMAN ERROR

Regarding the evidence of human error in additive manufacturing, deficiencies have been found in the communication process between the customer and the manufacturer, both in the designer work and in project management. For example, Moreno and Fernández (2020), point out that human error can be related to such critical aspects of AM as Defects that occurred during the manufacturing process, defective design, poor communication in the project team and insufficient financing (Moreno and Fernández, 2020). In addition, Abudi, (2013) identifies that the problems caused in the additive area are found from poor internal and external communication between the team and the rest of the organization, and even with the client, this can have a negative effect on the daily management of the project and reduce the productivity of the project resulting, therefore, in longer deadlines and exceeding budgets. It can also be a cause of conflict in the future and can deteriorate the atmosphere of the work environment.

Other problems related to human error in additive manufacturing refer to the waste of material due to problems in print handling. For example, Nagarajan et al.,

(2016) mention that energy is a dominant impact factor when evaluating the environmental performance of additive manufacturing, and highlight human action in this process. In addition, other authors affirm that inexperience can influence human errors and cause waste in energy and material within additive manufacturing (Song & Telenko, 2017).

Therefore, these problems expose the different human errors found in the product design process, such as the communication of the client with the manufacturer, the lack of experience in the field and in turn determining the different failures within the design process of product in additive manufacturing.

Although there is a wide variety of articles that promote the identification of the error in the additive area, they are limited only to talk about the error when interacting with the machine, therefore the objective of this research is to carry out a deeper search within bases of the most important data to carry out a systematic review of the literature on the subject. For Hunt (1997), he defines systematic review as the application of an objective and rigorous methodology to carry out the research review process in a specific field of knowledge and thus achieve an efficient accumulation of evidence. That is why the work of this research consists of an exhaustive search for articles that define the terms of human error within additive manufacturing, thereby raising the limitation of the search based on the errors of the operator when he comes into contact with the operator. Product design process in the additive area.

4. MATERIAL AND METHODS

When talking about additive manufacturing on the web you usually find searches that improve the user's knowledge related to the topic, but if you coin the term human error the search is compacted and creates a limited research on the topic, that is why within the various scientific databases provided by the Autonomous University of Ciudad Juarez, were chosen based on the information service provided by the accounts with access to various electronic articles which contribute to meet the information needs of the various academic programs offered by the University. A clear example is the search for the word "human error" that was performed in different electronic sources to learn more about the problem of human error, by typing the concept "Human error in additive manufacturing" you can find approximately more than 108,000 results among scientific articles, books, etc. The word "human error" usually identifies problems based on the user's responsibility for accidents.

In a first step, to identify the relevant studies for this analysis, the search included all the publications from January 17, 2003 to the present date, within the article 9 databases were included that are more related to the topic: Association for Computing Machinery, ACM, ACS Publications, Cambridge, EBSCOHOST, EMERALD, PUBMED, SCIENCE DIRECT.

It was decided to opt for this search based on recent studies that show that it is important to analyze the behavior of the operator or user by material consumable, (Song & Telenko, 2019). That is why it is important to carry out a deeper investigation of human error within the additive area and it was from various articles and from my own experience that we wanted to find out more about the opportunity of the field of study that we have.

The search was carried out based on keywords that influenced the result, which is why independent words began to be used and combined with each other to form verbs that would allow a more extensive search, articles were also identified by listing them in each word or verb that was used as can be seen in figure 1.

In a second step, it was decided to form 3 concepts that would identify the key words or verbs used to prioritize important articles and begin to indicate the reference areas of each one, as the field expanded to a more global approach due to the scarcity of the subject is therefore, it was easier to verify the specified criteria.

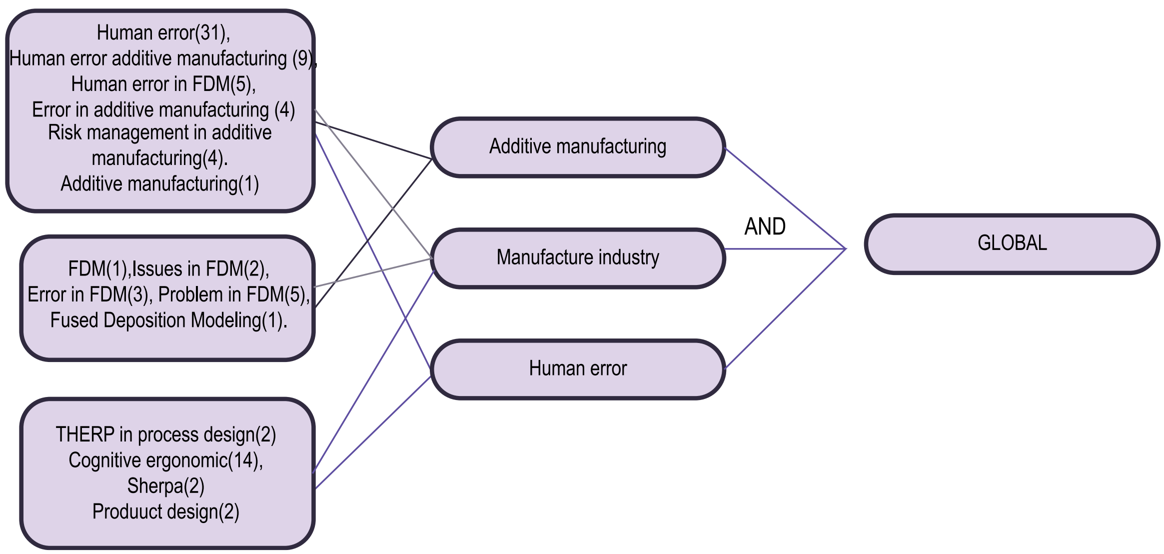

Figure 1. An analysis of 85 articles identified in 3 different areas in a global investigation is shown.

The delimitation criteria were performed based on related problems within the additive manufacturing area which were exculpating the operator's activity manifesting complicity that fluctuated due to machine failures. This was determined based on the analysis of the summary of each item that showed the machine deficiency or internal programming error of the machine. That is why it was determined to eliminate options with these filters.
- Filter 1. 17 articles are excluded because they do not belong to the industrial area.
- Filter 2. 36 articles of Machine-Human errors are omitted because they do not belong to the additive area.
- Filter 3. 32 articles are isolated for exculpating operator errors within the additive area.
- Filter 4. We work with the 5 potential articles for meeting the characteristics required by the user.

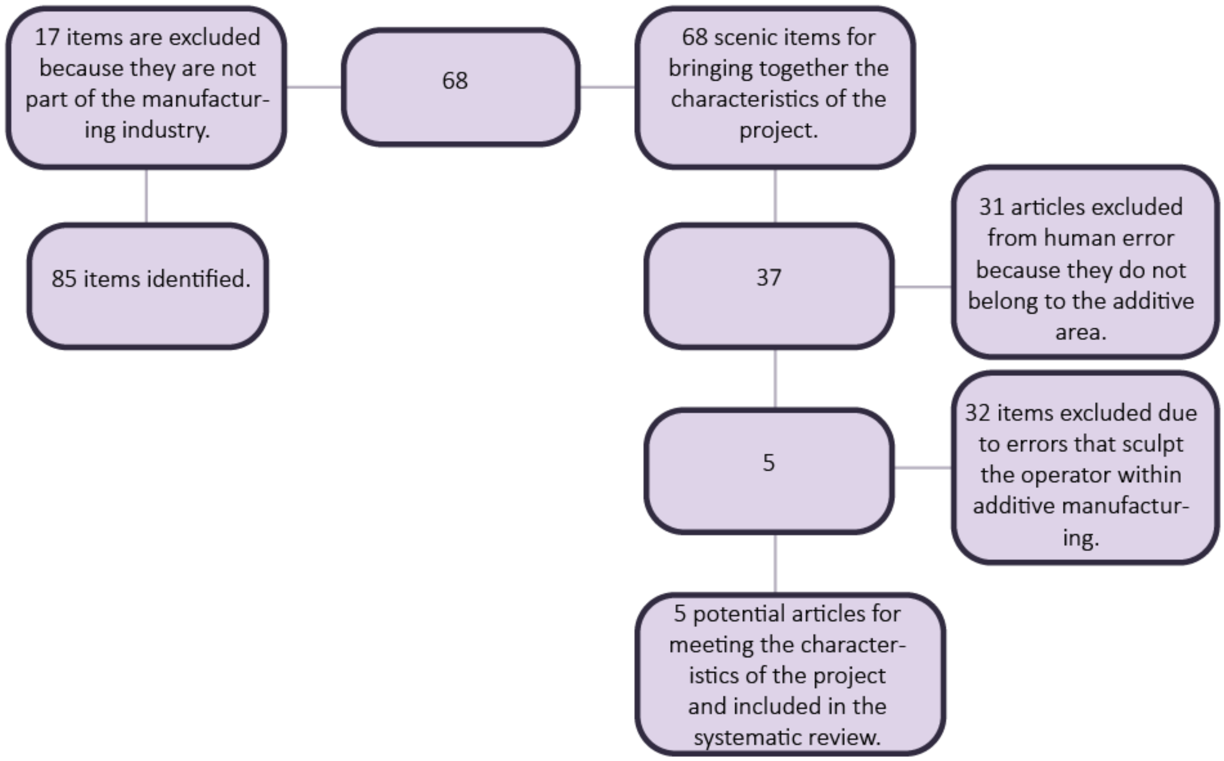

Figure 2. Shows an analysis of 85 articles identified, which were discarded due to different factors.

5. RESULTS

With the filters performed, 5 potential articles were identified that met the criteria described by the user. From the 5 potential articles, primary information was discovered that allows locating a recent problem by the formulated researches, February 6, 2017 was the first article related to the problem that allows opening an investigation by manifesting operator problems within additive manufacturing (Song & Telenko, 2017).

Other problems found in the background check within the additive manufacturing area were problems managing a project due to lack of communication and designer errors with the product, Project risks can cause cost overruns, delays in the completion, unsatisfactory results of the project, total failure (Raz et al., 2002) or even negatively affect the reputation of the project team and the company. For that reason, to increase the chances of project success, effective early risk management is needed to reduce uncertainty and improve decision making. (Moreno and Fernández, 2020).

Few studies investigate the causes of manufacturing failures in creation spaces. User experience and experience level can influence the possibility of manufacturing failure. Cerdas et al. found that experienced users were better able to select print parameters that minimized waste. This study aimed to investigate the failure rate based on user experience and the level of experience in university creation spaces. Print failures and daily users of various experience levels were studied at an open access university (Song and Telenko, 2019).

In the investigation it is mentioned that part of the operator's problems is due to errors of omission and action, the errors stand out due to the omission of steps of the program that is used, since the operator has vast experience so he does not proceed to perform a proper calibration. According to Salas et al., (2018) mentions that these oversights are attributed to the fact that the operator has more elaboration time in the company and therefore the work is repetitive, thus allowing the operator to assume that the process is carried out find it correct without carrying out a methodology with certain steps that must be followed within the process.

6. MOST APPLIED HUMAN RELIABILITY ANALYSIS (HRA) METHODOLOGIES

The evidence that human actions are a source of vulnerability for industrial systems has led to the birth of many Human Reliability Analysis (HRA) methods, which point to a deeper examination of the human factor (Di Pasquale et al., 2015). Although minor failures can seriously reduce the performance of the operation in terms of productivity and efficiency. That is, human error has a direct impact on productivity because errors affect the rejection rates of a product, thus increasing production costs and reducing subsequent sales (Cacciabue, 1998). Several researchers have focused on the concept of human error in order to understand, evaluate, and identify possible actions to limit it. Such evidence is a source of vulnerability for industrial systems gave rise to the Human Reliability Analysis (HRA), which aims at a more detailed examination of the human factor by predicting when an operator is most likely to fail. That is why special attention has been paid to dynamic HRA methods that use cognitive modeling and simulation to produce a data frame that can be used to quantify the probability of human error (HEP) (Di Pasquale et al., 2015).

There are different methods to evaluate the quantification of error in humans, the Swiss cheese model was first introduced by Reason (Reason, 1990). The basic basis of the model was the use of a production system with five layers of Swiss cheese slice: inadequate defenses, unsafe acts, psychological precursors of unsafe acts, deficiencies in line management and fallible decisions (organizational influence) (Reason, 1990). The hazard (represented by the hole) that appears in each layer must be lined up to make an adverse event. The improvement of this model is carried out by Reason (1990) to illustrate that the orifices will always move, changing in shape and size in reaction to the operator's actions and local demands. To overcome failures or danger, defenses must be built in the most possible way. Both the individual and the organizational accident should be minimized by using defenses that prevent active failures and latent conditions (Suryoputro et al., 2015).

Another of the most used methods within the industrial area that allows the evaluation of human behavior is THERP, which Di Pasquale et al., (2015) mentions that THERP, include levels of detail that may be excessive for many evaluations. Existing HRA tools allow very comprehensive assessments of human behavior in high-risk settings, but can be time-consuming and resource-consuming. First and second generation methods have focused on quantifying human error and identifying failure mode, while providing highly detailed and realistic frameworks and approaches for calculating HEP and human response.

Methods such as THERP or CREAM were born as approaches for nuclear power plants and consider only the typical accident scenarios in this context, so it is necessary to apply a lot of effort in different fields, such as manual assembly or manufacturing systems. (Schemeleva et al., 2012) In the same way, the main HRA simulation tools described are adapted to specific fields, such as aviation and nuclear power plant control rooms.

SHERPA's main objective is to provide a model to quantify the probability of human error in any work situation and in all contexts, a quantification that today is hardly possible given the lack of tools similar to that achieved in this work. Through SHERPA, the concept of human reliability, often treated only in theory, is approached in terms of production capacity (conforming and non-conforming articles or recovered articles), and useful information on human reliability can be obtained for all types of work (Di Pasquale et al., 2015).

The SHERPA model can be used effectively to assess changes in the probability of human error when there are changes in activity type, contextual conditions, work time, and assigned breaks during the shift. The main advantage of the model lies in its generic nature: it is suitable for any environment and working conditions, without limitations related to a particular sector or activity. A large number of scenarios can be simulated without consuming much time or resources (Di Pasquale et al., 2015).

7. CHARACTERIZATION OF RESULTS

Of the 5 selected articles, a table was made showing the breakdown of each of the words related to the operator's errors mentioned in said articles, this in order to give relevance to each of the problems made by the operator within the area of additive manufacturing, coupled with this, it was possible to identify the main reason for the failure caused by humans when coming into contact with the machines, in figure 3 the problem of the operator is manifested within the additive area, the results showed that in two articles refer to the problem of the omission of steps caused by the worker, in another article they mention the communicational failure that leads to operator errors, in three articles they agreed with the lack of skill of the operator, in one article they expose the lack of experience in purging filament of the machine, the last one does not inquire into the details of the manufacturer.

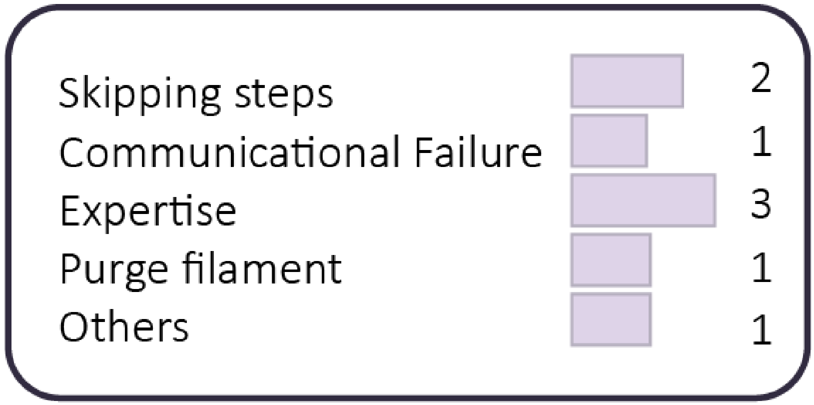

Figure 3. Articles exposing the different problems involving the operator in the additive area.

8. METHODOLOGICAL SCOPE OF RESEARCH

This study opens the door to future research to strengthen the various problems that cause millions in losses in the industrial sector. Projects have been proposed which analyze the waste of material within the additive area and its main errors due to the orientation of the part. But it is feasible to study human behavior and organizational behavior that leads to changes in failure rate (Song and Telenko, 2017). Most studies only consider the material and energy costs of buildings under ideal conditions. However, consumer use could have a large material impact for some products.

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STUDY OF MENTAL WORKLOAD IN HEALTH PERSONNEL DURING THE COVID-19 CONTINGENCY

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Resumen El estudio de los factores psicosociales y de carga metal en los sitios de trabajo siempre han sido de interés para el tomador de decisiones, sin embargo, es a raíz del inicio de la pandemia ante la aparición del virus COVID-19 que su análisis se ha vuelto indispensable para la calidad del trabajador. El presente estudio busca Determinar el nivel de carga mental y las características de sus dimensiones en asistentes médicos para la generación de propuestas que contribuyan a la mejora de dichos indicadores en una Institución de salud. El procedimiento empleado tiene su fundamento en el método NASA TLX el cual permite dictaminar la carga mental tanto por niveles y dimensiones. Como Resultados se obtuvo que el 50% (18) del personal de salud presenta carga mental Alta y 39% Media; en cuanto a las dimensiones con mayor presencia se tienen a la Frustración con 31% (11) y Rendimiento 19% (7); se estratificó la información recabada logrando la identificación de la condición en cada trabajador, así como la generación de propuestas que contribuyen a la mejora de los niveles antes mencionados. En conclusión, se tiene que se logró recabar información de gran relevancia para la atención de la carga mental en los trabajadores y así contribuir y/o evitar las complicaciones de salud física y mental derivadas de la misma.

Palabras clave: Carga mental, NASA TLX, COVID-19.

Relevancia para la ergonomía: Identificar de manera puntual y oportuna información esencial para la toma de decisiones relacionada con la presentación de factores de riesgo. De la misma forma el estudio permitirá complementar el análisis de riesgos del tipo psicosocial.

Abstract The study of psychosocial factors and mental workload in the workplace has always been of interest to the decision maker, however, it is because of the beginning of the pandemic due to the appearance of the COVID-19 virus that its analysis has become essential for the quality of the worker. The present study seeks to determine the level of mental workload and the characteristics of its dimensions in medical assistants for the generation of proposals that contribute to the improvement of these indicators in a health institution. The procedure used is based

on the NASA TLX method, which allows the mental workload to be determined by levels and dimensions. As results it was obtained that 50% (18) of the health personnel present High and 39% Medium mental workload; as for the dimensions with greater presence we have Frustration with 31% (11) and Performance 19% (7); the information collected was stratified achieving the identification of the condition in each worker, as well as the generation of proposals that contribute to the improvement of the levels mentioned above. In conclusion, it was possible to collect information of great relevance for the attention of the mental workload in workers and thus contribute and/or avoid the physical and mental health complications derived from it.

Keywords: Mental load, NASA TLX, COVID-19.

Relevance for ergonomics: To identify in a timely manner essential information for decision making related to the presentation of risk factors. In the same way the study will complement the analysis of psychosocial risks.

1. INTRODUCTION

Coronavirus is the name given to the family of pathogens that have caused various diseases in both animals and humans. (Editorial staff connects, 2020). The SARS-Cov-2 coronavirus is a virus that appeared in China. Then it spread to all continents of the world causing a pandemic. Currently Europe and America are the most affected. (Coronavirus Mexico, 2021).

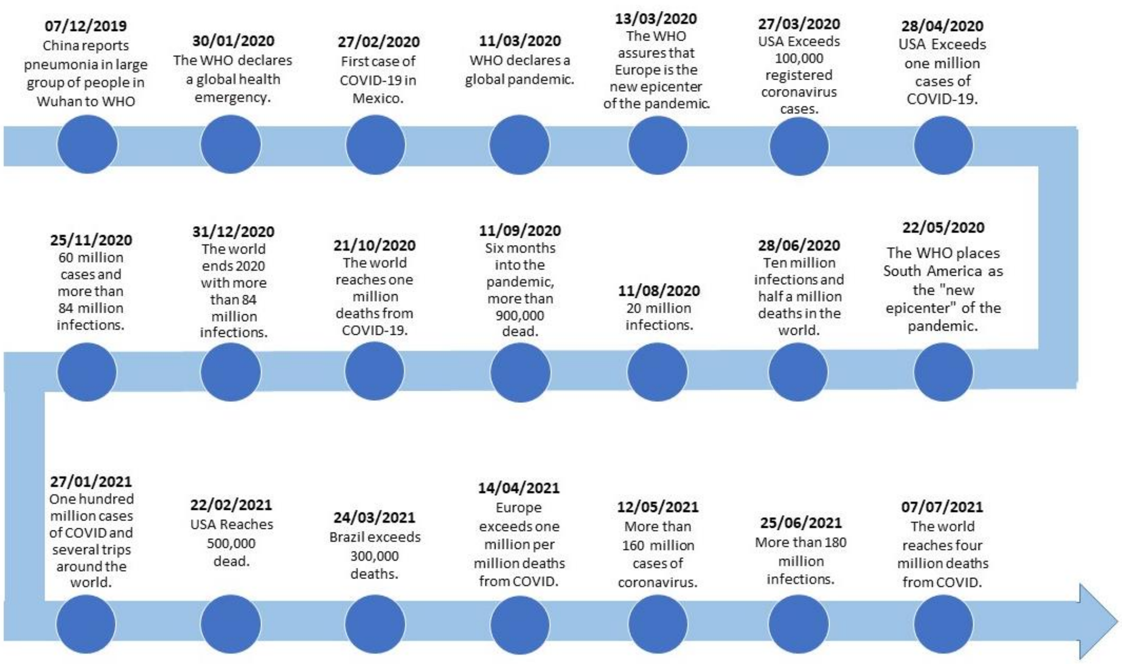

Figure 1. Timeline COVID 19
Source: Noticias en España RTVE (2021)

According to Figure 1 "Timeline" on December 7, 2019 China reported that a large group of people in Wuhan have pneumonia, being the beginning of a pandemic. Then on January 13, 2021 the same country publicly shares the genetic sequence of COVID-19, by the end of the month the World Health Organization (WHO) declares a health emergency. On March 11, 2021 the WHO declares COVID-19 a global pandemic. It can be observed that on March 13, 2020 the WHO assures that Europe is the new epicenter of the pandemic. Three months later the contagions increase to ten million contagions and half a million deaths in the world. 2020 ends with more than 84 million infections in the world and by July 7, 2021 the world reaches four million deaths due to COVID-19.

The SARS-COV 2 pandemic, although it has an unequal mortality in each country, has left more than four and a half million deaths worldwide, the countries with more deaths by COVID-19 are the United States, India and Brazil, the comparison between the deaths of countries with more than one million inhabitants in relation to their population shows that the country with a high mortality rate is Peru because for every 100,000 inhabitants there are more than 600 deaths. In the case of Spain currently reports a rate of 180 deaths, previously this country was in second place in this ranking and currently is not even in the top 20 countries with the highest mortality.

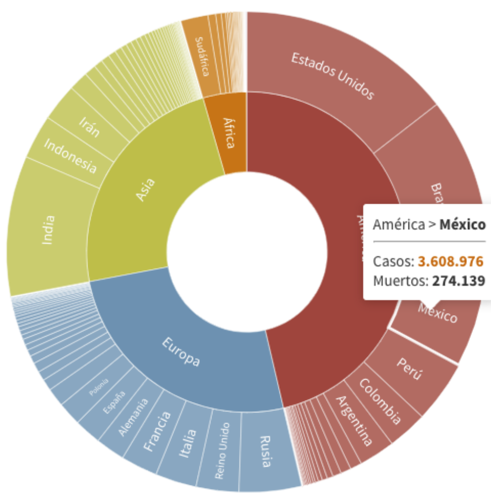

Figure 2. Coronavirus cases and deaths globally

Source: Noticias en España RTVE (2021)

The figure above shows the continents by color red (America), Blue (Europe), Green (Asia) and Orange (Africa). Based on the size of the color of the image shows the number of cases and deaths during the pandemic, in America the first place is the United States with 42,931,354 cases and 688,032 deaths, the country with more infections and deaths in Europe is Russia which has 7,313,112 and 200,245 respectively. In India, Asia has 33,652,745 cases and 446,918 deaths, and finally, in South Africa, a country on the continent of Africa, there are 2,896,943 cases and 87,052 deaths.

At December 2019 SARS-COV 2 appeared in the Middle East which triggered the disease we know today as COVID-19, its spread reached all corners of the world terrifying the population and finally being declared a global pandemic by the World Health Organization (WHO) in 2020. Since COVID-19 was declared a pandemic, several changes have taken place in the global medical community and health professionals are facing new challenges and unprecedented new situations (Díez, 2020). Currently in Mexico there are 3,608,976 confirmed cases and 274,129 deaths due to COVID-19.

Figure 3. Epidemiological Semaphore in Mexico
Source: Coronavirus.gob.mx/semaforo

The map above shows the current epidemiological traffic light in Mexico, which allows to easily observe the level of contagion in each state. (Ministry of Health, 2021) The highest level is red, currently no state has this color, this means that avoid going out if it is not strictly necessary, only essential economic activities are allowed. The states which should be more cautious are orange which means that the operation of economic and social activities will be with a capacity of 50%, in addition to reducing community mobility. The yellow color means that the operation of economic and social activities will be with a capacity of 75% and a slight decrease in public space. Finally, the green states have no mobility restrictions, the educational model will operate under the new normality as established by the SEP and the operation of economic and social activities will be carried out as usual.

As a result of the contagions, hospital occupancy increased abruptly, generating an increase in the workload of hospital workers in all established areas. One year after it began, in March 2021, hospital occupancy increased from 11% to 17%. (Government of the State of Sonora, 2021). Economic activities at the beginning of the COVID-19 pandemic were directly impacted by health containment strategies, which generated an economic crisis. As a result, businesses worldwide are suffering from a lack of revenue due to a lower rate of consumption. Depending on the industry, the estimated maximum time a company can operate without liquidity is between one and three months. Considering the estimated recovery time of an economic crisis as a multiplicative factor of the duration, i.e. if the crisis were to last 3 months, the recovery would take 9 months in addition to the duration of the crisis. So far it is estimated that the crisis could impact between 5% and 10% of the economic growth estimates of the countries. (Meade, 2020). In the first year of the study, there were about 151 COVID-19 deaths per 100,000 inhabitants and this disease has positioned itself as the leading cause of death, leaving behind cardiovascular diseases and diabetes mellitus (Cortés-Meda, 2021).

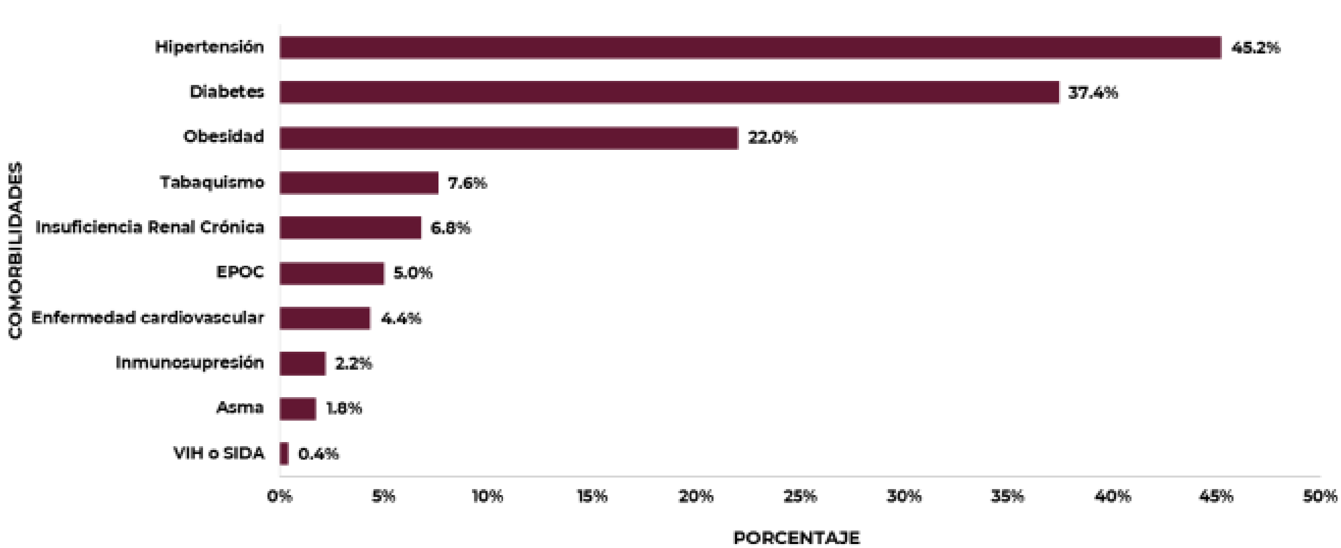

Figure 4. Main comorbidities in deaths positive for COVID-19
Source: EID, 2021.

During the first year of the COVID19 pandemic, the figure above shows the most common comorbidities in positive cases were hypertension (17%), obesity (15%), diabetes (13%), smoking (7%) and other diseases (8%); while in those who died from this cause, the most common comorbidities were hypertension (45%), diabetes (37%), obesity (22%), cardiovascular disease (11%), smoking (8%) and immunosuppression (5%). People who had two or more comorbidities increased their risk of dying. Twenty-eight percent had no comorbidity. (Cortés-Meda, A, 2021).

Of the total number of infections (2,144,588) in 2020, only 25% received hospital care. Nationally, only one in five people who died from COVID-19 was treated in an Intensive Care Unit (ICU). The most significant contrast is that of the IMSS, which only provided intensive care to 4% of the deceased persons it treated. In relation to intubation, a procedure that should be applied to the majority of serious cases, only 29% of the deceased were intubated. Again, the maximum contrast is observed in the IMSS, in whose medical units only 20% of the deceased were intubated. This is extremely relevant, because IMSS treats one out of every three people with COVID-19. (Canales AI, 2021)

Due to the seclusion and minimization of commercial activities and transport due to the state of alert, there has been a decrease in greenhouse gas emissions, especially from industry and road transport. In the short term, this is good news for the achievement of greenhouse gas mitigation targets, air pollution in cities has been reduced and one would even expect this to have an impact on the health of the people living in these areas, who are normally subjected to high levels of pollution. (Sanz, 2020)

Mental workload is defined as the number of processes required to finish an activity and according to the time in which a person can find the answers in his/her memory. (Mondelo, 2000) . With the application of new technologies, jobs increasingly require workers to process information. Being under so much pressure, health care workers are submerged to a high set of demands that, after being assessed as stressors, cause a systemic imbalance as shown in Figure 5.

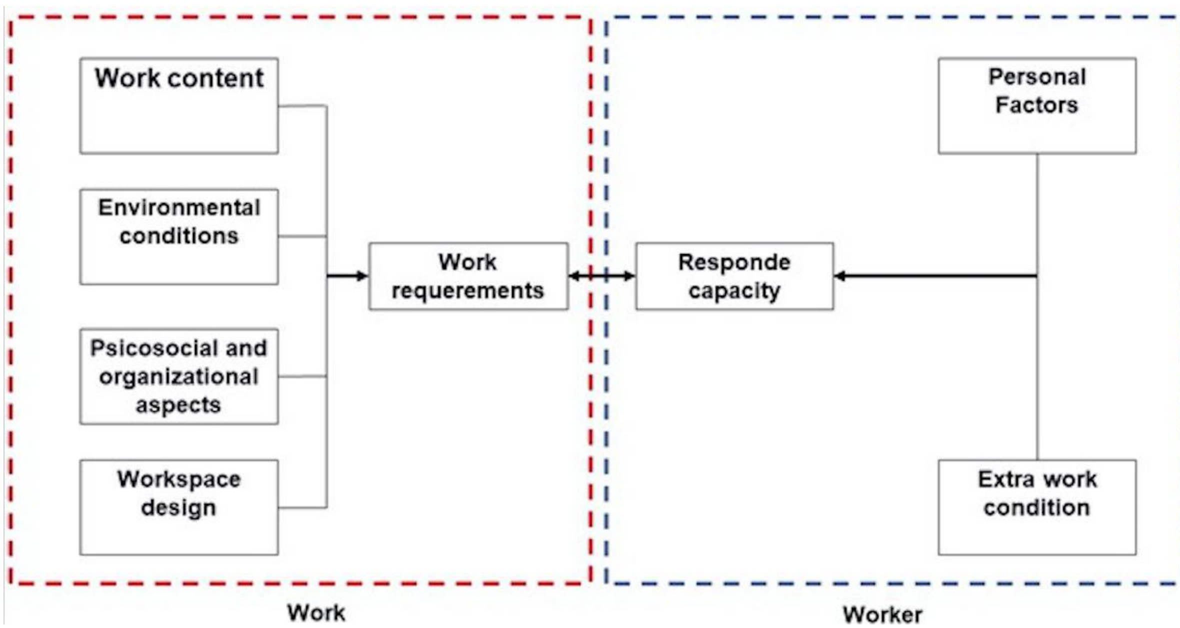

Figure 5. Groups of factors shaping mental workload and its effects
Source: INSHT (2002)

The above figure shows the factors of mental workload such as: *Content of the work*, demands of the task; *Environmental conditions*, noise, vibrations, lighting, temperature, etc.; *Psychosocial and organizational factors*, low work pace, the length of the working day, the number, duration and distribution of *breaks,* and other factors such as working relationships, communication possibilities, management style of the bosses, etc.; *Job design*, adaptation of the furniture and physical space, and the degree of comfort or discomfort.

In addition, with respect to the worker it is important to consider: Age, State of health, Degree of fatigue, Level of activation and variations in vigilance level, Sensory acuity and perceptual speed, Level and type of intelligence, Level of learning and experience in the task, Personality characteristics (anxiety, introversion/extroversion, etc.), attitude towards the task, motivation, interest in the task, satisfaction, etc. (INSHT, 2002).

In general, these stressors are considered by the workers, due to the amount of work and personal care when performing their tasks, with performance being the aspect most affected by health personnel when performing their activities.

The staff is made up of around 232 doctors, 583 nurses, 36 medical assistants, among administrative and cleaning personnel. To meet the demand for care in this region, there are 188 beds, 11 operating rooms, an Adult Intensive Care Unit, a Coronary Care Unit and a Cardiovascular Surgery Unit. In a single day, 388 consultations are provided -359 are specialty consultations, 20 surgeries are performed and 3,115 clinical analyses are carried out. Every day, 22 people are discharged and 21 are hospitalized, so its hospital occupancy rate is 91 percent.

Working hours are 8 hours with 2 days off per week, and in the case of night shifts, 11.4 hours 3 times per week. Although the working hours before the pandemic were not so long, after the pandemic the health institution requested extra shifts and they were rewarded as overtime, which caused their fatigue and mental workload to increase.

The situation generated in hospitals by the effects of the pandemic of covid-19 has generated in the people who work in these institutions that their workload increases and they work at more intense rhythms and workdays which has direct repercussions on their stress levels. Treating some of these stressors linked to the indicators described as: the number of patients that need to be treated, the material resources required for the treatment of patients, avoiding more infections from co-workers, among other factors that impact the life of health personnel.

Table 1. Health Indicators

Indicator	**Before the pandemic**	**During the pandemic contingency**
Number of patients	170	188
Material Resources	80%	65%
Number of infections	0	47
Percentage of cases of burnout	15%	40%

Health workers have seen how their colleagues during the pandemic were infected by covid-19, unable to provide humanitarian care due to work overload, and others became victims of aggression or social stigma. The workload exceeds personal resources. They stated that they lacked sufficient material resources to care for patients safely, so the mental health of these professionals has undergone profound changes. All of them increase the degree of stress, anxiety and depression, affect the performance of their professional functions and reduce their ability to concentrate, understand and make decisions. (Safety, 2020).

Health care workers have been observed to make complicated day-to-day decisions, including allocating scarce resources to equally needy patients and a constant search for how to provide care for all seriously ill patients. This can cause some workers to experience mental health problems that are compounded by their personal motives to balance their own physical and mental health needs with those of patients, families, and friends. Following the onset of SARS-COV-2 infection healthcare professionals have had a major psychological impact, about 40% suffer from some form of burnout either physical or emotional, thus, increasing the requirement for psychological care in hospital workers (Safety, 2020).

Given the situation described above, the following question arises: *¿What Will be the level of mental workload and its main dimensions in workers of a health institution?*

2. OBJECTIVE

To determine the level of mental workload and the characteristics of its dimensions in workers for the generation of proposals that contribute to the improvement of the indicators in a health institution.

3. METHODOLOGY

The subject under study includes health personnel with the category of medical assistant in a health institution. The methodology is based on the application of the NASA TLX method, the steps of which are shown below.

1. Determine the size of the sample to be studied: To determine the sample to be studied, a 95% confidence level and a 5% error rate were considered; however, for the study it was decided to consider the total population and/or health personnel.

2. Collect data: For this activity a survey was applied using the NASA TLX method instrument considering as the task all those activities that they perform daily in their work. Prior to its application, it was explained to each of the participants what each of the dimensions that make up the method and the importance of the study.

3. Analyze and interpret the data: A database made in Microsoft Excel was used to capture the information acquired, once the data capture was done the statistical analysis was performed by determining the percentages of incidence of the different variables, presenting these results in an orderly manner through graphs and inquire about the main reasons for the mental workload of the assistants.

4. RESULTS

As an initial phase, once a 95% confidence level and a 5% error rate had been calculated, it was determined that the number of surveys applied would be 36 medical assistants. The next step was to characterize the sample whose relevant data are listed below:

- 22.3% of the women surveyed were between 24-27 years of age, 16.7% of the women surveyed were 28 years of age, 24.9% were between 31-34 years of age and 28% were between 35-48 years of age.

- Regarding the marital status of the respondents it is known that 53% are single and 47% are married.

- With respect to the schooling of the respondents, 72% have university studies, 22% have high school and the rest have secondary education, while 22.2% have high school and only 5.6% have only secondary education.

Once the surveys had been applied and the relevant data obtained, the results were evaluated by organizing the data and observing the outstanding dimensions of the mental workload of the health personnel under study. The following is a graph showing the general results of the level of mental workload.

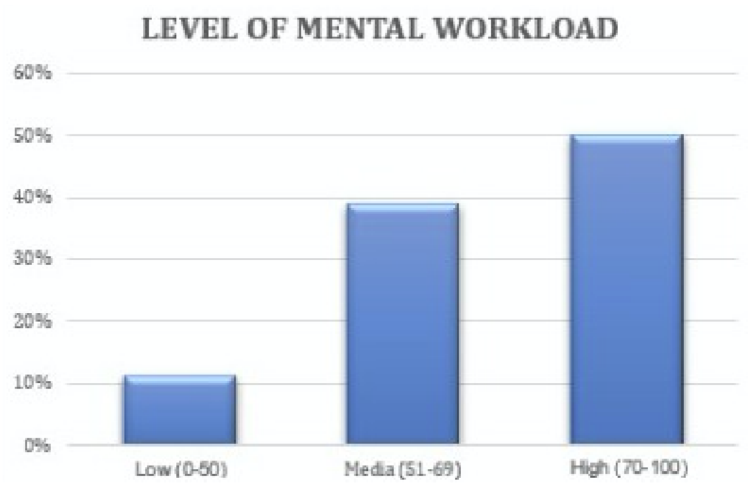

Figure 6. Level of mental workload

Figure 3 shows that 50% of the health personnel under study are in high level of mental workload, this is because it has been verified that the work environment has a strong impact on the mental health of the workers. Thirty-nine percent are in the medium level of mental workload, while 11% have a low level of mental workload. Taking into account that 41.8% are under 30 years of age, being young workers. The COVID-19 pandemic exposed health workers to situations in which they had to make complex decisions and above all work under pressure in situations of high stress, in terms of the highest dimensions we have the following.

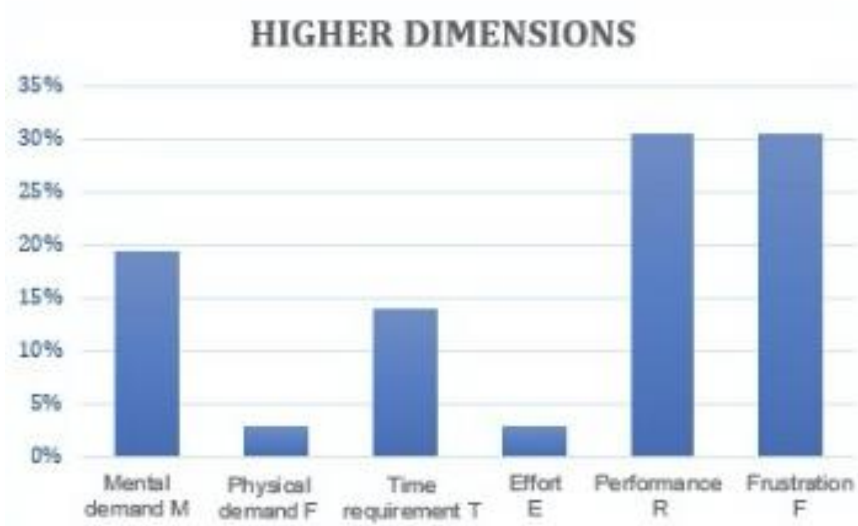

Figure 7. Higher dimensions

In the evaluated personnel as shown in figure 4 that the highest dimensions are performance and frustration with a percentage 31% corresponding to 11 people in each dimension, mental demand had a result of 19% with a total of 7.

Table 2. Study results

Workers	Higher dimension	Mental workload level	Risk	Workers	Higher dimension	Mental workload level	Risk
1	Fr	60	Media	19	Fr	73	High
2	M	55	Media	20	M	91	High
3	Fr	89	High	21	T	73	High
4	Fr	81	High	22	E	32	Low
5	R	61	Media	23	M	51	Media
6	M	88	High	24	Fr	69	High
7	T	54	Media	25	R	85	High
8	Fr	83	High	26	R	46	Low
9	T	54	Media	27	Fr	91	High
10	T	54	Media	28	M	93	High
11	M	29	Low	29	F	55	Media
12	T	61	Media	30	R	65	Media
13	R	74	High	31	Fr	82	High
14	R	70	High	32	M	64	Media
15	Fr	80	High	33	R	65	Media
16	Fr	73	High	34	R	63	Media
17	R	44	Low	35	Fr	85	High
18	R	57	Media	36	R	72	High

Table above shows the results of the study, the light green cells mean that the risk is low (0-50 points) only 4 workers have a low risk. Medium risk (51-69 points) is the yellow colour, 14 workers are medium risk. 18 workers are high risk (70-100 points). When evaluating 38 workers 50% have a high risk, so it is necessary to act.

The frustration of health care workers increased significantly from the beginning of the pandemic, due to the fact that they had a different work rhythm, which when the disease arrived caused tension and a bit of hysteria regarding the safety measures that were required, such as the distance greater than 1.50 meters, the use of masks and the continuous washing of hands. For health personnel at the beginning of the pandemic it was complicated to maintain all the safety factors when they had direct contact with COVID-19 positive patients, because they still did not have the necessary protective equipment and much less a vaccine to protect them, this caused the concern of bringing the disease to their loved ones. Some would stay away from their families for months at a time to avoid contagion.

When the information is sorted, the following diagram of attention by dimension is obtained

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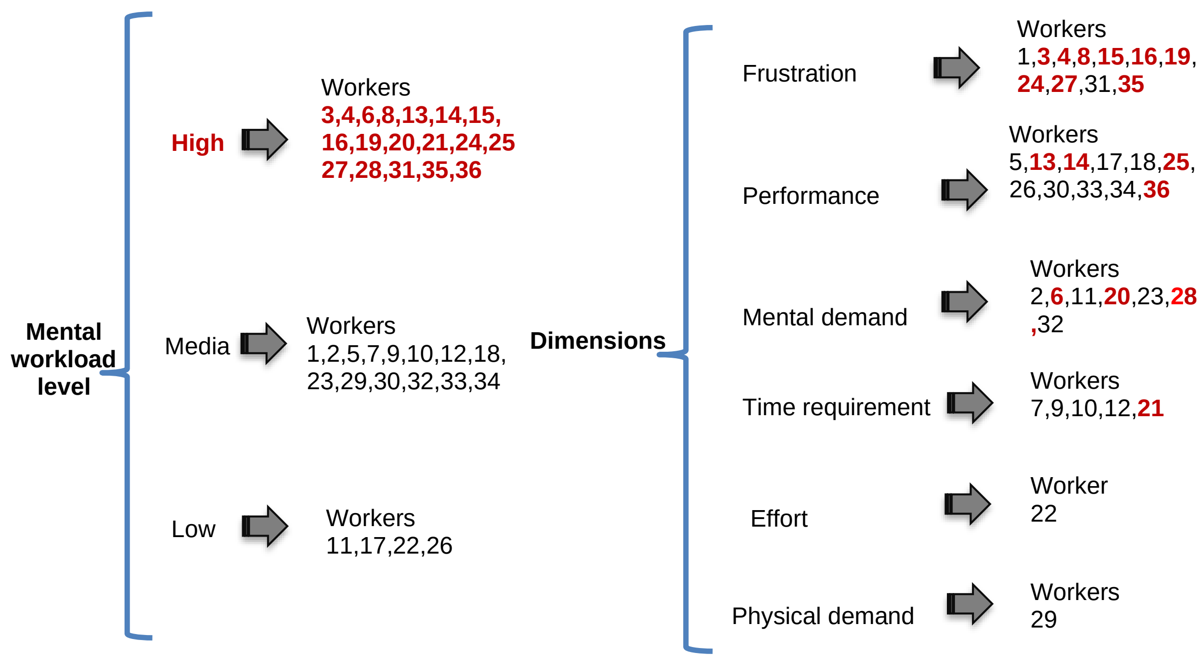

Figure 8. Stratification by mental workload level and by dimension

Figure 6 shows two synoptic maps, one shows the level of metal workload divided into high, medium or low, and then indicates the workers who suffer from each one. The following one shows the dimensions that are frustration, performance, mental demand, temporal demand, effort and physical demand, in each one are shown the workers that indicate in that dimension besides identifying in this last one in red color those of High mental load this for a greater approach at the time of establishing the proposals of improvement.

Once the workers have been identified by load level and size, the following recommendations are presented for their attention:

Table 3. Plan of attention of the dimensions

Dimension	Actions
Frustration	Set clear boundaries at work, promote healthy habits, and find strategies to counteract stress and frustration.
Performance	It is necessary to emphasize that the success of the programs in general is not the correction, but the prevention, as well as the strengthening of the own capacity of resistance, since each person has a different capacity of resistance, which is modulated depending on the age, sex, among others, as well as with healthy habits as much physical as mental. A restructuring of positions in the health institution could help in the performance of the staff, since the activities that are performed will be well distributed among them, providing better care to patients, in addition to less workload, greater efficiency and effectiveness.
Mental demand	Maintain direct communication with employees and unions about how the pandemic is affecting work.
Time requirement	Reorganise working time (type of working day, duration, flexibility, etc.) and provide sufficient time for self-distribution of some short breaks during each working day.
Effort	Update tools and work equipment (help manuals, checklists, registers and forms, work procedures, etc.) following the principles of clarity, simplicity and real usefulness.
Physical demand	Training to workers to facilitate and streamline patient care. Redesigning the workplace (adapting spaces, lighting, sound environment, etc.).

In addition to the above, workers with high mental workload will be supported through: the realization of workshops of interest with topics related to psychosocial factors and psychological support focused initially to address the high levels of frustration and performance.

5. CONCLUSIONS

When using the NASA TLX evaluation method, it was obtained that the mental workload of half of the health personnel evaluated is high, taking for granted the stress that they live day by day thanks to the COVID-19 pandemic. It was shown that the highest dimensions in the study are performance and frustration when performing their activities.

Due to the fact that 47.2% of the personnel evaluated are married and have families, in addition to the mental burden of their work activities, they also have personal matters, which increase their mental burden. Conducting this type of study allows us to identify how likely they are to suffer from stress, which is generated by their mental workload. It also provides information on the different dimensions that should be worked on to minimize this burden (mental workload, physical workload, time demands, frustration, performance and effort).

Knowing the mental workload to which health personnel are subjected will also allow the departments involved to generate programs or strategies to reduce this factor, thus reducing lag or even desertion, since this could lead to greater utilization during their workday and also prevent both physical and mental health problems.

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MENTAL LOAD ASSESSMENT OF THE MEMORY GAME FOR THE ANTHROPOMETRIC POSTURES USING THE NASA TLX METHOD

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Resumen: Este documento presenta un estudio comparativo entre dos formas distintas de aprender las posturas de antropometría básicas. El juego de memoria Posturama se trata de enseñar a las personas interesadas en la ergonomía las posturas de antropometría básicas y de la vida cotidiana, mediante un juego de memoria que al tratar de relacionar los pares de las postura correcta con la incorrecta , estos observarán como se realiza adecuadamente cada postura, también se añadió una breve descripción de cada postura para que así también puedan razonar como se debe implementar la postura mediante un poco de teoría, es aquí donde entra el aprendizaje cognitivo.

Se evaluó mediante el método NASA TLX la carga mental que implica el aprendizaje de memorizar, tal como lo son las posturas de antropometría. Es donde se aplicó el juego de memoria para agilizar el aprendizaje y a la vez ayudar a incrementar su capacidad de memoria o de retención de datos. La evaluación de la carga mental que presentaron los alumnos fue captada mediante una evaluación de entrada y otra de salida de pruebas que se aplicaron a lo largo de este proyecto para medir las dificultades de los alumnos al tocar el tema de las posturas antropométricas.

Los resultados finales de las dos pruebas realizadas con las que se evaluaron mediante el método NASA TLX con la primera prueba, los alumnos mostraron una carga mental media; en cambio al realizar la última prueba con Posturama, lo resultados demuestran que los alumnos presentaron una carga mental baja.

Palabras clave: Antropometría, ergonomía cognitiva, didáctico.

Relevancia para la ergonomía: Aprendizaje de la ergonomía cognitiva por medio del método NASA TLX

Abstract: This document presents a comparative study between two different ways of learning basic anthropometric postures. The Posturama memory game is about teaching people interested in ergonomics the basic anthropometric and everyday life postures, through a memory game that when trying to relate the pairs of the correct posture with the incorrect one, they will observe how each posture is performed properly; a brief description of each posture was also added so that they can also reason how the posture should be implemented through a little bit of theory, thus where cognitive learning comes in.

The mental load involved in learning to memorize, such as anthropometric postures, was evaluated using the NASA TLX method. This is where the memory game was applied to speed up learning and at the same time help increase the student memory or data retention capacity. The evaluation of the mental load that the students presented was obtained through entrance and exit evaluations of tests that were applied throughout this project to measure the difficulties of the students when being taught the subject of anthropometric postures.

The final results of the two tests evaluated with the NASA TLX method: with the first test, the students showed a medium mental load; on the other hand, when performing the last test with Posturama, the results show that the students presented a low mental load.

Keywords: anthropometry, cognitive ergonomics, didactic.

Relevance to ergonomics: Learning cognitive ergonomics through the NASA TLX method.

1. INTRODUCTION

The Posturama memory game is about teaching the students who take the ergonomics class the basic anthropometric and everyday life postures, through a memory game that when trying to relate the pairs of the correct posture with the incorrect one, they will observe how each posture is properly performed. A brief description of each posture was also added so that they can also understand how the posture should be implemented through a description, this is where cognitive learning occurs.

The evaluation was based on a test to assess the level of mental load that students present when taking a test of anthropometric postures. After applying the first evaluation with the NASA TLX method, the memory game was put to the test with ten students who answered the questions required by the NASA TLX method to evaluate the mental, physical, temporal, performance, effort and frustration load when using Posturama.

Based on the results of the two tests assigned to the students, they were evaluated using the NASA TLX method, considering for the making of Posturama.

2. OBJECTIVES

- Assess mental load through a memory game, using basic anthropometric postures, in order to achieve meaningful learning.
- Apply a survey to the students who study ergonomics to analyze the level of knowledge about the anthropometric positions that exist and the use of it.

- Evaluate using the NASA TLX method what kind of mental demand the Posturama requires.
- Apply the memory game in the ergonomics course as part of the student´s academic training.
- Make a Pareto chart to analyze the results of the survey.
- Design a memory game that facilitates the teaching of the basic concepts of anthropometry, as a learning tool for students.

3. METHODOLOGY

First, an idea was raised to create a memory game that would help students in the ergonomics class to have greater cognitive retention.

A cognitive ergonomic study was generated, applying input surveys to students who complete the ergonomics subject to justify its viability. As shown in the following Figure.

Cognitive Ergonomics.
Read each question and underline the answer according to your judgment. This survey is carried out to evaluate the knowledge of the fundamentals of ergonomics, as well as to present a method to facilitate the learning of correct and incorrect anthropometric postures.
Cognitive. It is the ability of a living being to process information from perception, acquired knowledge (experience) and subjective characteristics that allow the information to be valued. It consists of processes such as learning, reasoning, attention, memory, problem solving, the way of decisions, feelings.
Are you having trouble understanding the terms covered in ergonomics class? Yes ___ No ___
Have you tried any method or technique to learn ergonomics easier? Yes ___ No ___
Do you know the memory board game? Yes ___ No ___
Do you know the cognitive benefits of the memory board game? Yes ___ No ___
How do you consider that you have your memory receptor capacity? Good ___ Regular ___ Bad___
Did you know that there is a method to measure your memory? Yes ___ No ___ Other___
Did you know that playing a memory game frequently speed up your data retention capacity? Yes ___ No ___

Figure 1. Survey for the input evaluation test.

A knowledge test was formulated to the students taking the ergonomics subject to evaluate the memory game based on the NASA TLX method, this is shown in Figure 2.

Match each description to the position it corresponds to, placing the position number next to the description.

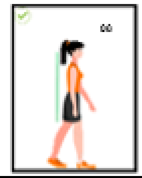
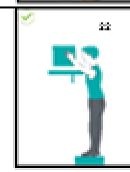
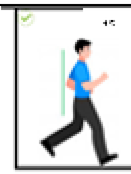
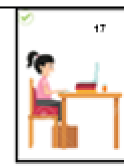
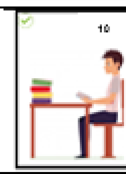
	Keep your gaze straight ahead with your shoulders relaxed, elbows at 90 degrees. Arms parallel to the trunk and fists loosely, keep the trunk upright above the hips without losing the alignment between pelvis and occiput, avoid excessive lateral displacements of the hip.	
	It is recommended that the column is aligned to the back of the chair, the hands with the book should be on the table, the soles of the feet aligned to the floor.	
	Do not bend your back, bend your knees and lean firmly on your feet and legs, when getting up, hold objects close to your body and lift objects only to chest height.	
	The back should be supported by the backrest, the shoulders relaxed, placing the forearms on the table. The soles of the feet resting on the ground, with the feet parallel and at the same level, if they do not reach the ground because the chair is too high, use a footrest as the feet should never hang.	
	When it is necessary to make turns, the torsion of the trunk with load should be avoided, the whole body should be turned by means of small movements of the feet.	
	The arms should never be raised, since in this way the object is very far from the lumbar spine, what should be done is to place ourselves at the same height as the object using a ladder, bring it as close as possible to the body and then descend.	
	Head and chest should be straight and aligned.	

Figure 2. First evaluation of knowledge.

The memory game (Posturama) was created with 25 descriptive cards of the different basic anthropometric postures and everyday life, based on the principles of cognitive ergonomics.

4. RESULTS

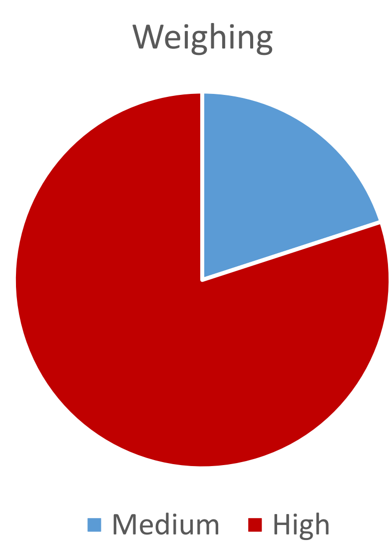
After applying the test with the anthropometric postures, the seventh semester students were evaluated with the anthropometric postures, the seventh semester students were evaluated with the NASA TLX Method format where the results regarding the evaluation showed that taking a theoretical test (Figure 1), is moderately frustrating, stressful and with a high mental load. As showing in the following table 1.

	No. of Student	Mental Demand	Physical Demand	Temporal Demand	Performance	Effort	Frustration	TOTAL	
WEIGHTED SCORE	1	650	100	1050	1050	1050	1200	850	Medium
	2	500	900	650	1200	1000	1500	958,3	Medium
	3	400	0	975	75	1250	1300	66,7	Medium
	4	2500	850	1425	525	400	450	1025	High
	5	1375	400	525	1500	350	1500	941,7	Medium
	6	1700	450	600	1500	1000	275	920,8	Medium
	7	1800	700	375	1125	450	500	525	Medium
	8	475	1050	600	1600	500	1500	954,2	Medium
	9	650	100	1050	1050	1050	1200	850	Medium
	10	1500	0	1600	275	800	2375	1091,7	High
							TOTAL	908,33	

Medium	20%
High	80%

Table 1. Weights before Posturama.

80% of the students who were evaluated by the input test presented a medium mental load, above 500 points and below 1000 points. The remaining 20% had a high mental load over 1000. As shown in the following graph 1.



Graph 1. Weights before Posturama

After applying the Posturama memory game to the seventh semester students, they were again evaluated with NASA TLX. The evaluation yielded the following results (shown in Tables 2 and 3).

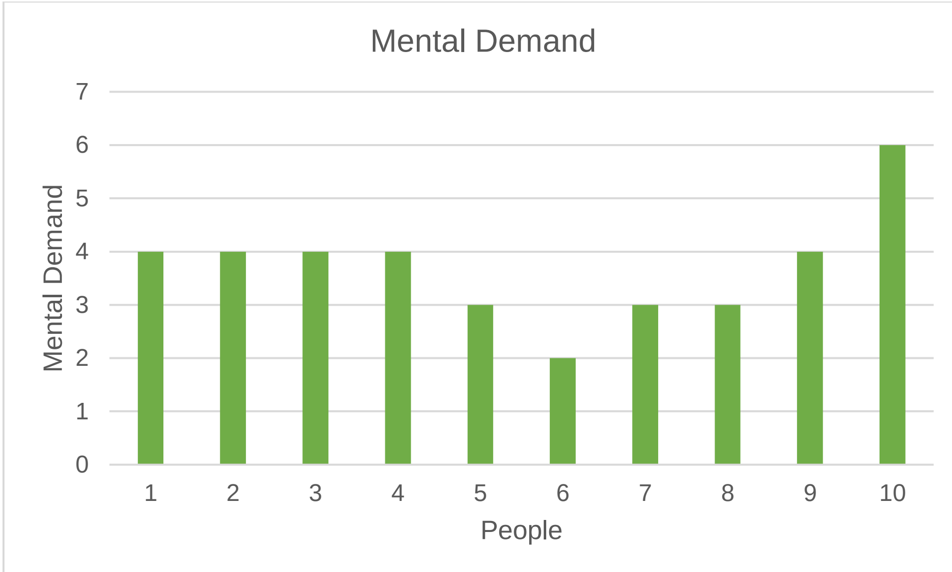
Table 2. Weights after using Posturama

	No. of Student	Mental Demand	Physical Demand	Temporal Demand	Performance	Effort	Frustration	TOTAL	
WEIGHTED SCORE	1	600	700	600	1000	75	75	508,3	Medium
	2	375	150	450	1000	200	150	384,5	Low
	3	225	300	225	1000	125	125	333,3	Low
	4	150	300	150	1000	300	300	36637	Low
	5	250	150	150	100	100	50	133,3	Low
	6	75	200	100	1500	300	150	387,5	Low
	7	500	75	0	1500	450	450	495,8	Low
	8	200	0	75	1350	500	600	454,2	Low
	9	300	0	75	250	500	300	237,5	Low
	10	500	75	0	1500	450	450	495,8	Low
							TOTAL	380	

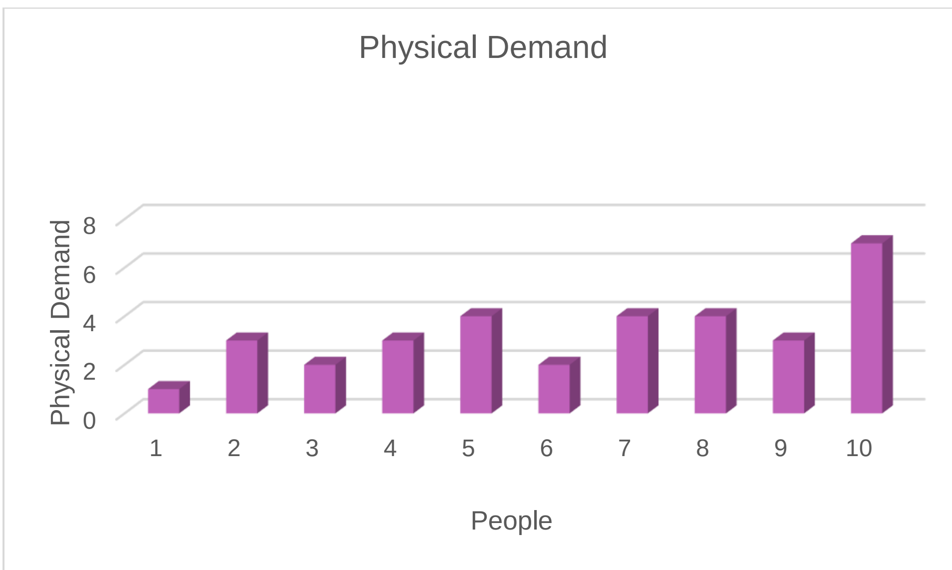
Table 3. Scores after using Posturama

PEOPLE	Mental Demand	Physical Demand	Temporal Demand	Performance	Effort	Frustration
1	4	1	1	10	5	3
2	4	3	3	18	4	6
3	4	2	6	20	8	6
4	4	3	7	20	6	6
5	3	4	2	20	3	2
6	2	2	2	20	2	2
7	3	4	3	20	4	4
8	3	4	3	20	5	5
9	4	3	6	20	4	2
10	6	7	8	20	3	3

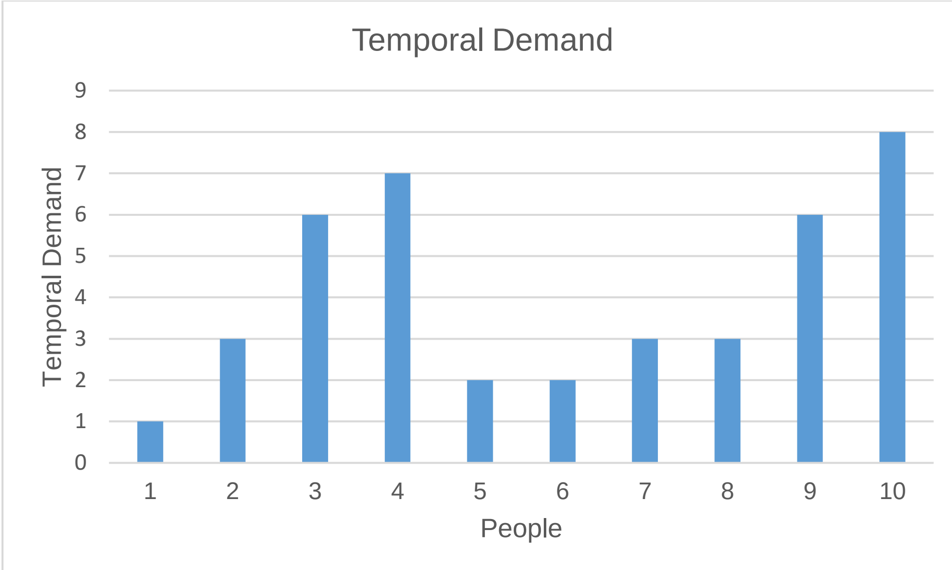
Tabulation of factors of the NASA TLX Method using Posturama for the evaluation of mental load (as illustrated in Figures 2, 3, 4, 5, 6 and 7).



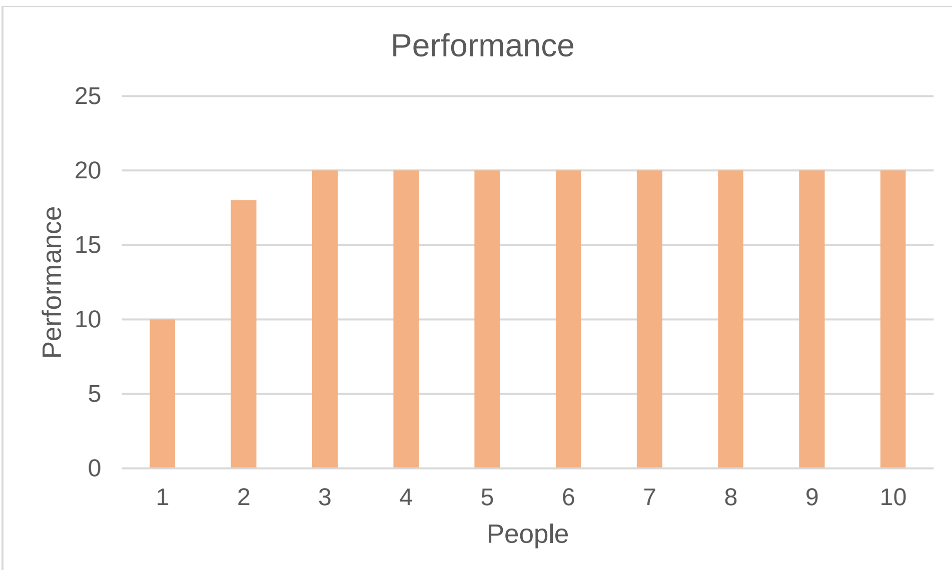
Graph 2. Mental Demands after using Posturama.



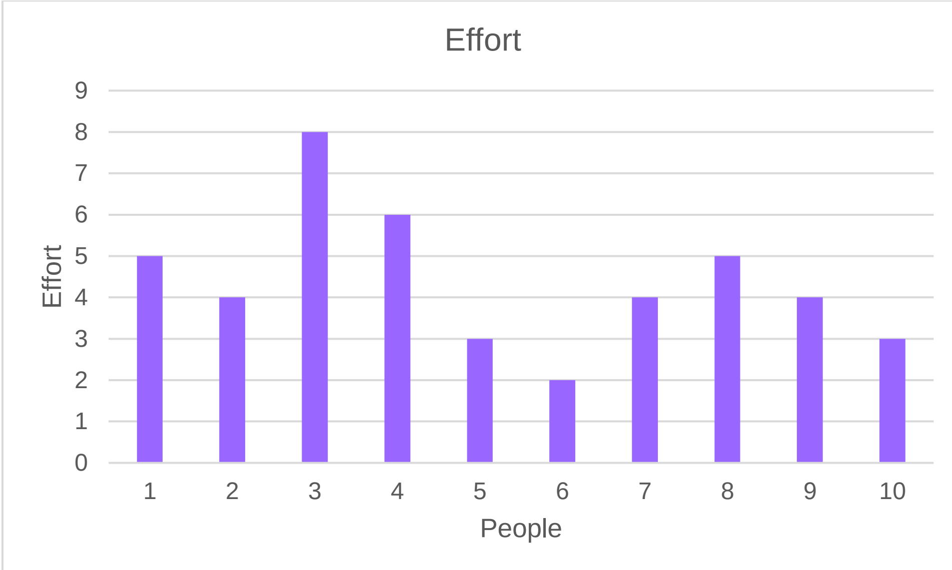
Graph 3. Physical Demand after using Posturama.



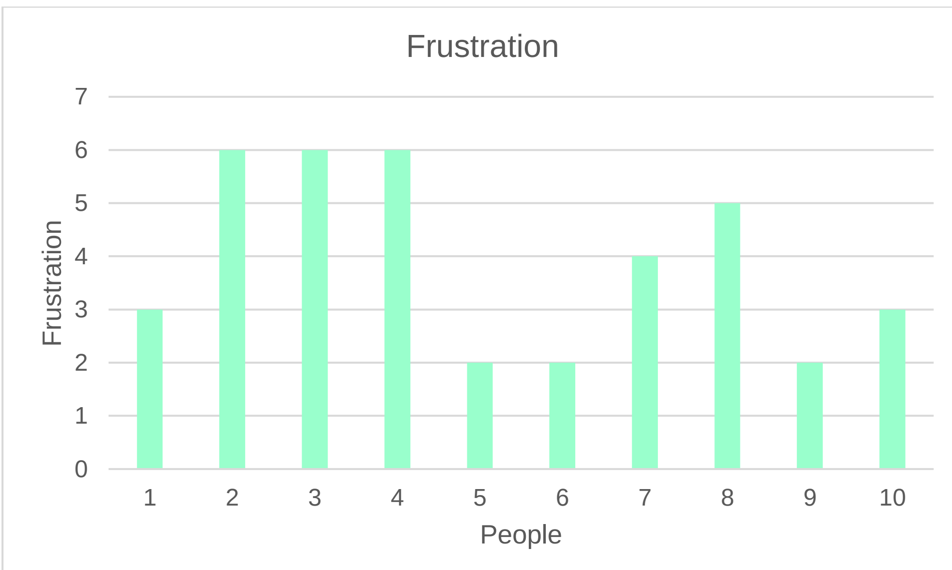
Graph 4. Temporal demand after using Posturama.



Graph 5. Performance after using Posturama.

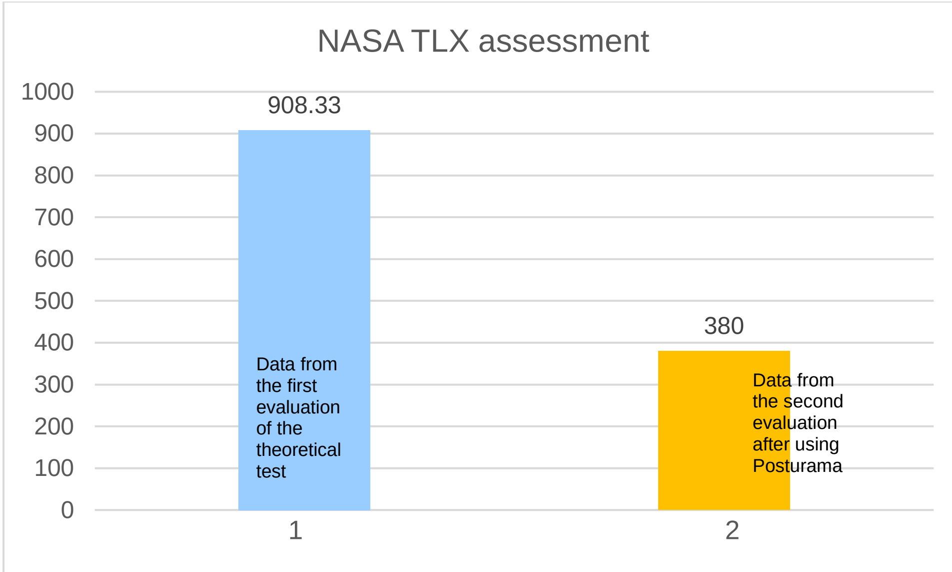


Graph 6. Effort after using Posturama.



Graph 7. Frustration after using Posturama.

Taking as a basis the results obtained by the NASA TLX method, making the comparison between the first evaluation and the second after applying the Posturama memory game; showed that the first evaluation carried out on the students demanded a medium to high mental load, in the second evaluation they presented a low mental load, that is, it is cognitively ergonomic. As shown in the following graph 8.



Graph 8. Comparison between evaluations.

The Posturama game with the descriptive cards of the anthropometric postures is shown in Figure 3.

Figure 3. Posturama game.

5. CONCLUSIONS

With this Project, awareness is raised about how dynamic learning influences our memorization and learning in a more agile way. With this Posturama game, the learning level in cognitive ergonomics with respect to anthropometric postures is improved; thus, learning is stimulated in a fun and enjoyable way. Therefore, the students present a higher mental load with theoretical tests and a low mental load with the Posturama game, then frustration is closely linked with the Mental Load based on the results obtained, consequently Posturama turns out to be cognitively ergonomic.

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ERGONOMICS APPLIED IN THE ICE CRAM INDUSTRY

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Resumen: La máquina automatizada de bolis (MABS) fue elaborada con la finalidad de mejorar las condiciones físicas del operador que realiza el proceso de envasado y sellado de productos congelados de PALETERÍA LA REYNA. Se realizó un análisis ergonómico para poder determinar el desgaste físico que el operador estaba teniendo al momento de trabajar con la máquina convencional de elaboración de bolis, sin embargo con el rediseño de una máquina automatizada (MABS), se logró mirar el gran cambio y disminución de esfuerzo del operador ya que sus actividades se han reducido y solamente tiene que estar al pendiente de rellenar la máquina de materia prima.

Palabras clave: Condiciones, proceso, análisis ergonómico, máquina, rediseño

Relevancia para la ergonomía: con la aplicación de las herramientas ergonómicas se pudo llegar a mejorar la postura del operador y e incremento el nivel de producción ya que con la maquina automatizada el operador disminuye el contacto con la máquina.

Abstract: The automated ice cream machine (MABS) was developed in order to improve the physical conditions of the operator who performs the packaging and sealing process of frozen products from ICE CREAM SHOP LA REYNA. An ergonomic analysis was carried out to determine the physical wear that the operator was having when working with the conventional machine for making pens, however with the redesign of an automated machine (MABS), it was possible to look at the great change and decrease operator effort since his activities have been reduced and he only has to be aware of filling the machine with raw material.

Keywords: Conditions, process, ergonomic analysis, machine, redesign

Relevance for ergonomics: with the application of ergonomic tools it was possible to improve the position of the operator and increase the level of production since with the automated machine the operator reduces contact with the machine.

1. INTRODUCTION

Handicraft production is developed in various areas, this activity is based on the use, exploitation and creative transformation of various materials.

MABS was elaborated through the intensive analysis of the processes developed in ICE CREAM SHOP LA REYNA, since two of the creators are children of the owners of this company, who have a family tradition in the production and commercialization of frozen products. This environment allows an analysis of the artisanal process in this company.

Based on this continuous observation, the idea of automating the packaging and sealing processes was developed. Through an analysis of process engineering for manufacturing, the adequate structure was obtained according to the initial needs of the company ICE CREAM SHOP LA REYNA; However, as MABS research and development progressed, it was identified that the conventional machine operator was presenting some problems with bodily mobility (Lobato2016).

This is when the investigation begins and the important role that the operator plays at the time of Working with the machine and with some ergonomic principles we realize the bad design of the machine and the dangerous and excessive loads that the operator carries out.

An improvement will be made in the ice cream production area since there is an economic loss of production in an 8-hour workday, these costs are generated by the use of a manual ice cream machine that is more than 30 years old. .

The ice cream making activity is carried out manually as shown in figure 1. In this machine, bad postures are obtained as well as highly dangerous jobs such as heavy loads on dangerous heights and repeated operations.

Figure 1. Manual machine for making pens
Source: Image taken at ICE CREAM SHOP LA REYNA

This Research has taken its progress to the level of the prototype design for a multipurpose manufacturing system, where its main objective is the packaging and sealing of various products seeking quality, efficiency and health care for the operator.

2. OBJECTIVES

The benefits that arose with the completion of this research are defined below.

General objective

Improve operator health with improved machine utilization and increase operator performance as well as increase production of sealed products.

Specific objectives

• Analyze the process and determine sub-tasks that are defined as dangerous according to ergonomic principles.
• Analyze the severity of each activity through different tools.
• Redesign every activity that damages the operator, even his work station.

3. JUSTIFICATION

With the realization of this project, benefits will be obtained not only for the worker, but also for the company since the process and the machinery will make everything faster and well defined, the worker will feel more comfortable with the realization of the activity and will be more efficient in its functions. With the improvement to the machine, the knowledge of its use will be available and it will be possible to facilitate the performance of the task. When the defined process is found, waste reduction will be obtained. Something that makes the operator feel very important is that much of the process is improved with the operator's help and input.

4. DELIMITATION

The improvement of this project will be carried out in the area of ice cream production precisely in the sealing process in the ice cream machine, an activity that is carried out in the LA REYNA ice cream parlor, in the machine for sealing and packaging for food products.

Ergonomic evaluation methods

Currently, workers complain of muscle aches and back pain, all associated with the physical load of work or the misuse of equipment and machines and this leads to the appearance of fatigue, discomfort, pain or injuries.

That is why it must be taken care of and prevented to avoid and that workers suffer injuries.

Symptoms related to the appearance of musculoskeletal disorders include muscle and/or joint pain, tingling sensation, loss of strength and decreased sensation. It can also cause tiredness and decreased ability of the worker.

The cost for damage generated in a person who continues with the manual process for making ice cream is depending on its damage in different areas, the most common areas of the body where damage occurs are:

- Lumbar.
- Sacred.
- Shoulder.
- Knees.
- Thighs.
- Ankles.
- Neck.

Depending on the severity of the injury is the economic impact for a company that is why risk factors must be identified and evaluated, to avoid negative effects on individuals and entities.

5. METHODOLOGY

In order to make the improvements, we first used the 12 ergonomic principles (Middlesworth 2013), with this we detected the first problems such as elbow positions, the polyethylene grip with the hands, and the bad design of the chair that the operator is using from the structure of the first machine used, of the 12 principles the operator could only correctly comply with only 4 of them and the other 8 principles are the ones that most damage his health.

For the liquid refilling process, the operator had to lift high risk loads from a bucket of more than 10 Liters as shown in figure 2 and also the operator could load the bucket above his head more of 18 times with a duration of at least 5 seconds and to verify its severity we used the NIOSH analysis . (Rochalimaea 1995), at the time of using this tool it gave us surprising information since the operator was performing a high risk activity.

Figure 2: Lifting the cuvette on the operator's head.
Source: Image taken at ICE CREAM SHOP LA REYNA

And finally we use the RULA method (Lopez,2014), this helps us to see the activities that are repetitive since the operator at the time of filling the polyethylene machine puts the plastic film inside a stainless steel tube and makes a horizontal movement from right to left to go through the polyethylene and fill it, on the other hand we have the activity of pulling the polyethylene to be able to make the cut with hot sealing and then be able to pass the pens to the machine that freezes them and the damage caused by poor working conditions , since the machine is not adapted to the operator. To improve production and reduce waste, the cutting / sealing method was analyzed, which was the one that produced a large amount of waste since if the operator did not seal the pen well, that pen would be wasted and at the end of the day the company had to at least a loss of 300 pesos per day of production.

6. PROCEDURE

First, you start looking for a problem that is easier to investigate and in the case of an ergonomic improvement, it helps a lot if the operator has a very close approach to find in an easier way possible failures or damages to the operator.

The analysis begins by looking at the process of making pens and especially at the operator who uses the manual packaging machine, followed by knowing what are the annoyances that are occurring at the time of carrying out their operations, when having an interview with him, we He comments that his main complaints are in his ankles, his instep on the right side as well as his lower back, followed by a discomfort in his right arm.

The operator is a person with a very large size as shown in figure 3, in the eyes of a person without knowledge of ergonomics could say that he is in good condition but nevertheless, it is possible to observe the damage that is generating on his shoulders when stopping the bucket, on the other hand you can see the chair with a bad design for the operator and without reloading for his elbows and finally we have the bad position of his ankles, generating a problem in his instep such as shown in figure 4.

Figure 3: Operator sealing ice cream.
Source: Image taken at ICE CREAM SHOP LA REYNA

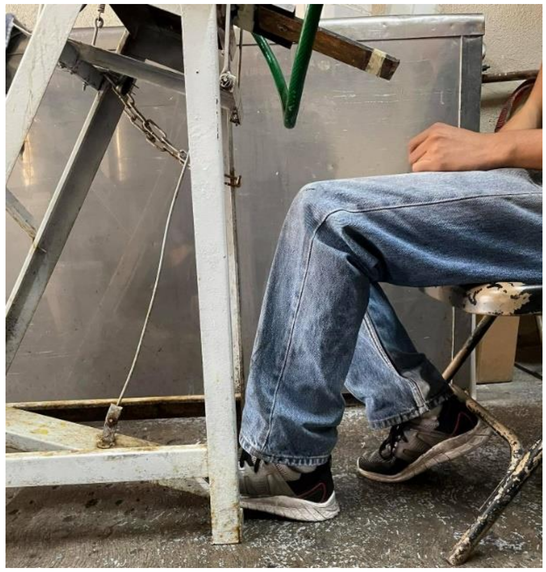

Figure 4: Operator showing the damage to his instep.
Source: Image taken at ICE CREAM SHOP LA REYNA

On the other hand, automated machines are also analyzed in order to obtain information on how it is that operators can also be damaged but designers do not think about the damage they cause them, in the following figure 5 it is shown that the machine performs its operation but nevertheless the operator does not have a chair and especially with bad posture.

Figure 5: Operator takes care that the machine does not have faults.
Source: Image taken at ice cream La Regia

On the one hand, there is the information that the operator cannot provide on the part of his health but something that will also be improved with this research is the reduction of waste and the increase of production since the machine tends to have bad seals and that is why that the losses are increased and the production is reduced.

Once the information is taken into account and the process is analyzed, the main parts of the machine are taken so that it can be taken to a machine that can be controlled by means of an application so that the operator stops having contact with the machine so that do not have damage to your health, once you have the parts, they are assembled in a stainless steel box to be friendly with the products since they are food grade and it is the most correct for hygiene.

Counting on the information, with the parts of the manual machine and once taking it to an assembly of a steel box, tests will begin with an application that is friendly to the operator to be able to work with the machine, at this stage it is taken quite a long time since the machine called MABS (figure 6) is working by trial and error, but the engineers improve the methods and give it a higher quality and precision when producing ice cream.

Figure 6: MABS machine and sealing of pens.
Source: Image taken at ICE CREAM SHOP LA REYNA

The operator's performance is greater since it presents a great change since it is active and can carry out other operations if the need to be aware of the machine since it alone produces and there is a failure to the operator will receive the information to your telephone by means of alerts and if these are not attended to, the machine stops completely and waits to be attended by the operator.

Being able to carry out an improvement or renovation or adaptation of an old process that has been inherited generation after generation is a bit complex since the owner of the company can get into a dilemma of how an old process that has always been used reaches a time that becomes obsolete because of an automated machine that helps the performance of the operator and the company.

7. RESULTS

The operator will no longer use the common machine for the packaging process, but to have optimal results in all areas, the MABS machine will be used (figure 7), increasing the number of production, reducing the number of waste and above all improving the quality of life of the operator since his effort will be the minimum (figure 8). Table 1 makes a comparison of results with the two packaging machines.

Table 1. Comparison of packaging machines.

INDICATOR	MABS PRODUCTION	PRODUCTION BY HAND
SPACE	Reduced, less than a square meter.	Wide, requires space according to industrial machines or manual liquid packaging machines.
OPERATOR	Monitoring is carried out by application, it does not require an operator dedicated to the process.	It requires at least one operator dedicated to the process.
PRODUCTION PER HOUR	360 ice creams per hour.	315 ice creams per hour.
SCRAP PER HOUR	0%, this is 0 only in case of defect of polyethylene or of the product delivered by the supplier.	14.28% of production per hour, that is 45 out of 315 ice creams are waste.
REAL TIME OF PRODUCTION PER HOUR	One hour dedicated.	30 minutes, since the operator is distracted, or dedicates to doing other processes if required.
PRODUCTS TO BE PACKAGED	Liquids. Solid. Sausages. Seeds.	Liquids.
INDUSTRY THAT SUPPORTS	Nutritional. Restaurateur.	Only food.

	Hotelier. And in any place where product is packaged.	

Figure 7. MABS machine.
Source: Image taken at ICE CREAM SHOP LA REYNA

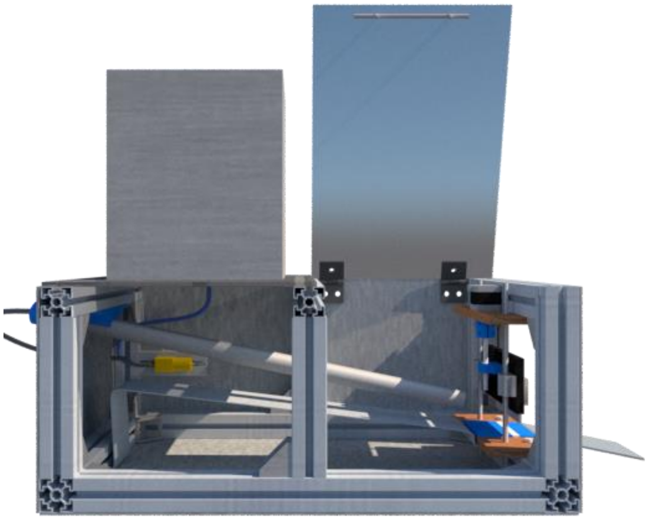

Figure 8. MABS design inside part
Source: Image taken at ICE CREAM SHOP LA REYNA

On the part of production and performance we have good results since in one hour the production of ice cream can be increased from 315 packaged ice creams to 360 ice creams, that is, in one working day 360 ice creams can be produced that were not produced before or in an extra hour of work, on the other hand we have the error in the polyethylene sealing, the machine has a failure in the cut and 45 waste ice creams can be produced, translated into money is 225 Mexican pesos, in the (figure 9) we have the products that have been sealed with the MABS machine, the evolution of a machine that only bottled liquids changed to a machine that could pack liquids, sausages, grains and seeds.

Figure 9. Different types of fillings.
Source: Image taken at ICE CREAM SHOP LA REYNA

The MABS machine can be compared with common machines or machines that are automated but many of them can increase production but due to the care of the operator it can be very harmful since they keep it in terrible conditions work and the postures in which he has to work damage his back, ankles.

8. CONCLUSIONS

This machine is an improvement on all existing machines, but it should be noted that it increases business economy and above all improves the quality of life of people who usually work with different machines that perform this work.

The machine continues to be observed in order to continue improving and not causing any health damage to the operator, since the objective of the MABS machine is to continue producing a large amount of packaged products but above all to take care of the operator who has contact with the machine.

9. ERGONOMIC CONTRIBUTIONS

Through this research, a basis is left for the improvement in the occupational(Velandia,2013)health of the operator who uses this type of manual machines, as part of the work, all the damage that the worker recently caused due to repetitive activities was discovered (figure 10) and on all bad postures (figure 11) at the time of interacting with the machine, since it is not suitable for the operator, this also improves work efficiency since the knife cut is more precise and therefore the quality of the product is better .

Figure 10: Repetitive polyethylene tracing and sealing activities
Source: Image taken at ICE CREAM SHOP LA REYNA

Figure 11: Terrible postures in the 8-hour workday.
Source: Image taken at ICE CREAM SHOP LA REYNA.

As part of the contributions that we have identified has been the lifting of loads, since in a working day the operator lifted a bucket full of liquid over his head (figure 12) the operator can lift the 20-liter bucket more than 18 times in a working day and this activity from an ergonomic point of view is determined as a high-risk activity.

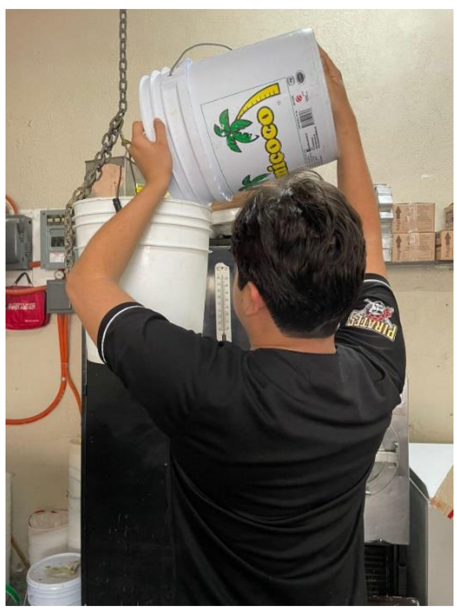

Figure 12: Draining of liquid to bucket.

Source: Image taken at ICE CREAM SHOP LA REYNA.

Finally, the polyethylene filling activity is eliminated since it is a repetitive activity that damages the operator from his shoulder, elbow, wrist and fingers as shown in figure 13 since what he does is press and pull the polyethylene film , but thanks to an electric band the operator stops having the problem of doing the refilling activity.

Figure 13: Polyethylene filling of the ice cream machine
Source: Image taken at ICE CREAM SHOP LA REYNA.

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REDESIGN OF PACKAGING STATION

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Resumen: Empresa dedicada a la fabricación de aislantes de fibra de vidrio manifestó que al realizar una investigación de rutina en el departamento de empaque detectaron malas posturas en los trabajadores al realizar el empaque de la fibra de vidrio en bolsas de plástico y un cumplimiento regular en los requerimientos de COVID en esa área de la planta.
Uno de los retos fue mejorar las posturas por medio de un rediseño de la estación de trabajo para que el operador desempeñara el trabajo con las posturas correctas y disminuyera la probabilidad de sufrir alguna lesión o malestar en espalda y hombros. Se aprovechó ofrecer mejor calidad en el proceso de empaque.
Para validar las posturas antes y después de la mejora se optó en el proyecto por aplicar diferentes metodologías y normas que permitieron mejorar posturas de 20% hasta 60% partes del cuerpo críticas para el desempeño de la tarea.
Las áreas adjuntas a la estación de empaque, con las valoraciones y propuestas llegaron a excelentes resultados en el cumplimento de requerimientos COVID al alcanzar un 90.53% de cumplimiento, después de aplicar la mejora en los parámetros que requería. Afortunadamente al valorar el cumplimiento de las Normas Mexicanas se identificaron buenas condiciones físicas de trabajo.
Para alcanzar la mejora fue necesario aplicar tres métodos para el análisis de riesgos ergonómicos. Para las condiciones de ambiente de trabajo se requirió validación de riesgos físicos con aplicación de las normas mexicanas de la Secretaria del Trabajo y Previsión Social (STPS) , así como las recomendaciones de la Organización Internacional del Trabajo (OIT) referente a los 10 puntos de verificación y recomendaciones aplicables por el retorno de los trabajadores bajo condiciones de riesgo COVID. Para cubrir cada uno de los puntos de rediseño se apoyó en herramientas de mejora industrial apoyado en las medidas antropométricas y dimensiones de las estaciones de trabajo.

Palabras clave: OIT, STPS, Empaque, COVID

Relevancia para la ergonomía: Importancia del análisis de riesgos ergonómicos y cumplimiento de las recomendaciones de COVID en empresas, para mejora las posturas de los operadores y mantener un ambiente se seguridad en las empresas

Abstract : Company dedicated to the manufacture of fiberglass insulators said that when conducting a routine investigation in the packaging department they detected bad postures in the workers when packaging the fiberglass in plastic bags and a regular compliance with the COVID requirements in that area of the plant.
One of the challenges was to improve the postures through a redesign of the workstation so that the operator could perform the work with the correct postures and reduce the probability of suffering any injury or discomfort in the back and shoulders. We took advantage of offering better quality in the packaging process.
To validate the postures before and after the improvement, the project opted to apply different methodologies and standards that allowed to improve postures from 20% to 60% of body parts critical to the performance of the task.

The areas attached to the packing station, with the evaluations and proposals reached excellent results in the fulfillment of COVID requirements by reaching 90.53% compliance, after applying the improvement in the parameters it required. Fortunately, when assessing compliance with Mexican Standards, good physical working conditions were identified.

To achieve the improvement it was necessary to apply three methods for ergonomic risk analysis. For the working environment conditions, validation of physical risks was required with application of the Mexican standards of the Ministry of Labor and Social Welfare (STPS), as well as the recommendations of the International Labor Organization (ILO) regarding the 10 verification points and recommendations applicable for the return of workers under COVID risk conditions. To cover each of the redesign points, it relied on industrial improvement tools supported by anthropometric measurements and dimensions of the workstations.

Keywords. ILO, STPS, Packaging, COVID

Relevance to Ergonomics: Importance of ergonomic risk analysis and compliance with COVID recommendations in companies, to improve the positions of operators and maintain a safe environment in companies

1. INTRODUCTION

The company where the research was carried out is responsible for providing fiberglass insulation. In production, the assembly of the pieces is carried out, the fiber is packed, and quality is responsible for verifying the packages with insulators.

In the area of fiber packaging is where the problem was detected, which are bad postures in workers when packaging fiberglass insulation in plastic bags.
The challenge of redesigning the workstation and attached area was to find that the operator performs the work with the correct postures decreasing the probability of suffering any injury or discomfort in the back and shoulders. Offering quality at work

is something we are looking for when carrying out this project by applying different methodologies and standards that allowed to improve postures by up to 40%.

This project was selected because an area of improvement was observed that at that time was critical, it was noticed that there were movements and positions uncomfortable for the worker at the time of performing his work, an improvement in the application of ergonomics and Mexican standards was required.

A study analysis of ergonomic risks, physical risks was carried out and the Mexican standards of the Ministry of Labor and Social Welfare (STPS) appropriate to the project were applied, as well as recommendations of the International Labor Organization (ILO) regarding the 10 points of verification and recommendations applicable for the return of workers under conditions of COVID risk which were generally complying with almost 90.53%

2. OBJECTIVES

Redesign packaging station applying ergonomic risk analysis, ILO recommendations and validations of Mexican standards through proposing a station that allows safety postures to avoid possible injuries to the worker at the time of packing.

3. METHODOLOGY

To validate the fiberglass packaging job, the following methodology listed below was applied in the company.

Mexican Standards were validated according to the STPS in packing station with for noise and lighting conditions in the workplace to confirm that the values are within the values of conformity with the environment in your workplace, see in table1 the standards applied.

Table 1. List of Mexican Standards according to the STPS applied to the station

Norma	Análisis
NOM-011-STPS-2001	Condiciones de seguridad e higiene en los centros de trabajo donde se genere ruido.(STPS,2002)
NOM-015-STPS-2001	Condiciones térmicas elevadas o abatidas-Condiciones de seguridad e higiene. (STPS,2002)
NOM-017-STPS-2008	Equipo de protección personal-Selección, uso y manejo en los centros de trabajo. (STPS,2008)
NOM-025-SPTS-2008	Condiciones de iluminación en los centros de trabajo (STPS,2008)
NOM-035-STPS-2018	Factores de riesgo psicosocial en el trabajo Identificación, análisis y prevención. (STPS,2018)

The recommendations of the ILO for redesign in the workplace (ILO, 1996), and the ILO to reduce the risks of contagion by COVID, in this case applied in the areas attached to packaging, were validated.

a. Applied in bathrooms and toilets

b. Dining rooms and rest areas
c. Work utensils

It was analyzed and evaluated according to ergonomic risk methodologies before redesign and after improvement with RULA, Suzanne Rodgers and WERA (Workplace Ergonomic Risks Assessment) obtaining results that allowed us to validate the improvement applied.

The station dimensioning and associated anthropometry were carried out to redesign the station that was.

5's and SMED continuous improvement methodologies were applied to increase the productivity of the workstation

4. RESULTS

4.1 Mexican Standards according to STPS

The recommended values of the Mexican standards to validate the physical conditions of the workstation were validated in the workstation

NOM 011 STPS, we realized when validating it that they are within the permissible values of decibels 73 dB in the station, see Table 2 and Figure 1.

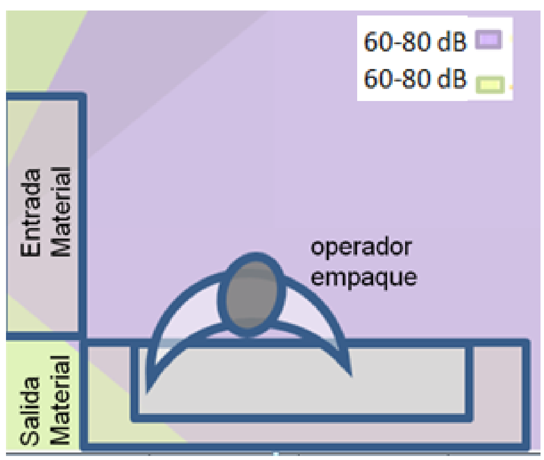

Figure 1. Noise Level Condition in Packing Station

NOM 015 STPS 2011 The Temperature is more critical in summer, however at this time it is within the permissible parameters of thermal comfort of 26.5°C, since it has air conditioning, see Table 2.

NOM 025 STPS corresponding to Lighting it was found that the packing station is above the necessary 501 lux, see Table 2 and Figure 2.

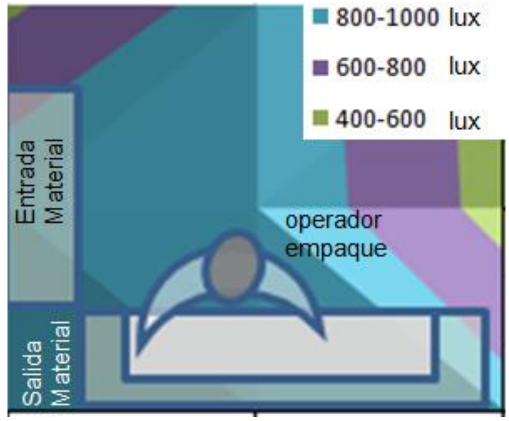

Figure 2. Condition of Lighting Levels in Packing Station

When evaluating the conditions of the operator in the NOM 017 STPS workstation if they use the necessary protective equipment for the process and work area, NOM 035 STPS does not manifest critical values when applying the survey carried out to evaluate the psychosocial conditions in which the work area is located.

Table 2. Some values of Mexican Standards according to the STPS applied to the station

Norma STPS	NOM STPS Decibel	Real Decibel	Observación de resultados obtenidos
NOM 011	80dB	73 dB	El Ruido cumple con los decibeles establecidos por norma, no rebasa los niveles permitidos. (Niebel, 2014)
Norma STPS	NOM STPS Celsius	Real Celsius	Observación de resultados obtenidos
NOM 015	25-38°C	26.5°C	La temperatura esta dentro de lo establecido por norma, no rebasa grados centígrados con aire acondicionado
Norma STPS	NOM STPS Lux	Real Lux	Observación de resultados obtenidos
025	500-700 lux	591 lux	Cumple con los luxes establecidos por norma, no se rebasan

4.2 ILO recommendations regarding COVID

ILO recommendations to reduce COVID risks were validated, in this case applied in areas attached to packaging

a. Applied in bathrooms and toilets see figure 3, before recommendations were met in 81.25%, after the improvement they are attended in 87.5%, they have been improved by 6.25% comparing a before and after application, see table 3 and figure 6.

Figure 3. Bathrooms and toilets used in shared packaging

b. Dining rooms and rest areas see figure 4, before recommendations were attended by 79.5%, after the improvement they are attended by 84.1%, they have been improved by 4.55% comparing a before and after application, see table 3 and figure 6.

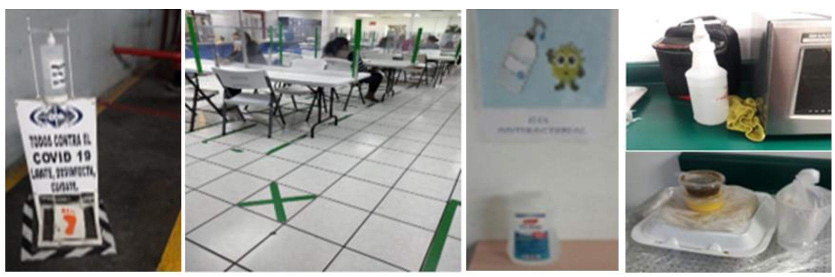

Figure 4. Dining rooms and rest areas used in shared packaging

c. Work utensils see figure 5, before recommendations were met in 58.33%, after the improvement they are attended in 87.5%, they have been improved in 41.67% comparing a before and after application, see table 3 and figure 6.

Figure 5. Work utensils used in packaging that are shared

Benefits were obtained in an area of opportunity to apply COVID improvements before recommendations were met in 73.04% after the improvement are attended in 90.53% have been improved in 17.49% comparing a before and after application, see table 3 and figure 6.

Table 3. Percentages of compliance with ILO COVID recommendations in areas close to packaging

EMPRESA. Áreas cercanas a estación Empaque	ANTES	DESPUES	Mejora
a. Cuartos de baño y aseos	81.25	87.5	6.25%
b. Comedores y las áreas de descanso	79.5	84.1	4.55%
c. Utensilios de trabajo	58.33	100	41.67%
Mejora	73.04%	90.53%	17.49%

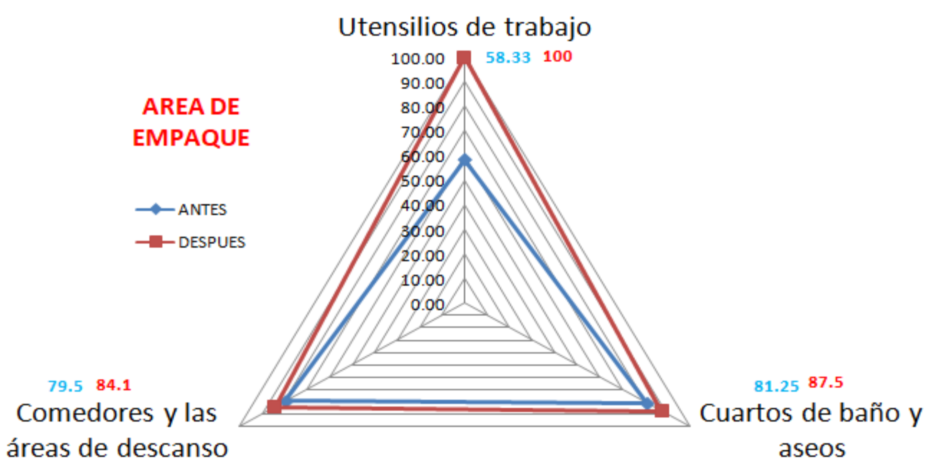

Figure 6. Behavior of ILO COVID recommendations before and after improvement applied

4.3 Application of ergonomic risk assessment methods

Packaging station was validated by means of the ERGONOMIC RISK ASSESSMENT METHOD WERA (Workplace Ergonomic Risks Assessment), obtaining the results observed in Table 4 and Table 7

Table 4. Valuation of packing station by WERA method

Factor de riesgo	Puntuación	
	Antes	Después
Hombro	5	4
Muñecas	4	3
Espalda	5	2
Cuello	5	3
Piernas	5	2
Fuerzas	2	2
Vibración	2	2
Stress por contacto	2	2
Duración de la tarea	4	4
TOTAL	34	24
Observación	Se necesita investigar más y se requieren cambios	Tarea aceptable

Packaging station was validated by means of the Suzanne Rodgers ergonomic risk assessment method, obtaining the results observed in Table 5 and Table 7

Table 5. Valuation of packing station by Suzanne Rodgers method

Factor de riesgo	Puntuación	
	Antes	Después
Cuello	10	5
Hombro Izquierdo	6	2
Hombro derecho	5	1
Espalda	7	1
Brazo y codo izquierdo	5	2
Brazo y codo derecho	5	1
Muñeca Mano dedo izquierdo	4	1
Muñeca Mano dedo derecho	4	2
Piernas y tobillos	7	1

Packaging station was validated by means of the RULA ergonomic risk assessment method, obtaining the results observed in Table 6 and Table 7

Table 6. Valuation of packing station by RULA method

Factor de riesgo	Puntuación	
	Antes	Después
Brazo antebrazo y muñeca	5	2
Antebrazo	3	2
muñeca	3	2
Giro muñeca	1	1
Cuello	4	2
Tronco	5	1
Piernas	2	1
Puntuación	7	3
Nivel de Riesgo	4	2
Observación	Requiere análisis y cambios inmediatos	Requiere evaluar detallado y posible algún cambio

Table 7. Percentages improved when assessing ergonomic risk methods at packing station

Factor de riesgo	Mejoras encontradas en cada método de evaluación		
	WERA	Suzanne Rodgers	RULA
Hombro	20	40	33.3
Muñecas	20	30	25
Espalda	60	60	66.6
Cuello	40	50	33.3
Piernas	60	60	50
Mejora aplicada	40	48	41.64

4.4 Dimensions and anthropometry

In the analysis of the sizing of the stations according to anthropometry of operators see table 8, before they did not comply with the dimensions of operating comfort on the work table, see photograph of Figure 7. Recommendations and redesign of workstation workspace were applied

a. The feeding tables were sized below the elbow to facilitate extraction of the feeder container
b. The packaging table is adapted at the elbow level facilitates the comparison and sizing of the product when packing it
c. Mobile work table with wheels was added for packaging material and packaging in height below shoulders and below elbow to compensate for height of packaging pieces, see preliminary project applied in figure 7.

Table 8. Some anthropometric measurements taken to operator are shown

Descripción	Medición (cm)	Descripción	Medición (cm)
1.Peso	85 kg	13.Anchura de tórax	47.9
2.Estatura	177	14.Ancho de codo a codo	33.8
4.Altura al hombro	165	32.Perimetro de cabeza	65
5.Altura codo flexionado	112	33. Profundidad de la cabeza	19.7
6.Altura al nudillo	78	35.Longitud de la cara	16.2

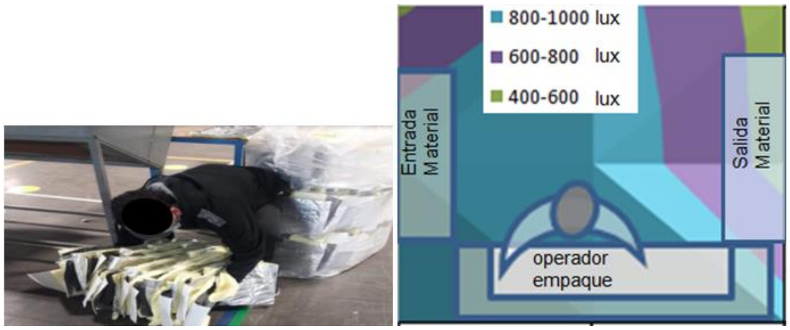

Figure 7. Reconditioning of mobile packing and packing station at the outlet

4.5 Continuous improvement

4.5.1 14 principles of movement

- The 14 principles of movement were validated to improve the design, 13 applied in the project, as can be seen in figure 7 we were allowed to only show the preliminary project.
- Initially, only 4 of 13 movement principles were met that apply in the project 30.8%
- After improvement, 12.3 of 13 principles of movement are met, 94.6% applied with the redesign of the area
- The final arrangement remained as a manufacturing cell, everything within reach and most of the points are met, the only thing that does not have is visual aids, only the exit criteria indicated by the client, required in its packaging, was improved in design by 63.8%

4.5.1 SMED (rapid preparations)

- The internal preparation became external preparation, now the packing bag is placed on the same output product warehouse table
- Decreased distance and unnecessary movements
- In the refinement it is stored directly in the pack and packaging is carried out at the same time

- The time of packaging and transfer of the finished product is reduced, since the same table serves as a transport of the finished product

5. CONCLUSIONS

- The improvements in the redesign of the station were validated through ergonomic analysis and evaluation in the workstation, applying the WERA, Suzanne Rodgers and Rula methodologies. Improvements of up to 60% were found in the back, 33.3% in the neck, 50% in the legs and 20% in the shoulders and wrists, when applying the proposed improvements. It was possible to verify by this means up to a 40% improvement, representing a comfort for the operator and a decrease in possible injuries
- The ILO recommendations allowed to redesign the station, to provide comfort and certainty, when operating the station designed according to the requirements of the operator. It is now a safer place from any COVID risks, as it meets the recommendations by up to 90.53% after the improvement, when going to eat or doing your personal hygiene.
- Great certainty is obtained by validating the Mexican standards that the operator works within the parameters that allow him to perform adequately within the favorable operating environments
- Comfort was achieved by redesigning the workstation by conditioning its anthropometric dimensions with the dimensions of its workstations, and adding a mobile warehouse station, which allows it to carry out its work in an optimal working position.
- Applying the tools of continuous improvement increased production volume, comfort of movements, less rework and repetition of unnecessary activities that accumulated fatigue.

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TRANSPORTER - POTS IN BLUEBERRY PRODUCTION

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RESUMEN: En todas las empresas agrícolas se pueden generar situaciones desfavorables, con pérdidas económicas y humanas e impacto en la sociedad y el medio ambiente. En nuestra región, crece la necesidad de cultivos agrícolas, especialmente arándanos, en los que los arbustos se plantan en macetas no directamente en el suelo. Al realizar maniobras entre las macetas es necesario generar movimientos manuales de estas, siendo el trabajador el motor impulsor para mover las plantas. Es por ello que se propone generar un dispositivo que ayude al operador a realizar su trabajo, de tal forma que faciliten la actividad y ofrezcan mayor seguridad en su ejecución, facilitando la labor del traspaso de las macetas y reduciendo el riesgo de malas posturas en el área de operaciones. Se visitó un cultivo de arándanos durante las labores y se analizó la forma de trasladar las macetas de un lugar a otro, se hizo una comparación de las formas en que podríamos mejorar el proceso observado determinado las medidas antropométricas necesarias para el diseño de la herramienta a diseñar, posteriormente se aplicaron mediciones y cálculos percentiles que ayudaron a generar el prototipo. Éste se diseñó llevando a cabo una de las ideas propuestas en base al análisis antropométrico, de tal manera que permita cumplir con el objetivo propuesto. Como resultado se obtuvo un diseño en AutoCAD del prototipo de la herramienta ergonómica que ayuda a la movilización de macetas en el cultivo de arándanos y permitirá realizar la actividad de forma segura para el trabajador.

Palabras clave: Posture, pot, Transferencia.

CONTRIBUCIÓN A LA ERGONOMÍA: Se busca la concientización en el trabajo de la industria agrícola sobre la necesidad de aplicar la ergonomía en las actividades de los trabajadores del campo que están sometidos a una alta carga de trabajo diariamente

ABSTRACT: In all agricultural enterprises, unfavorable situations can be generated, with economic and human losses and impact on society and the environment. In our region, there is a growing need for agricultural crops, especially blueberries, in which the bushes are planted in pots and not directly in the ground. When maneuvering between the pots it is necessary to generate manual movements of these, being the worker the driving engine to move the plants. That is why it is proposed to generate a device that helps the operator to perform his work, in such a way that facilitates the activity and offers greater safety in its execution, facilitating the work of transferring the pots and reducing the risk of bad posture in the area of operations. A blueberry crop was visited during the work and the way of transferring the pots from one place to another was analyzed, a comparison was made of the ways in which we could improve the process observed and the anthropometric measurements necessary for the design of the tool to be designed were determined, then measurements and percentile calculations were applied to help generate the prototype. The prototype was designed by carrying out one of the ideas proposed based on the anthropometric analysis, in such a way that it would allow the proposed objective to be fulfilled. As a result, an AutoCAD design was obtained of the prototype of the ergonomic tool that helps the mobilization of pots in the cultivation of blueberries and will allow the activity to be performed safely for the worker.

KEYWORDS: Posture, pot, transfer.

CONTRIBUTION TO ERGONOMICS: Awareness is sought in the agricultural industry work on the need to apply ergonomics in the activities of field workers who are subjected to a high workload on a daily basis.

1. INTRODUCTION

In all agricultural companies, unfavorable situations can be generated, with financial and human losses and impact on society and the environment. In our region, the need for agricultural crops is growing, especially blueberry, in which the bushes are planted in pots, not directly in the ground. When carrying out maneuvers between the pots, it is necessary to generate manual movements of these, the worker being the driving force to move the plants, this is the reason why it is proposed to generate a device that helps the worker to carry out their work in such a way that facilitate your work and offer greater security in its execution, facilitating the activity of transferring the pots and reducing the risk of bad postures in the operations area.

2. DELIMITATIONS

Agricultural enterprises involved in the cultivation of blueberries in pots.

3. METHODOLOGY

The sample was taken from 41 students of the TecNMX industrial engineering career to make the calculations.

Table 1. Results of the sample.

Descripcion	Media
Ancho de los hombros	45.9925
Altura a la muñeca	85.55
Agarre a la muñeca	5.047368421
Ancho de la palma de la mano	9.165

This will help us to be used by different people with different measurements based on their body dimensions, since these dimensions will provide us with the distance that must be adjusted to be used by different users.

CALCULATION OF PERCENTILE

	Ancho de los hombros
	34
5%	36
	36
	37
	38
	38
	45
	45
	45
50%	46
	46
	46
	46
	47
	52
	52
	52
	54
	55
95%	61
	65
	72
	Media
	45.9925

Data 1. Sample data.

	Altura a la muñeca
	70
5%	70.5
	74
	77
	77
	77
	79
	79
	79
	79.5
	80
	81
	81
	84
	84
	84
	85
	85
	85
50%	85
	86
	86
	87
	87
	87
	88
	88
	88
	89
	90
	90
	90
	90
	91
	94
	94
	94
95%	95
	102
	110
	Media
	85.55

Data 2. Sample data.

	Diametro de agarre
	2.5
5%	3
	3
	3
	3.5
	3.8
	4
	4
	4
	4
	4
	4
	4
	4
	4
	4.5
	4.5
50%	4.5
	5
	5
	5
	5
	5
	5
	5
	5
	5
	5
	5
	6
	6
	7
	7
	7.5
	7.5
	7.5
95%	8
	12
	Media
	5.047368421

Data 3. Sample Data.

	Ancho de la palma de la mano
	6
5%	7
	7
	7
	7
	7.5
	7.5
	7.7
	8
	8
	8
	8
	8
	8
	8
	8
	8
	8.5
	8.5
50%	8.5
	9
	9
	9
	9
	9
	9
	9
	9
	9.4
	10
	10
	10
	11
	11
	11
	11
	12
95%	13
	13
	19
	Media
	9.165

Data 4. Sample Data.

Table 2. Percentile results

Numero de Datos	40
valor i (posicion)	
percentil 5	2.5
percentil 50	20.5
percentil 95	38.5
Valor Percentil	
5%	36
50%	46
95%	63

The handlebar for the two-wheel prototype should measure 46cm based on the 50% percentile.

Table 3. Percentile results

Numero de Datos	40
valor i (posicion)	
percentil 5	2.5
percentil 50	20.5
percentil 95	38.5
Valor Percentil	
5%	72.25
50%	85.5
95%	98.5

.

The extendable should adjust the height between 72.25cm-98.5cm to cover most of the population according to their height.

Table 4. Percentile results

Numero de Datos	38
valor i (posicion)	
percentil 5	1.9=2
percentil 50	19.5
percentil 95	36.1=37
Valor Percentil	
5%	3
50%	4.75
95%	8

The diameter of the wrist grips must be a maximum of 3 centimeters based on the 5% percentile.

Table 5. Percentile results

Numero de Datos	40
valor i (posicion)	
percentil 5	2.5
percentil 50	20.5
percentil 95	38.5
Valor Percentil	
5%	7
50%	8.75
95%	13

The width of the palm of the hand to grip the tool should not be greater than 7 centimeters based on the 5% percentile.

Table 6. Measure description to the desing

Descripcion	Media
Ancho de los hombros	45.9925
Altura a la muñeca	85.55
Agarre a la muñeca	5.047368421
Ancho de la palma de la mano	9.165

The extendable should adjust the height between 72.25cm-98.5cm to cover most of the population according to their height.

The diameter of the wrist grips should be a maximum of 3cm based on the 5th percentile.

The width of the palm of the hand to grip the tool should not be greater than 7 cm based on the 5% percentile.

RESULTS

Table 7. Final percentile results

Percentiles		
5	50	95
36	46	63
46	85.5	98.5
61	4.75	8
7	8.75	13

.

As a result, we have the reduction of injuries or inside work, and the satisfaction of the user by having a tool according to their body dimensions for better performance and less risk of an accident through anthropometric design. It has an ergonomically acceptable approach to be used in any work area.

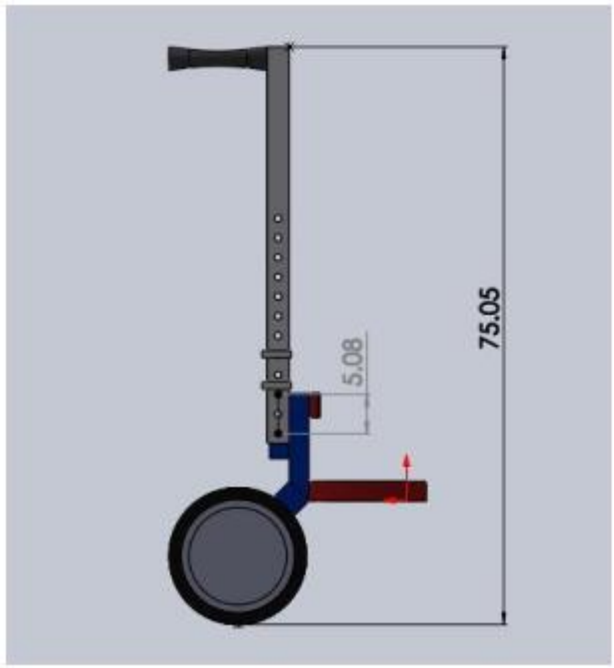

Figure 1. Prototype

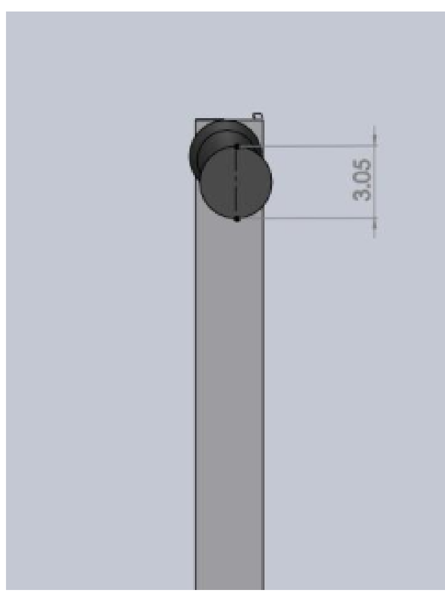

Figure 2. Prototype technical specifications.

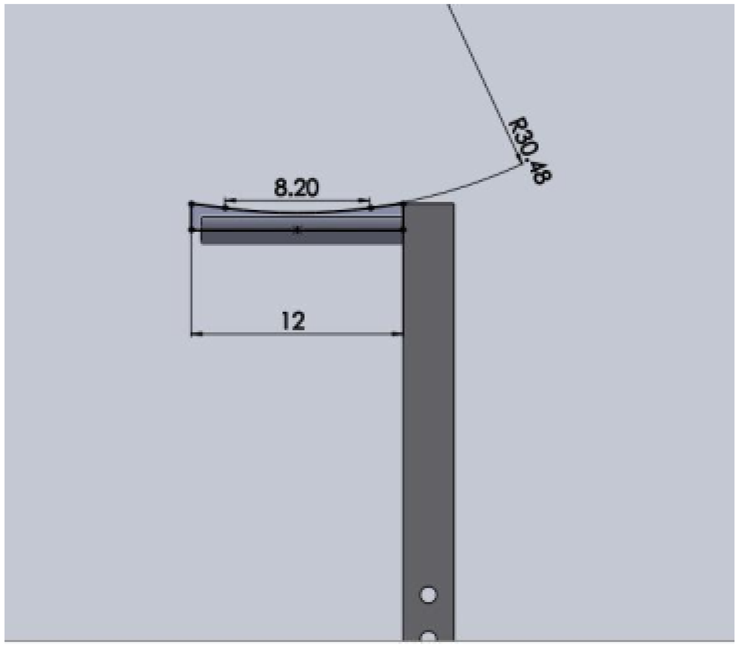

Figure 3. Prototype technical specifications.

4. CONCLUSIONS

In conclusion, we can highlight that the development of this prototype will help us reduce the workload of workers in this area as well as help us to emphasize the importance of ergonomists in Mexico paying more attention to the agricultural sector where workers are more neglected in the aspects of safety and ergonomics, where they put their bodies to the maximum effort to be able to carry out their work day by day.

In addition, we are giving solutions but there are more riskies to work on it like the musculoskeletal disorders:

"Musculoskeletal disorders (MSDs) are increasingly recognized as a significant hazard of agricultural occupation. In agricultural jobs with significant physical labor, MSDs are typically the most frequently reported injury. Although not as lethal as tractor roll-overs, MSDs can result in disability, lost work time, and increased production costs. MSDs increase production costs as a result of worker absence, medical and insurance costs, decreased work capacity, and loss of employees to turnover and competition from other less physically demanding industries. This paper will provide an overview of what is currently known about MSDs in agriculture, including high-risk commodities, tasks and work practices, and the related regulatory factors and workers' compensation costs. As agricultural production practices evolve, the types of MSDs also change, as do ergonomic risk factors. One example is the previous higher rates of knee and hip arthritis identified in farmers in stanchion dairies evolving into upper extremity tendonitis, arthritis, and carpal tunnel syndrome now found in milking technicians in dairy milking parlors.

This paper summarizes the presentation, “Musculoskeletal Disorders in Labor-Intensive Operations,” at the Agricultural Safety and Health Council of America/National Institute for Occupational Safety and Health conference, “Be Safe, Be Profitable: Protecting Workers in Agriculture,” January 27–28, 2010, Dallas/Fort Worth, Texas. The primary focus of the paper is to address current research on ergonomic solutions for MSDs in agriculture. These include improved tools, carts or equipment, as well as work practices. One of the key challenges in this area pertains to measurement, due to the fact that musculoskeletal strain is a chronic condition that can come and go, with self-reported pain as its only indicator. Alternative measurement methods will be discussed. Finally, the implementation of research into practice is reviewed, with an emphasis on best practices that have been demonstrated to be effective in the agricultural setting, based on worker acceptance and comfort, improved productivity, and decreased MSDs. The paper will provide an overview for agricultural stakeholders as to the current science and practice of ergonomics in agriculture” (Kirkhorn, 2010).

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DESIGN OF THE ERGONOMIC CONDITIONS OF THE PRODUCTION PROCESS OF A BIORRATIONAL INSECTICIDE PREPARED ON THE BASIS OF NIM.

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Resumen El presente proyecto muestra información de una investigación que se desarrolló con la finalidad de generar un diseño de las condiciones ergonómicas en el área de producción de un insecticida biorracional elaborado a base de Nim, en el Tecnológico Nacional de México campus Guasave.

"Ergonomía es la disciplina científica que trata de las interacciones entre los seres humanos y otros elementos de un sistema, así como, la profesión que aplica teoría, principios, datos y métodos al diseño con objeto de optimizar el bienestar del ser humano y el resultado global del sistema". (EIA, 2000).

Las condiciones ergonómicas que se desarrollaron en el área de producción de insecticida biorracional ayudo de manera significativa a mejorar el proceso en las operaciones y las condiciones de trabajo, seguridad, control de inventarios, reducción de tiempo, logrando un mejor manejo en esa área. Sé evaluará las condiciones de trabajo del proceso de producción
de bioinsecticidas, Se realizará la toma de datos durante 3 semanas para después presentar la propuesta de diseño de condiciones ergonómicas.

Palabras clave: Insecticida biorracional, Método Rula, Condiciones ergonómicas

Relevancia para la ergonomía: El diseño de condiciones ergonómicas en los procesos de producción permite un aumento de productividad. La Aportación de la ergonomía garantiza la optimización de los recursos y la optimización de los sistemas Hombre- Máquina. Generando un sistema más eficiente en sus operaciones, cuidando la seguridad y salud del trabajador.

Abstract: This project shows information from an investigation that was developed in order to generate a design of ergonomic conditions in the production area of a birational insecticide made from Nim, at the National Technology of Mexico campus Guasave.

"Ergonomics is the scientific discipline that deals with the interactions between human beings and other elements of a system, as well as, the profession that applies theory, principles, data and methods to design in order to optimize the well-being of the human being and the result global system ". (EIA, 2000).

The ergonomic conditions that were developed in the biorational insecticide production area significantly helped to improve the process in operations and working conditions, safety, inventory control, time reduction, achieving better management in that area. The working conditions of the bioinsecticide production process will be evaluated. Data collection will be carried out for 3 weeks and then the ergonomic conditions design proposal will be presented.

Keywords: Biorational insecticide, job analysis, Ergonomic conditions

Relevance for ergonomics: The design of ergonomic conditions in production processes allows an increase in productivity. The Contribution of ergonomics guarantees the optimization of resources and the optimization of Human-Machine systems. Generating a more efficient system in its operations, taking care of the health and safety of the worker

1. INTRODUCTION

Sinaloa is the main producer of grains and vegetables in Mexico, due to the great variety and quality of food derived from the field, which are recognized nationally and internationally. The agricultural leadership of our state is based on the production of crops such as corn, wheat, potatoes, squash and many others. It makes this one of the most representative activities in our region. (CODESIN, 2020).

The presence of musculoskeletal disorders is an important issue in the public health of farmers. There are a small number of studies that have examined the ergonomic risk and working conditions associated with the presence of these disorders. Agriculture has been shown to be an occupation that requires a large amount of physical demand that includes difficult movements and postures, repetitive and monotonous tasks and a high possibility of suffering and accidents due to falls due to the unevenness of the terrain. (Garzón, Vázquez, & Molina, 2017). According to data from the Mexican Institute of Social Security in 2018, it was found that of 100 agricultural workers, about 2.2% have occupational risks and 1.8% may have occupational accidents. (IMSS, 2019). The objective of this work is to analyze the ergonomic conditions in the production process of an irrational bioinsectide based on Neem.

2. OBJETIVES

2.1 General objective

Design ergonomic conditions in the production process of a biorational insecticide made from neem.

2.2 Specific objectives

Carry out a diagnosis of production activities through the application of ergonomic principles and detection of risk factors.
• Apply the RULA ergonomic evaluation method to improve the optimal conditions in the production process of a biorational insecticide

3. METHODOLOGY

1.- Carry out a current diagnosis of the production areas of the biorational insecticide. Through the identification of risk factors and ergonomic principles.
2.- Analysis of workstations for a certain time and to identify the activities that present risk factors in the production process.
3.- Design the ergonomic and safety conditions in the production process

4. RESULTS

The production process of the biorational neem insecticide (Azadiracta indica), is composed of 30 metabolites with anti-food and suppressive action of the hormones responsible for growth; among them the most important is the substance identified as azadirachtin.
This process contains 6 activities:

1. Collection of leaves.
2. Washing process sheets.
3. Dry for 2 days,
4. Grinding the leaves in a manual or electric mill and the active ingredient is extracted.
5. Mix 400 grams of ground leaves in 1 liter of water, and let it rest for 24 hours.
6. The liquid part is separated by decantation or filtering.

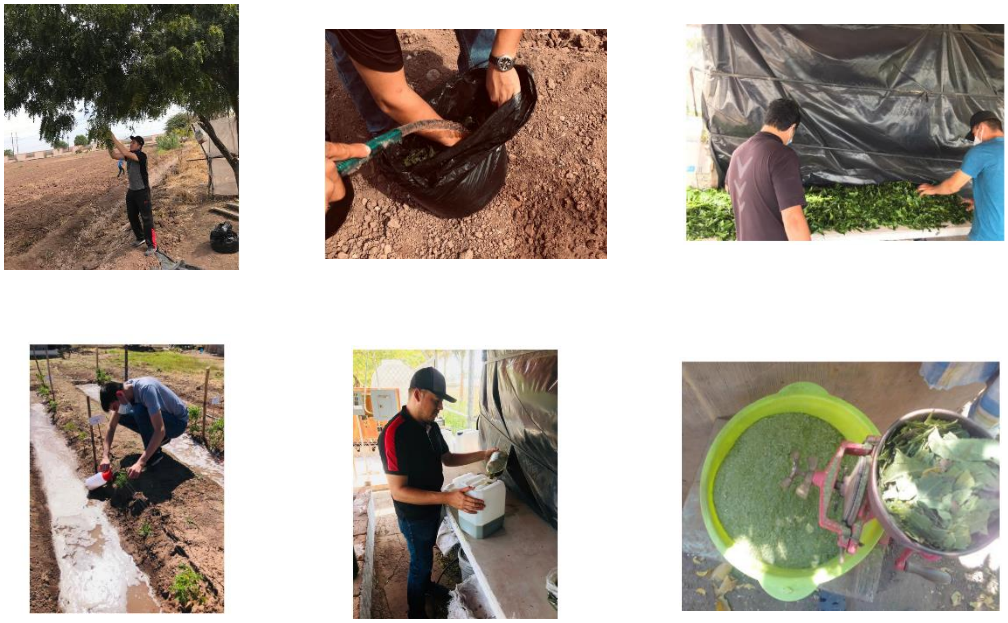

Figure 1. Biorational insecticide production process.

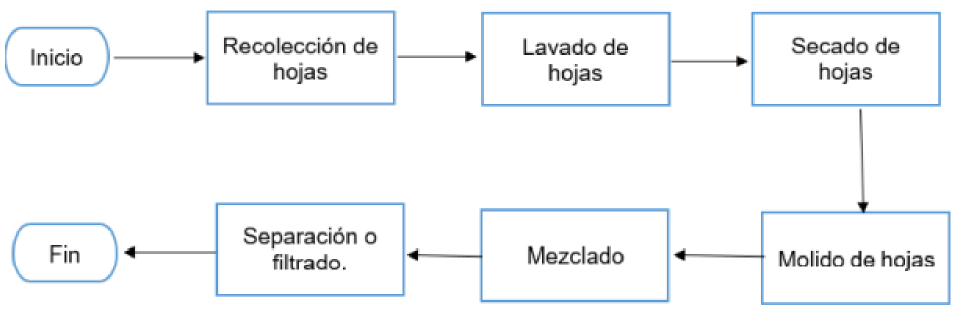

Figure 2. Production process diagram

The elaboration of the biorational insecticide was carried out with 3 workers, all men with an age range of 20 to 48 years, with a duration of 5 hours. All operators carry out 3 to 5 activities. The environmental conditions to which they are exposed during the working day: temperature between 38 to 42 degrees Celsius and a humidity of 35% during the working day.

During the analysis of the stages, the stations with the highest risk factors were inadequate postures, inadequate instruments for the tasks, heights and dimensions out of reach, in the workstations of leaf collection, drying, separation or filtration. Applying ergonomic principles.

Table 1. Ergonomic principles check sheet

ergonomic principles	meets	Fails	Does not apply	Observations
.1-Keep everything within reach. -Over effort. -Positions that make work difficult		x		The operator needs to reach further to reach the blades.
2. - Use elbow height as a reference. -Wrong position -Unnecessary effort		x		The band is at a height higher than the height of the elbows.
3. - Find the correct position for each work. -Pressure on the body. -difficulty of work.		x		The table is low to the elbows and requeried inmediatily change
4.- Adjustment and change of posture -pressures. -Uncomfortable postures.		x		Adjustment and change of position are not fulfilled.
5.-Highlight clearly to improve compression. -bad display of controls. -Bad visualization of boards. -Errors due to bad design			x	

During the analysis of the process stages, it is observed that the station with the highest risk factors is 3 (Leaf collection, leaf grinding, and Separation or filtration).

The RULA ergonomic evaluation method was applied to the 3 stations with the highest risk factor.

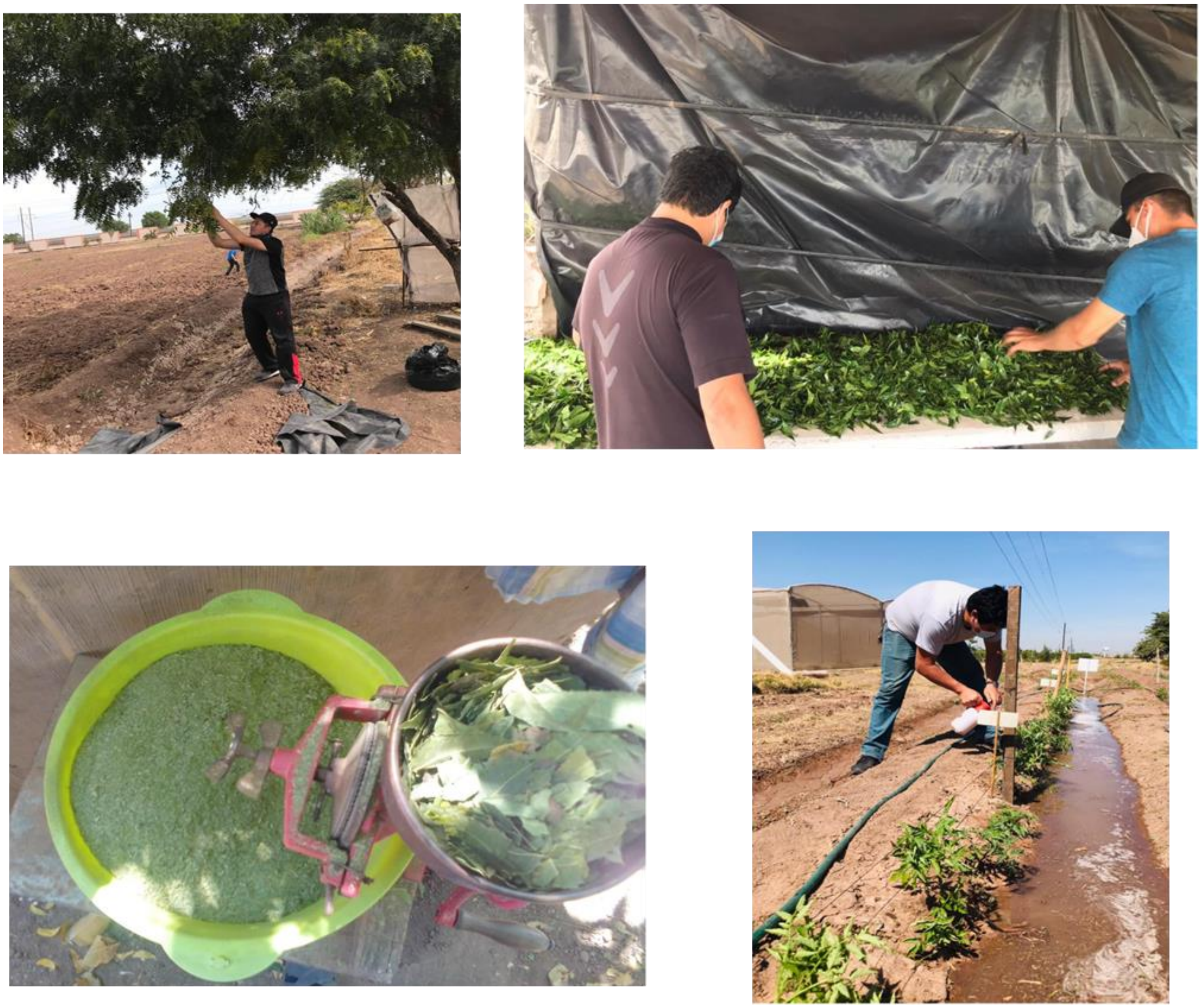

Figure 3. Workstations with risk factors

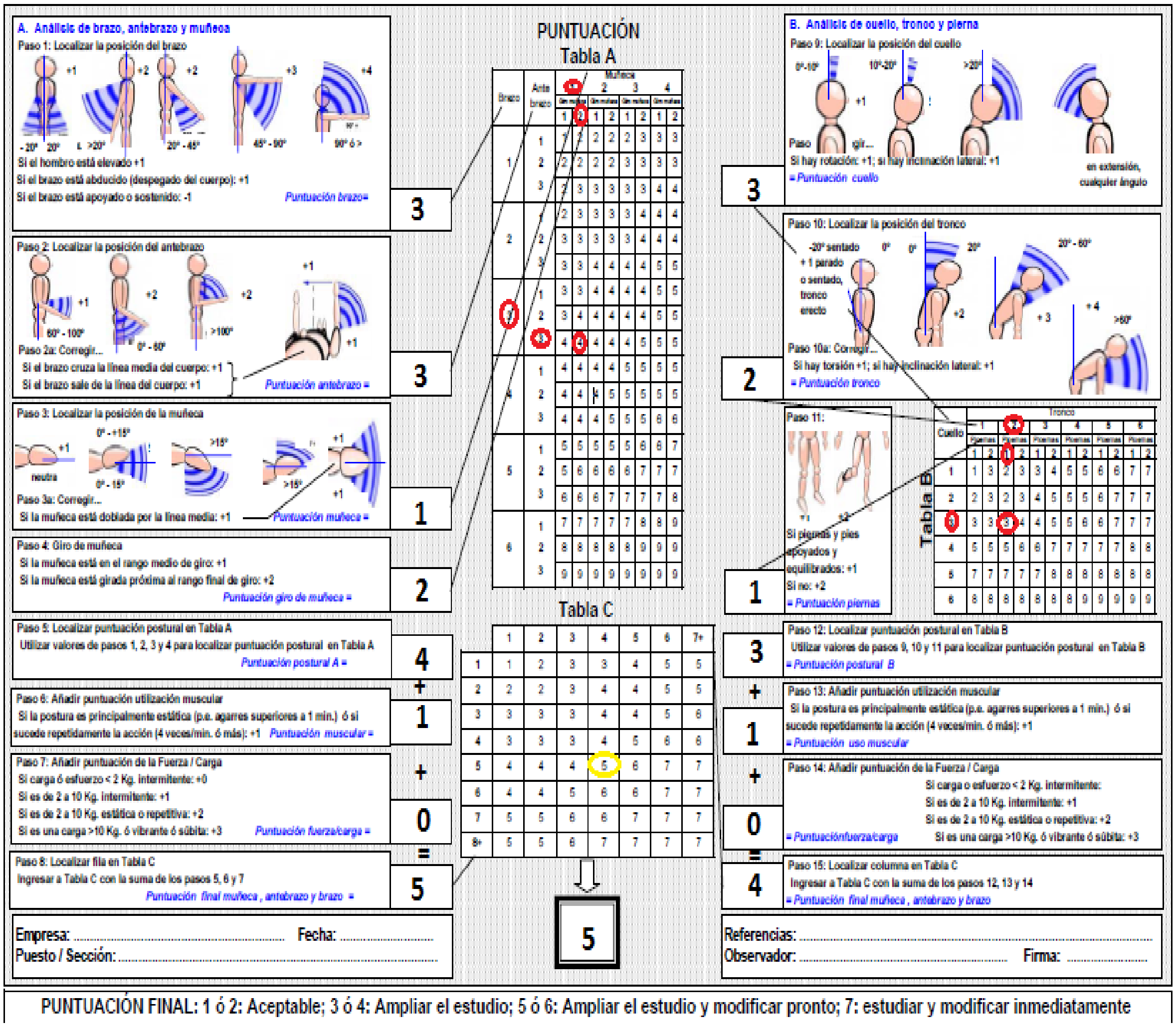

Figure 4. Application of the RULA method at the Leaf Collection station.

In the leaf collection activity, the RULA method yielded the result of 5, which indicates that the task needs to be redesigned, making pertinent changes, because the worker's posture develops cumulative trauma disorders.

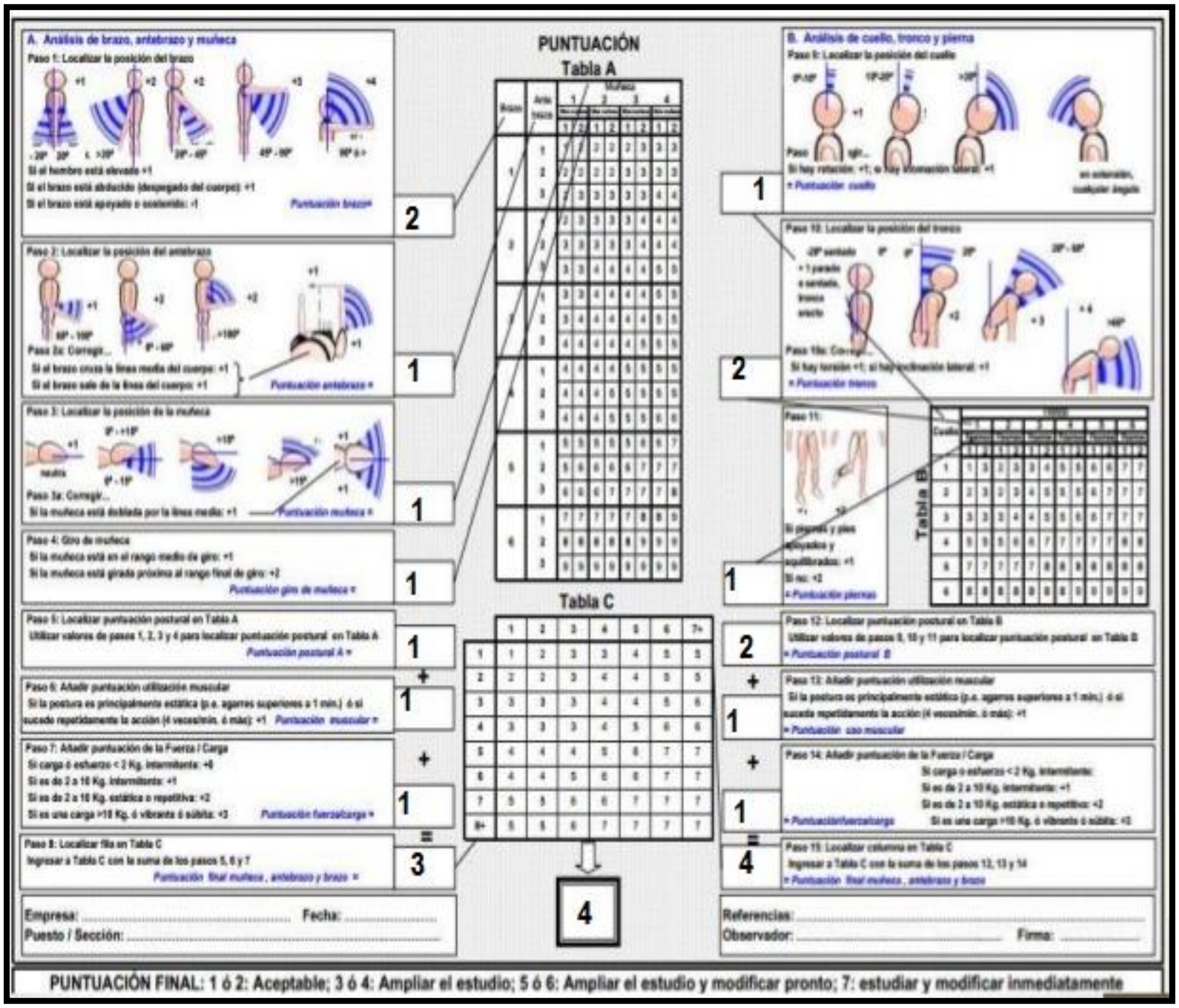

Figure 5.- Application of the RULA method in the sheet grinding station

In the activity of milling leaves, the RULA method yielded the result of 4, which indicates that the study needs to be expanded, for the proposal of pertinent changes, it presents a worker's posture that develops cumulative trauma disorders.

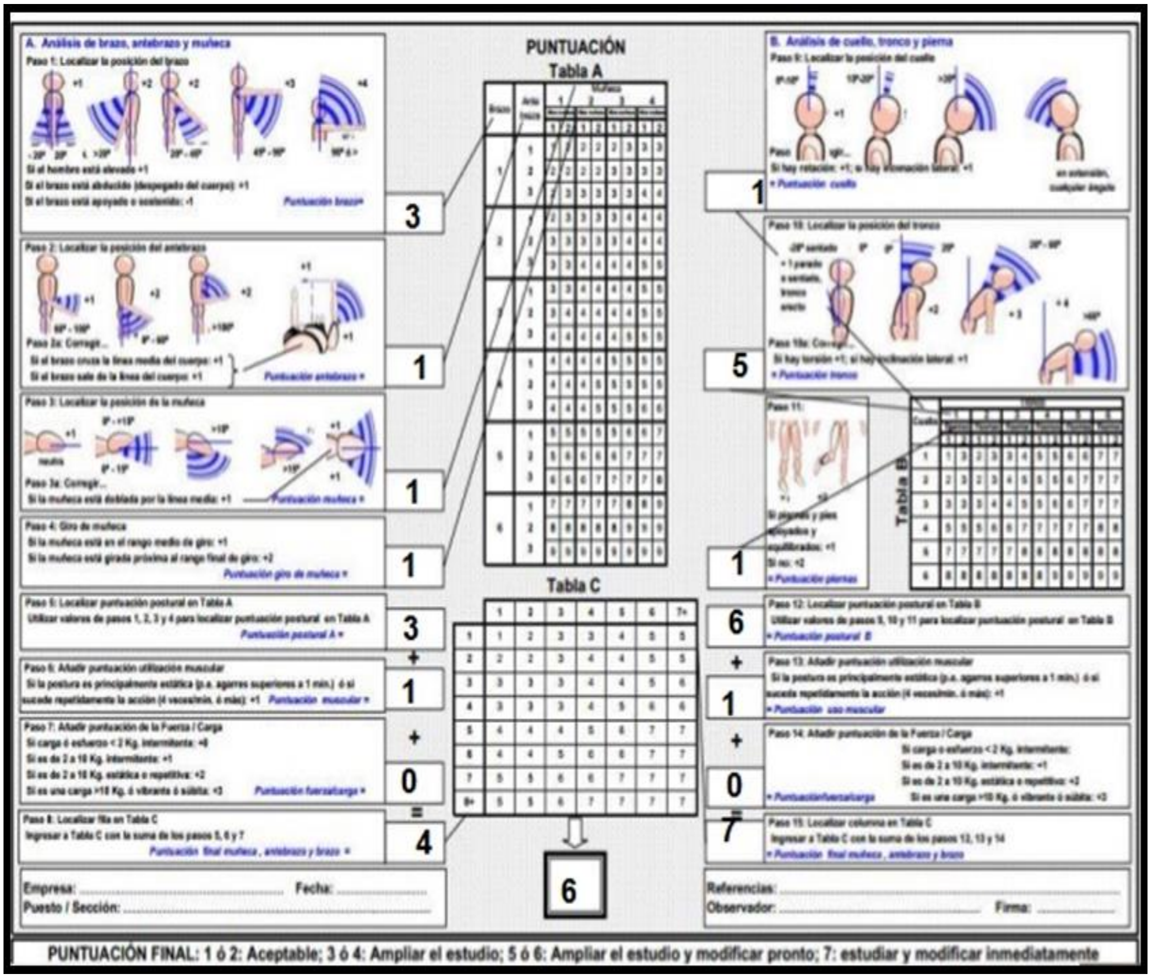

Figure 6.- Application of the RULA method in the Separation or filtration station

In the screening and testing activity, the RULA method yielded the result of 6, which indicates that the task needs to be redesigned, making immediate pertinent changes, because the worker's posture develops cumulative trauma disorders.

5. DISCUSSION/CONCLUSIONS

The analysis of the ergonomic conditions, allows to detect the risk factors that the workers are exposed when they carry out operations in the agricultural field. Worker productivity is affected by environmental conditions, temperature, humidity, and unsuitable work methods.

In the production process of the biorational insecticide, 3 stations were detected (leaf harvesting, leaf grinding, Separation and filtration) that are affecting worker productivity and health.

With the application of the RULA Method in these 3 areas, level 5, 4, 6 is detected for each analysis posture. For the collection of leaves, a device is presented that collects the leaves for the scope and a transfer device for the raw material. On the Leaf Mill, it is recommended to change the height of the mill, raising the height to an additional 20 cm so that it is within reach and achieves the effectiveness of the activities. In the separation or filtration change the height of the work table with 10 cm downwards so that the operation does not generate a shoulder lift, as well as the tests of the product, perform it with a transport device (hoses) so that the product reaches more fluently and not being in the wrong posture for long periods.

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RISKS IN TELEWORKING IN BASIC EDUCATION TEACHERS

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RESUMEN: A principios del año 2020 a causa de la pandemia por el COVID-19 miles de docentes en México cambiaron la forma tradicional de impartir sus clases a realizarlas de manera remota, actividad denominada home office o teletrabajo, un cambio de modalidad de trabajo súbito, pues no cambió solamente el canal de comunicación, también se modificaron las condiciones de trabajo, desde un salón de clases a algún puesto dentro del hogar. Este proyecto tiene como objetivo conocer las experiencias de los docentes e identificar los riesgos ergonómicos a los que estuvieron expuestos con esta modalidad. Los sujetos de estudio son los docentes de educación básica que residen en la región del noroeste de México. Para realizar la investigación se aplicó un cuestionario, adaptación de uno realizado por la Universidad de Concepción y SORCHEGO denominado “Entorno ergonómico del teletrabajo en situación de pandemia”, se colectaron las respuestas por medio de formularios de Google. El nivel de confianza es de un 90%. Entre los resultados más significativos está que un 84.11% no había realizado teletrabajo antes de la pandemia, un 48.37% no recibieron instrucciones de cómo realizar las tareas de la mejor manera, un 79.42% no tiene entrenamiento y/o capacitación en ergonomía, un 71.11% tiene menor actividad física comparado el teletrabajo con el trabajo de clases normal; un 58.11% no cuenta con escritorio, silla ajustable o reposapiés; de un 24.55% a un 43.32% no considera las posturas que adoptará en distintas partes del cuerpo al trabajar, un 45.81% no cuenta con un lugar fijo de trabajo, un 38.63% considera su lugar de trabajo como ruidoso. Los resultados también muestran que la mayoría, han tenido alguna molestia o tienen la necesidad de adaptar su lugar de trabajo.

Palabras clave: Ergonomía, Riesgos, Teletrabajo, Home office

Relevancia para la ergonomía: El estudio contribuye a la difusión del conocimiento sobre las condiciones de riesgo que se presentan en el Teletrabajo y la relación con la Ergonomía, de tal manera que se identifiquen las oportunidades de mejora y se determinen acciones que permitan mejorar los elementos de diseño, organizaciones y cognitivos en lo usuarios de esta forma de trabajo.

ABSTRACT: At the beginning of the year 2020, due to the COVID-19 pandemic, thousands of teachers in Mexico changed the traditional way of teaching their classes to remote teaching, an activity called home office or telework, a sudden change of work modality, since not only the communication channel changed, but also the working conditions were modified, from a classroom to a position at home. The objective of this project is to learn about the teachers' experiences and identify the ergonomic risks to which they were exposed with this modality. The subjects of the study are elementary school teachers residing in the northwestern region of Mexico. To carry out the research a questionnaire was applied, adapted from one made by the University of Concepción and SOCHERGO called "Ergonomic environment of telework in pandemic situation", the answers were collected by means of Google forms. The confidence level is 90%. Among the most significant results is that 84.11% had not performed telework before the pandemic, 48.37% did not receive instructions on how to perform the tasks in the best way, 79.42% have no training and/or training in ergonomics, 71. 11% have less physical activity compared teleworking with normal classroom work; 58.11% do not have a desk, adjustable chair or footrest; 24.55% to 43.32% do not consider the postures they will adopt in different parts of the body when working, 45.81% do not have a fixed place to work, 38.63% consider their workplace as noisy. The results also show that the majority have had some discomfort or have the need to adapt their workplace.

KEYWORDS: Ergonomics, Risk, Telework, Home office

Relevance to Ergonomics: The study contributes to the dissemination of knowledge about the risk conditions that occur in Telework and the relationship with Ergonomics, in such a way that opportunities for improvement are identified and actions are determined to improve the design, organizations and cognitive in the users of this form of work.

1. INTRODUCTION

The United States is one of the pioneers in telework, to support this idea, in the year 1988 California had already established a telework pilot program. However, it is until 2010 that telework is defined by law 111 in December in this country (EU congress, 2010, cited by Rodriguez, 2017), and it is in that same year that is dictated the Telework Enhancement Act or Telework Enhancement Act in English (Alvarez, 2018). Currently, as Rodriguez (2017) points out, the provisions by the government vary depending on the state, the similarities in the policies are about working hours, location, safety aspects, as well as selection and termination criteria according to a study conducted in 35 states of the country.

According to the European Union, in 2001 the Social Dialogue Committee of the Telecommunications Sector published a document with indications that should be applied to telecommunications telework in Europe. (Rodriguez, 2007). By July 16, 2002 the European Trade Union Confederation, the Union of Confederations of Industry and Employers of Europe, the European Union of Craft, Small and Medium Enterprises and the European Centre of Public Enterprise, signed the European Framework Agreement On Telework, which in its own terms "seeks to modernize the organization of work" in order to increase productivity and competitiveness, as well as to increase the level of safety and adaptability to different forms of work (Rodriguez, 2007).

Although in Latin America has tried to include telework as a modality to provide employment, the structuring of laws and regulations in most countries is not enough and makes it very difficult to carry it out in a formal way (Fernandez and Bravo, 2019). On the other hand, Argentina has been located as the main precursor of telework in Latin America (Osio, 2015), this is evidenced in its background, among the most prominent: in 2003 is created the Telework Commission corresponding to the Ministry of Labor, Employment and Social Security (Ramirez, 2008, as cited by Osio, 2015); in 2007 is enacted the Law Legal Regime of Telework. In addition to private sector initiatives to regulate telework, the most prominent is of the company Telecom, based in Buenos Aires, which developed its own manual to regulate telework (Osio, 2015).

Another country that has telework regulation by the government is Colombia, telework is regulated by Law 1221 of 2008 and Decree 884 of 2012 that regulates it. While Law 1221 recognizes telework as a modality of work, Decree 884 specifies the working conditions for private and public entities, the obligations and rights of the employer and teleworker (Barona, 2013).

In Mexico, as mentioned by Valle (2018) telecommuting is a trend that is expected to gain greater importance as time goes by. In Mexico, there is a space in the Federal Labor Law in the sixth title under the name of "special jobs" chapter Xll "Home-work" with several articles that tries to keep track of work activities at home (DOF, 2019), however, the definition given in Article 311 of work at home is not the same as telework or home office.

This means that teleworking is not regulated in detail in the existing labor legislation, it is only validated with home-based work, which is different from the term teleworking, one of the main differences between the two terms is that the services of the home-based worker end at the time of delivering the finished product; with the teleworker a stable work situation is maintained, where the activities can vary continuously (Silva et al., 2013).

With the passage of time, there has been an attempt to increase the level of acceptance of teleworking with different strategies, such as the so-called "office in your home" that took place in Mexico City in 2017 (ILO, 2017). Regarding legal advances by the government, the Commission of Labor and Social Welfare in the Chamber of Deputies approved the opinion that seeks to regulate telework in Mexico, which had already been presented by senators in 2018, whereby Article 311 of the Federal Labor Law will be reformed resulting in chapter Xll bis. (Martínez, 2020). With the reform of the article will be accepted by law the term of telework and will be added specifications on different points of telework, modifications that are still in process.

Actually, in March 2020 it was decided that there would be no return to the classroom because the necessary conditions against Covid-19 in Mexico were not available (Health Sector, 2020), so classes began to be taught remotely/virtually from basic to higher levels, which meant a change in the work modality from face-to-face to virtual for teachers and students at all educational levels, causing a change in the working conditions for educators and students.

As described by Cifre and Alonso, (2002) telework brings with it new needs and demands, as well as health risks. The existing health risks in teleworking can be related to those that occur in office jobs, since both tasks are performed with the help of Information and Communication Technologies. On the other hand, as mentioned by Mondelo et al. (2013) in offices musculoskeletal problems occur mainly due to the position in front of the desk and the computer. In addition to the above, according to Erika Villavicencio, a researcher at UNAM, mentions that only 2 out of 10 companies in Mexico are prepared to apply the telework modality as a result of the health emergency due to Covid-19. (Miranda, 2020).

Given this context, the following question arises: what are the main ergonomic risk factors in the telework modality in which teachers of basic education are exposed to.

Objective

To know the ergonomic environment where teleworking is currently developed in teachers of basic level by means of an online instrument in order to obtain proposals for improvement.

2. METHOD AND MATERIALS

Subject under Study

The subject under study in the research was determined to be basic education teachers (preschool, elementary and high school) residing in northwestern Mexico.

Procedure

In order to fulfill the objectives, set forth, the order of the steps to be followed is presented below:

Determination of the sample.

1.- Identification of the total number of the population of the subject under study by means of the Statistical and Geographical Yearbook by federal entity carried out by INEGI in 2019.

2.- Identification of the formula for the calculation of the proportion sample with finite population (Valdivieso et al., 2011):

$$\boldsymbol{n} = [\boldsymbol{N} * (\boldsymbol{Z^2}) * \boldsymbol{p} * \boldsymbol{q}] / [(\boldsymbol{e^2}) * (\boldsymbol{N-1}) + (\boldsymbol{Z^2}) * \boldsymbol{p} * \boldsymbol{q}]$$

Design of the instrument

1.- To adapt the instrument developed by the Department of Ergonomics of the University of Concepción and the Chilean Society of Ergonomics (SOCHERGO), called "Ergonomic environment of telework in pandemic situation" (2020). to a format that allows the distribution and answer at a distance and in a fast way.

2.- To adjust the questions that require it so that they are in agreement with the culture of the subject of investigation and to add questions in the spaces where more information is required.

Analysis of results.

1.- Break down the results obtained through the questionnaire, express them in percentages and present them graphically.

2.- Identify points that had a higher percentage with negative connotation, for example: does not have, does not consider it or has inconveniences.

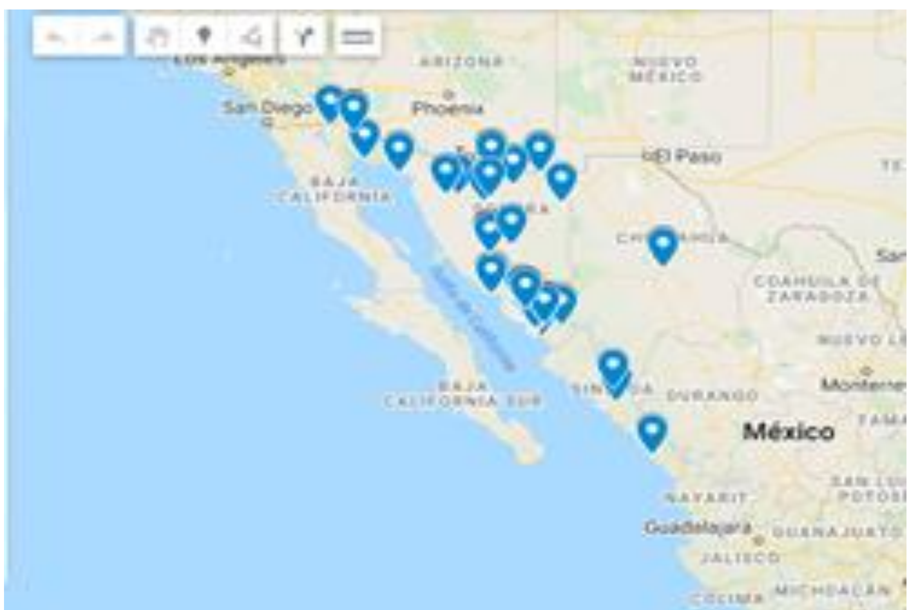
Materials

● Instrument.

●Social networks to disseminate the instrument.

3. RESULTS AND DISCUSSION

Considering a finite population sample of N=152,524 and a 90% confidence level, an n of 272 subjects was obtained, distributed as follows:



The instrument "Ergonomic environment of telework in pandemic situation" was adapted to Google form. The questions are grouped as shown below:

1. general information,
2. work situation

3. telework experience,
4. nutrition and physical activity,
5. conditions for the development of telework and postural aspects,
6. aspects of the environment
7. Aspect of mental workload, work demands and working hours, 8.
8. Telework and consequences.

In the process of adaptation, two sections were added called "work situation" and "telework and consequences" respectively. The first item was added to identify if the respondent belongs to the group of interest of the research, and the second item was added so that the respondents could give a general response to the acceptance of teleworking.

The most relevant results are presented below:

1.- The surveys answered by the teachers of basic education were a total of 277 surveys.

2 .- 71.84% of the surveys were answered by women and 28.15% by men.

3.- 53.79% of the people who participated were between 20-29 years old, the second group with the highest percentage was 30-39 years old with 21.66%, the third group was 40-49 years old with 14.07%, the fourth group was 50-59 years old with 9.02%, the fifth group was 60-69 years old with 1.08% and the last group was >70 years old with 0.36%.

4.- 47.29% of the sample is single, 44.76% of the sample is married, 5.77% of the sample is cohabiting, 0.72% of the sample is widowed and lastly 1.44% of the sample is divorced.

5.- 4.33% live alone, 12.99% live with 2 persons, 22.01% live with 3 persons, 31.41% live with 4 persons and 29.24% live with 5 or more persons.

6.- 64.98% live with adults, 22.02% live with adolescents, 6.13% live with children from 6 to 10 years old, 2.16% live with children from 3 to 5 years old and 4.69% live with breastfed babies.

7.- 1.08% have high school education, 0.36% have technical studies, 54.87% have university studies, 34.29% have a master's degree and 9.38% have a doctorate.

8.- 32.85% of the population lives in homes between 50 and 80 m2 , 27.07% of the population lives in homes between 81 and 100 m2 , 20.93% between 101 and 140 m2 and 19.13% over 140 m2 .

9.- 43.32% have a fixed-term contract, 45.84% have a permanent contract, 2.16% are self-employed and 8.66% are self-employed and dependent.

10.- 80.14% are in the basic-public education sector and 19.85% are in the basic-private education sector.

11.- 15.88% had done telework and 84.12% of people had not developed telework before COVID-19.

12.- Among those who developed telework prior to COVID-19, 76% developed telework at home and 24% developed telework at home and/or in public places.

13.- About 48.37% of people with no experience in telework, did not receive instructions on how to perform the tasks in the best way.

14.- The advantages of teleworking are, lower costs 67.15%, greater flexibility 57.04%, better reconciliation of family life and work 28.52%, 9.39% indicate that having the possibility of teleworking increases their job satisfaction, 1.44% other and 4.69% do not find any advantage.

15.- 20.77% have training and/or formal training in ergonomics and 79.42% do not have. People with training in ergonomics indicate better health, productivity, quality and better labor relations.

16.- 66.42% of the people did make adjustments in their way of eating and 33.57% did not make adjustments in their way of eating.

17.- 44.76% of the people stated that they have increased their weight, 38.98% have maintained their weight and 16.24% have decreased their weight.

18.- 40.07% of the people eat the same quantity and quality, 22.38% eat more quantity, but healthier, 19.49% eat more quantity, but less healthy and 18.05% eat less and healthier.

19.- 49.09% do not engage in regular physical activity, 28.15% engage in physical activity 1 to 3 times a week and 22.74% engage in physical activity 3 or more times a week.

20.- 71.12% of people have less physical activity comparing teleworking with traditional office work, 14.08% have the same physical activity and 14.80% have more physical activity.

Conditions for the development of teleworking and postural aspects.

21.- About the technologies used, 75.81% indicate to work with notebook, 88.09% with smart phone, 19.49% with fixed pc and 19.13% with tablets.

22.- 46.93% have a desk, 22.74% have an adjustable chair, 2.89% have a footrest and 50.18% have none of the above.

23.- In the case of the notebook, 81.58% do not have a support that allows them to adjust to the height.

24.- 32.88% use a peripheral mouse and 67.12% do not use a mouse.

25.- 21.27% have a peripheral keyboard and 78.73% do not.

The following shows the percentage of those who have had discomfort and the severity, where 1 is no discomfort, to 5 very strong discomfort.

	1	2	3	4	5
Neck	19.13%	22.02%	28.52%	16.97%	13.36%
Shoulder	31.77%	24.55%	23.83%	11.91%	7.94%
Back	11.55%	16.61%	29.24%	21.30%	21.30%
Elbow or Forearm	52.71%	23.47%	17.33%	3.97%	2.53%
Hand/wrist	40.43%	26.35%	19.49%	9.03%	4.69%
Legs, knees.	31.05%	25.27%	24.55%	10.83%	8.30%

● Aspects of the environment:

26.- 54.15% have a workplace designated for work space, 45.85% do not have a fixed place.

29.- 41.52% carry out their activities in the dining room, 7.58% in the kitchen, 57.04% in the bedroom, 23.83% in the living room, 7.94% in an office, and the remaining 1.81% in another place.

30.- 76.17% consider that their family respects their work space and time, the remaining 23.83% do not consider it so.

31.- 38.63% consider their teleworking environment as noisy, the remaining 61.37% do not.

32.- Of the persons who consider their work environment as noisy, 23.61% are bothered by it, 37.96% do not allow them to concentrate, 38.43% find it difficult to communicate with colleagues and / or students.

33.- When concentrating, 16.97% use headphones with music, 10.11% use headphones without music, 0.72% use earplugs or similar systems, 21.30% listen to background music, and 50.90% do not perform any of the activities mentioned above.

34.- To 14.08% the illumination does not allow him to realize the telework without generating some annoyance or inconvenience, to the remaining 85.92% it does not generate any problem to him.

35.- The problems that generate that the illumination is inadequate (if it applies), 36.79% is by the scarce illumination, 37.31% is by reflections and/or annoying glare and 25.91% is by problems of contrast.

36.- 88.09% consider that the ambient temperature is adequate and 11.91% consider that it is not.

● Aspects of mental workload, work demands and work schedules:

37.- 14.44% consider that they have 100% control over the pace of work, 53.07% 75% of the time, 23.83% 50% of the time, 6.50% only 25% of the time and 2.17% consider that they never have control.

38.- Regarding supervision during the workday, 7.22% had it 100% of the time, 18.05% 75% of the time, 24.55% 50% of the time, 25.63% 25% of the time and 24.55% never had supervision.

39.- 19.49% can negotiate deadlines and deliver results 100% of the time, 31.41% 75% of the time, 23.10% 50% of the time, 12.64% 25% of the time and 13.36% never.

40.- 3.97% of the time demands exceed their ability to handle them 100% of the time, 18.41% 75% of the time, 24.91% 50% of the time, 22.74% 25% of the time and 29.96% never.

41.- 61.01% have established work and rest schedules, 31.05% do not and 7.94% prefer not to answer.

42. 55.23% respect work schedules and 44.77% do not respect them.

43.- Of the total population that is not able to respect work schedules, the main reasons are: household chores (32.13%), because the boss and/or colleagues do not respect the work schedule (21.66%), because the students do not respect the schedule (44.04%) and, finally, 34.30% have not had any problems of this kind.

44.- 84.48% have a schedule between 8:00 and 12:00 hours, 43.68% between 12:00 and 16:00 hours, 38.27% between 16:00 and 20:00 hours, 14.80% between 20:00 and 24:00 hours and 3.97% between 24:00 and 4:00 hours.

45.- 80.14% respect the domestic chores and responsibilities of children and/or adults who require help in the home, 18.77% do not respect them and 1.08% do not apply or differ from the two previous answers.

46.- The domestic activities that most distract during the development of teleworking are: 55.23% cooking, 56.32% cleaning, 31.05% shopping for supplies, 20.58% washing clothes, 29.96% care of children and / or adults who require it, 29.60% support for children in school activities.

● Telework and consequences

The following is the perception as to whether it has improved or worsened in the following aspects:

	Has improved	Remains unchanged	Has worsened	Not applicable	I prefer not to answer
Health	11.91%	65.70%	18.41%	2.17%	1.81%
labor productivity	13.00%	58.84%	23.10%	2.17%	2.89%
Quality of work	14.80%	59.21%	22.74%	1.08%	2.17%
Relations with colleagues	9.39%	64.62%	19.86%	4.69%	1.44%
Relations with headquarters	8.66%	74.01%	12.27%	3.97%	1.08%
Customer/student relations	11.91%	53.79%	28.16%	3.97%	2.17%
Relationships with your family	31.41%	55.23%	12.27%	0.36%	0.72%

48.- 11.19% are worried about being fired, not renewing their contract or fear losing their clients; 16.97% are worried that the work they do may be changed against their will, 19.49% feel that their boss/clients recognize their work and 52.35% are able to respond adequately to work and domestic demands.

49.- On a scale of 1 to 5, where 1 is bad and 5 is excellent, 11.55% rated their teleworking experience as 5, 48.01% as 4, 32.85% as 3, 5.42% as 2 and 2.17% as 1.

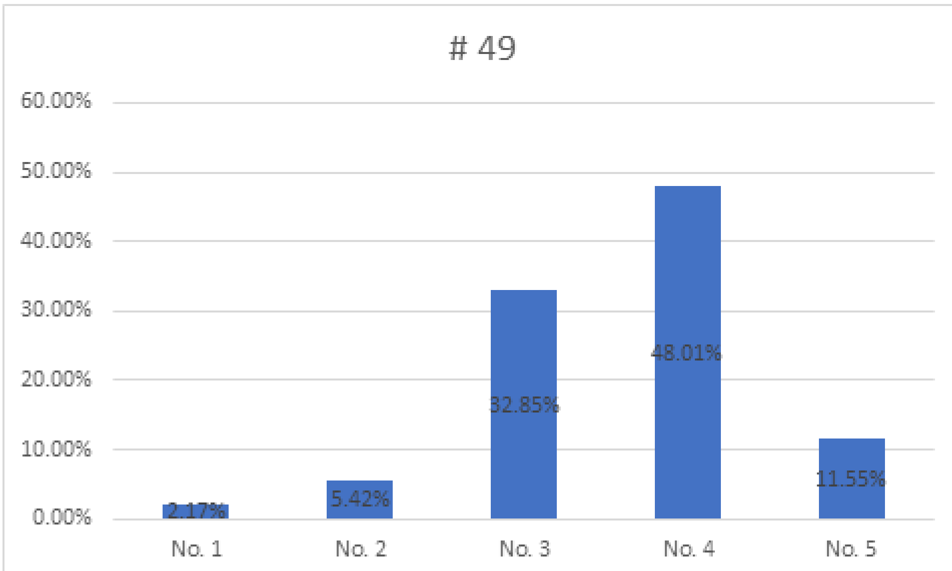


Figure 2. Telework Perception

Discussions

Before the pandemic, 84% had not developed telework, and yet 79.42% of the population did not receive training and/or training in ergonomics or instructions on how to perform the activities. This indicates risks of damage to health, such as weight gain, physical discomfort and a less healthy diet.

One of the most notorious problems is that almost 50% do not have a fixed workplace and 14.08% have lighting problems, an inconvenience that can cause discomfort and damage to the eyesight over time. In terms of physical discomfort, pain in the neck and back stand out, as 13.36% and 21.30% say they have had very strong discomfort, for example, more than 50% of the population suffers from some physical discomfort and it is related to the fact that the percentage that considers the positions when working is lower than those who do not, only in the back the percentage of 35% is higher than those who do not consider their position of this part of the body.

45% do not have a fixed place to perform the work, a fact that makes it difficult that the conditions are suitable for teleworking, because it would have to design and adapt several spaces in the home. 31% do not have a work schedule and 44% do not comply with the established schedule, which means that a percentage of people who have planned working time is not possible to continue with what they initially planned.

4. CONCLUSION

As mentioned before, teleworking is the action of carrying out the tasks designated by a boss from a place outside the facilities of the company or established place, making use of the Information and Communication Technologies. To identify the experience of the teleworkers in the remote work it is necessary to know their opinion in different points. In this case with the help of a questionnaire on teleworking it was possible to collect information from 277 people by means of an instrument of 50 questions about the workplace.

Regarding the personal experience of the people, the majority qualified the experience as good or regular, only a small percentage of 5% to 1% approximately qualified as excellent and bad respectively the realization of the remote work, the above indicates in a general way their perception, but, it is possible to identify more in depth the ergonomic conditions. For example, 49% do not perform regular physical activity, 71% perform less physical activity than when they worked in person, 33% did not make adjustments to their diet and 44% have gained weight, these data are related to each other and generate attention in the high percentages because the four points are important for the health of the population.

The activities that present greater risk according to the level of manifestation 81% do not have a support to adapt the height of the monitor, 78% do not have a peripheral keyboard, 71% perform less physical activity contrary to when they worked in person, a little more than half consider that they have control approximately 75% of the time in their tasks; most consider that labor relations and productivity have remained the same, the percentage that believes that it has worsened is greater than that which considers that it has improved, only in family relations a greater percentage of improvement is observed; 38. 6% consider their work space as noisy, 23.8% consider that their family does not respect their space, 18.7% say that household chores are not respected, 16.9% fear that the work they perform will be changed without notice, 14.08% are bothered by the lighting and 3.97% perform their work from 24:00 to 4:00.

RECOMMENDATIONS:

The recommendation for the present study is to capture more responses in order to achieve a higher level of confidence. In addition, since teleworking is a modality that has been gaining more relevance, more lines of research can be generated to complement the present one, for example, the economic evaluation of home office in the teaching population, to define the cost benefit of improving the ergonomic conditions of work and evaluations with other types of ergonomic methodologies. These topics, and many others, would help to create a solid research base that would facilitate the adoption of measures to reduce the ergonomic risks inherent to teleworking.

Finally, it is recommended to follow up teleworkers to check the degree of evolution, considering the various impacts that the modality can have on the person, at professional, personal, family and psychic level.

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ASSESSMENT OF MUSCLE FATIGUE IN STUDENTS DUE TO PERFORMANCE BY ONLINE SCHOOLING.

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Resumen: El inicio de la enfermedad altamente contagiosa conocida como COVID-19 es originada en la Ciudad de Wuhan, China el 31 de diciembre de 2019. Mediante el transcurso del tiempo se presenta la expansión del virus impactando a todos los países del mundo, generando en la sociedad un cambio en las actividades cotidianas.

Las medidas establecidas generan un gran cambio en la forma de impartir clases, sin embargo, mediante el uso de la tecnología se emplean diversas estrategias de comunicación mediante plataformas y lograr continuar las clases de forma virtual. La nueva modalidad establece un nuevo panorama en el proceso enseñanza-aprendizaje, presenta cambios en investigaciones y proyectos realizados desde el hogar, origina una serie de modificaciones en el entorno donde los alumnos llevan sus clases virtuales, originado porque los estudiantes no se encuentran en la misma área, considerando los diferentes distractores y largos periodos de tiempo al mantener la misma posición, a su vez; se agrega la condiciones de acuerdo a los recursos y capacidades de cada uno de ellos, presentando una gran variedad de mobiliario a utilizar como silla, escritorio, mesa y su equipo tecnológico como el uso de computadora, tableta, mouse, auriculares, entre otros. Esto lleva a que presenten diversos tipos de dolencias y fatigas en su cuerpo ocasionadas por las horas que pasan asistiendo a los cursos en línea y otras actividades académicas que se conllevan. En este estudio se propone un análisis mediante la evaluación de la fatiga muscular en estudiantes, apoyados con el cuestionario nórdico.

Palabras clave: Evaluación de la fatiga; Cuestionario Nórdico; Fatiga en estudiantes; Ambiente de estudio; Pandemia por COVID 19.

Relevancia para la ergonomía: El estudio de evaluación de la fatiga es un punto muy importante, pues se dan a conocer los riesgos ergonómicos a los que se exponen los estudiantes, en la situación actual de la modalidad de estudios en línea, donde pasan largos periodos frente a una computadora, pues esto puede tener una gran repercusión en su salud; con el presente estudio se puede detectar los riesgos posturales, con lo cual se puede proponer acciones de mejora con el fin de identificar, evitar o disminuir los riesgos por causa de malas posturas.

Abstract: The onset of the highly contagious disease known as COVID-19 originated in the City of Wuhan, China on December 31, 2019. Over time, the expansion of the virus occurs, impacting all countries in the world, generating in the society a change in daily activities.

The established measures generate a great change in the way of teaching, however, through the use of technology, various communication strategies are used through platforms and to continue classes virtually. The new modality establishes a new panorama in the teaching-learning process, presents changes in research and projects carried out from home, originates a series of modifications in the environment where students take their virtual classes, originated because the students are not in the same area, considering the different distractors and long periods of time when maintaining the same position, in turn; The conditions are added according to the resources and capacities of each one of them, presenting a great variety of furniture to be used as a chair, desk, table and its technological equipment such as the use of a computer, tablet, mouse, headphones, among others. This leads to various types of ailments and fatigue in their body caused by the hours they spend attending online courses and other academic activities that are involved. In this study, an analysis is proposed through the evaluation of muscular fatigue in students, supported with the Nordic questionnaire

Key words: Assessment of fatigue; Nordic Questionnaire; Fatigue in students; Study environment; COVID 19 pandemic.

Relevance to Ergonomics: The fatigue evaluation study is a very important point, since the ergonomic risks to which students are exposed are made known, in the current situation of the online study modality, where they spend long periods in front of a computer, as this can have a great impact on your health; With this study, postural risks can be detected, with which improvement actions can be proposed in order to identify, avoid or reduce risks due to poor posture.

1. INTRODUCTION

Due to the prevention measures carried out for the continuation of classes virtually, students are forced to maintain certain postures during an average period of 6 hours a day using electronic devices, It is suspected that such positions could directly affect the student's academic performance causing fatigue and musculoskeletal injuries long-term. By using various equipment, as an example the Heavy keyboard use has been associated with a risk of developing symptoms skeletal muscles and hand, wrist and arm disorders (Quin, Chen & Dennerlein, 2013).

Considering the academic load and the hours of work that this entails, it is convenient to analyze if the student's conditions are adequate to perform in a way correct the level of academic load currently assigned, students usually have break time between classes, as well as the impact on the mental and physical health of the student dedicating 6 to 12 hours a day to academic activities, situating itself in the context of a crisis health and economic world.

Life of the Average Student During the Virus Pandemic COVID-19, was radically affected, classrooms were changed, classmates, green areas, mastered by a screen which is supposed to provide useful knowledge for your training as a professional. However, the population student has not accepted the change that this modality implied, seeing overwhelmed by the excessive academic load assigned to them and the long working hours that this represented. Investigation of the factors that cause such fatigue in the student, the consolidation of a limit in school work and promoting postures and activities that reduce continuous exposure to stress on the student's body.

2. OBJECTIVES

Analyze the fatigue caused by the performance of school activities due to of the confinement caused by the COVID-19 pandemic. The investigation is will be carried out through an analysis of the changes and conditions of bachelor students, in order to detect the generative aspects fatigue, in this way it will be possible to generate comparisons of the various circumstances and in turn make suggestions to improve the study environment.

3. METHODOLOGY

The research study will be focused on the students of the Tecnológico Nacional de México / Campus Hermosillo studying industrial engineering in the seventh semester, during the semester. The reason for the analysis is with a focus on students with a workload similar in school activities, the vast majority of them are studying similar subjects.

The activity required for the data collection of the study, is carrying out a online survey, that way the results will be obtained for later, make conclusions from the information obtained, whose purpose is the analysis of the conditions of the students before the new online modality and the detection of regions of the body that generate discomfort susceptible to generating a disorder. The population is a quantity of 160, before this a procedure of acceptance sampling, developing the procedure described by Gutiérrez and De la Vara, (2009). This project is of the type of cross-sectional study, it is focused on practical application aimed at the students. The results are obtained through a series of questions conducted through a survey, including the Nordic questionnaire and questions identification.

The study considers variables dependent on the time period of the discomfort that is 8 months. The Nordic questionnaire considers a time lapse greater, but due to the time of confinement on the date of study of the population, the consideration of 8 months is the appropriate time to establish. Another dependent variable is the duration of episodes with discomfort, the frequency and the time when you start to feel discomfort. As dependent variables, the question is asked if they have used any treatment for discomfort, if you have changed posture due to discomfort and if they have impeded school activities. The neck, shoulder, lumbar, arm, elbow, hand and wrist are considered as independent variables.

The preparation and collection of survey data is done through a sequence of steps in a chronological and orderly manner. A survey was carried out in the system to create questionnaire in the Survio program in which the objective is to know about injuries arising from online classes for technology students.

The data to consider to identify the sample are: gender, age and semester, the last piece of information being useful to develop a filter to take into account its answers in relation to the objective we seek due to the population to which it goes directed are 7th semester students, this means they are in average in a range of 22-23 years, so that the respondents did not take a Semester other than the seventh are not considered for the development of results. After discarding the surveys that did not have the necessary requirements, a count was made to see if there were enough responses to meet the sample size. In presenting the situation of no meet the minimum number of responses, it will be necessary to continue with the application of surveys until the objective is met. The results of the survey will be developed in an Excel spreadsheet. I know will fully break down all the issues, adding frequency, frequency cumulative, percentage and cumulative percentage.

4. RESULTS

Data collection is based on the survey focused on analyzing fatigue and repercussions that are caused by the performance of school activities with the new online mode. The results obtained in the survey are generated from a database, in a Excel spreadsheet in which all the
questions, adding frequency, cumulative frequency, percentage and percentage accumulated. The surveys are based on the Nordic questionnaire to analyze muscle fatigue in the neck, shoulder, elbow or forearm, thoracic or lumbar area and wrist or hand. 43 test subjects were interviewed, of which 58.1% are female and 41.9% male, as shown in figure 1.

In order to identify the environment that the student has when found in classes with the online mode, because there can be several objects by which the area can be made up, the respondent has the option to say between 6 that they are desk, dining table, desk chair, dining chair, armchair and bed. Table 1 indicates the frequency of the mentioned options. Of the options that are presented; carry out your activities online, be in the dining table has a higher frequency with a value of 24 (representing a percentage of 31.2%) and continuing downwards, using a desktop has a frequency of 18 (representing a percentage of 23.4%). The data obtained with less frequency is the desk chair and armchair with a frequency of 7 data (9.1%).

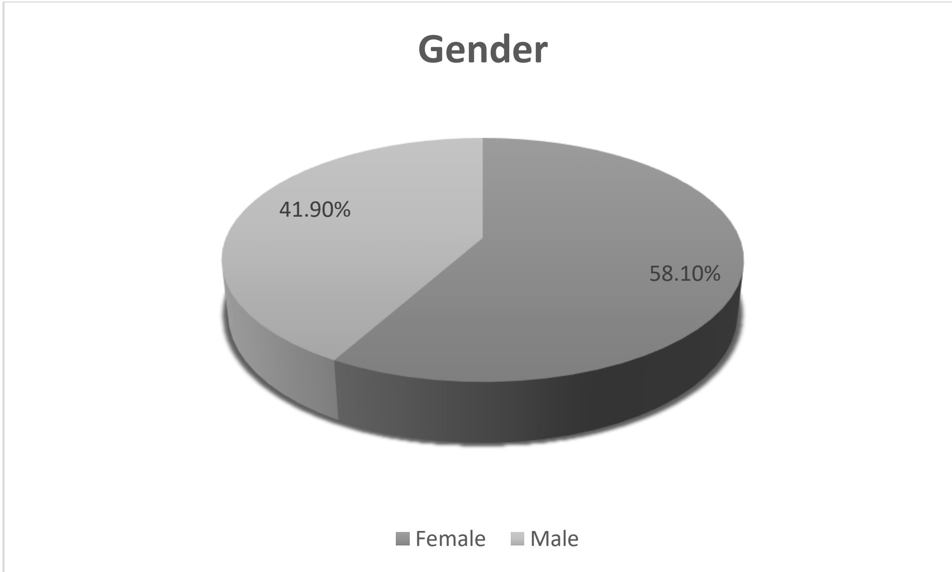

Figure 1: Test subjects by gender.

Table 1: Frequent area for study.

Workplace		Frequency
Frequent study area	Desk	18
	Dining table	24
	Desk chair	7
	Dining chair	9
	Arm chair	7
	Bed	12
	Other	0

Through the application of the Nordic questionnaire, several divisions are indicated, initially the regions where the respondent has presented discomfort are identified, of which they are; neck, shoulder, dorsal or lumbar, arm or elbow and hand or wrist, then the frequency of each response obtained and the percentage that each option represents is presented. The regions where the most discomfort has occurred are in the neck and in the thoracic or lumbar region, with the least amount of frequency being the arm or elbow, as shown in Table 2.

When asking, if you have received treatment for discomfort, the most frequent is the neck, then the dorsal or lumbar, shoulder and hand or wrist are the areas that follow it and finally there is the area of the arm or elbow which does not present records of having received treatment among the surveyed population.

Table 2: Nordic questionnaire application.

			Frequency	Percentage
Has you felt discomfort in?	Neck	Yes	39	91%
		No	4	9%
	Shoulder	Yes	25	58%
		No	18	42%
	Dorsal or lumbar	Yes	29	67%
		No	14	33%
	Arm or elbow	Yes	12	28%
		No	31	72%
	Hand or wrist	Yes	24	56%
		No	19	44%

Once the survey has been carried out and the data collected, the results indicate that in the neck area the two highest percentages in the causes of discomfort are long periods of study with 42% and the posture taken by students with 39% this being the area in which the most responses were given for the proposed causes. The shoulder area has the highest percentage, like the neck already presented previously, to posture with 43% and long study periods with 34%.

The dorsal or lumbar shows that the posture and long study periods are the cause of the discomfort with 44% and 36% respectively, like the two previous areas. The arm or elbow area has the lowest frequency of results with a total of 24, with 50% of the posture as the major cause of discomfort.

Finally, we have the hand-wrist area in which 21 of the 52 students who responded to the discomfort in this area, which gives us 40% in posture as the main cause. After reviewing the graphs we can easily realize that the discomfort of the high school students is caused mostly by the bad postures adopted at the time of taking online classes or carrying out their activities on the computer and this is also reflected in the same way way in the long periods of study and tasks that they present.

5. CONCLUSIONS

The elaboration of the research gives results of fatigue analysis in the different regions of the body, the study is carried out in a reduced way directed to the industrial students of the seventh semester, because of the ease of communication with the students who attend this level, however, it is important to consider the willingness or ease that students have in taking the survey, so it is recommended that it be a brief survey. One point of view that should have been considered in the analysis is the sports activities that the student performs because it may happen that due to physical activity some of the injuries may occur.

The results obtained in the surveys indicate that the neck and back region is where the greatest discomfort occurs, due to the posture and long periods of study of the student and one of the causes is the conditions not suitable to continue in classes online as the most frequently used workspace was identified is in a dining room. Considering the period of time, more than half of the students have presented discomfort and it is mainly in the neck region.

A series of interesting aspects were identified to analyze during a second phase of the project, some of them is the eye fatigue that implies being a long period using an electronic device, another factor is the average of the rest periods that students have between classes and the average time spent on daily school activities. A future investigation would be properly carried out in 3 samples, that is, to analyze the results of the student's conditions at the beginning of the semester, another analysis in the intermediate term and finally at the end, this allows a comparison of the state of the three phases with the modification of the rhythm of work.

The communication that exists between the respondent and the interviewer, because it may happen that the respondent understands the context of the question and responds in a way that is inconsistent or related to what is requested. One of the limitations is the database created, when using the survio program for the application of the surveys is the trial license, this generates limitations such as downloading the database to an electronic sheet, before it was required to perform each graph of each question.

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FATIGUE ANALYSIS AND EVALUATION OF WORK AREAS IN CONFINED SPACE WELDERS IN LOS MOCHIS, SINALOA.

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Resumen: Un espacio confiando es un espacio cerrado, que presenta, para los trabajadores, posibles riesgos de incendio, explosión, pérdida de conocimiento, asfixia o agotamiento.

Puede ser pequeño y restrictivo (conductos o depósitos) o de gran tamaño (silo de almacenamiento de grano de una capacidad de hasta cientos de metros cúbicos).

Los principales riesgos que presentan los trabajadores cuando laboran en lugares como estos son: inhalar humos nocivos, los bajos niveles de oxígeno, o el riesgo de incendio.

Otros peligros incluyen el ahogamiento o la asfixia por otras fuentes como polvo, grano u otros contaminantes.

Aquí se van a presentar los resultados de diferentes estudios realizados a trabajadores sometidos a este ambiente laboral.

Una vez analizados los estudios definiremos cuáles son las áreas que necesitan mayor grado de cuidado, debido a que están perjudicando en mayor medida la salud del empleado.

Una vez identificados los puntos claves, desarrollar una evaluación completa sobre el ambiente laboral, que nos ayude a tener datos en tiempo real sobre la salud del trabajador y poder asegurarnos de una manera más precisa que aún se encuentra dentro de los parámetros normales y no están dañando su salud.

Ya con los datos estructurados y analizados brindaremos propuestas que hagan el trabajo menos demandante y genere menos desgaste para el trabajador asignado.

Palabras clave: Espacios confinados, ergonomía, posturas.

Relevancia para la ergonomía: El no dar el suficiente cuidado a los trabajadores que operan en espacios confinados puede llegar a dar problemáticas de corto a largo plazo. Por ello, el estudiar la fatiga y las áreas en las que labora un operador en espacios confinados, en este caso, un soldador, da por relevante el riesgo que propicia su labor como también el daño a su cuerpo a largo plazo.

Abstract: Confined space is an enclosed space, which presents, for workers, possible risks of fire, explosion, loss of consciousness, suffocation or exhaustion.

It can be small and restrictive (pipes or tanks) or large (grain storage silo with a capacity of up to hundreds of cubic meters).

The main risks that these workers present when they work in places such as: inhaling harmful fumes, low oxygen levels, or the risk of fire.

Other hazards include drowning or suffocation from other sources such as dust, grain, or other contaminants.

Here we will present the results of different studies carried out on workers subjected to this work environment.

Once the studies have been analyzed, we will define the areas that need a greater degree of care, because they are harming the employee's health to a greater extent.

Once the key points have been identified, develop a complete evaluation of the work environment, which helps us to have real-time data on the health of the worker and to be able to ensure in a more precise way that it is still within normal parameters and that they are not damaging your health.

With the structured and analyzed data, we will provide proposals that do less work and generate less wear and tear for the assigned worker.

Keywords. Confined spaces, ergonomics, postures.

Relevance to Ergonomics: Not giving enough care to workers operating in confined spaces can lead to short- to long-term problems. Therefore, studying fatigue and the areas in which an operator works in confined spaces, in this case, a welder, gives as relevant the risk that promotes his work as well as the damage to his body in the long term.

1. INTRODUCTION

Confined space welding work has a variety of hazards that must be considered and tried to be minimized as much as possible.

Specifically in this type of work in confined spaces there is a risk of suffocation, excessively high temperatures, explosions and serious physical wear, which, for us, is of the utmost importance to carry out the highest possible degree of vigilance despite the complications. That means working in such a small space.

During the development of this article, we will observe, analyze and evaluate the physical and mental fatigue and the environment to which the workers in the welding area who are in charge of the water filters produced by the company are subjected daily, these analyzes will be overcome. by yoshitake and corlett & bishop studios. On the other hand, the light and sound measurements to which they are subjected, we will compare them with the parameters of the corresponding standards. Once with the results of the studies, we will graph it and evaluate the answers to determine the physical and mental conditions of the worker. Later we will analyze the possible proposals to improve the work environment in that area.

2. OBJECTIVES

The main objective with which this research was carried out is to clearly analyze the results are the factors within the work area in confined spaces that can harm the health of the worker.

2.1 GENERAL OBJECTIVES

▪ Ensure the physical integrity of the worker
▪ treat so that the job requires less effort.
▪ Make sure that the environment is under the established.

2.2 SPECIFIC OBJECTIVES

▪ Avoid temporary or permanent damage to the worker's health
▪ To avoid repercussions in your adult life due to work
▪ Verify that the confined space has an environment that does not over-exploit the capabilities of the worker
▪ Propose changes that can improve the work environment in that area.

3. METHODOLOGY

3.1 DATA COLLECTION.

During the span of a working week (from Monday to Saturday) data were collected based on the ergonomic situation in which the dedicated and trained workers for the manufacture of industrial water filters are located, which at one point in their elaboration is to perform welds within said element, resulting in activities in confined spaces.
In the first instance we decided to go to a company in which work is carried out in confined spaces and also to be able to analyze the postures taken by the worker, as well as to take measurements of the noise and lighting to which they are exposed while in the area, for this we have the contribution of Eng. Ramos who provided us with information about the precautions and care that apply both to the worker and in the environment.

Theoretical Basis: Official Mexican Standard,

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

TABLA A.1 LIMITES MAXIMOS PERMISIBLES DE EXPOSICION

NER	TMPE
90 dB(A)	8 HORAS
93 dB(A)	4 HORAS
96 dB(A)	2 HORAS
99 dB(A)	1 HORA
102 dB(A)	30 MINUTOS
105 dB(A)	15 MINUTOS

DAYS	ENTRANCE	EXIT	PERMISSIBLE TIME IN DECIBELS (dB)
MONDAY	59.9	62.2	102
TUESDAY	61.2	63.4	102
WEDNESDAY	62.5	61.3	102
THURSDAY	60.3	59.7	102
FRIDAY	61.2	59.9	102
SATURDAY	59.8	62.1	102

Theoretical Basis: Official Mexican Standard, **NOM-025-STPS-2008**

Tabla 1

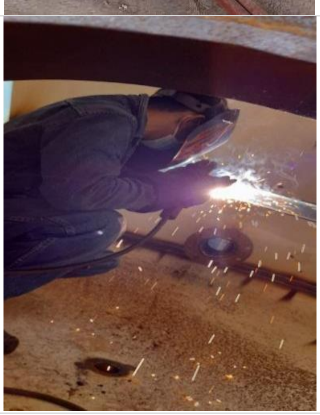
Niveles de Iluminación

Tarea Visual del Puesto de Trabajo	Area de Trabajo	Niveles Mínimos de Iluminación (luxes)
En exteriores: distinguir el área de tránsito, desplazarse caminando, vigilancia, movimiento de vehículos.	Exteriores generales: patios y estacionamientos.	20
En interiores: distinguir el área de tránsito, desplazarse caminando, vigilancia, movimiento de vehículos.	Interiores generales: almacenes de poco movimiento, pasillos, escaleras, estacionamientos cubiertos, labores en minas subterráneas, iluminación de emergencia.	50
En interiores.	Areas de circulación y pasillos; salas de espera; salas de descanso; cuartos de almacén; plataformas; cuartos de calderas.	100
Requerimiento visual simple: inspección visual, recuento de piezas, trabajo en banco y máquina.	Servicios al personal: almacenaje rudo, recepción y despacho, casetas de vigilancia, cuartos de compresores y pailería.	200
Distinción moderada de detalles: ensamble simple, trabajo medio en banco y máquina, inspección simple, empaque y trabajos de oficina.	Talleres: áreas de empaque y ensamble, aulas y oficinas.	300

DAYS	ENTRANCE	EXIT	MINIMUM LIGHTING LEVELS (LUXES)
MONDAY	51	23	300
TUESDAY	30	16	300
WEDNESDAY	70	31	300
THURSDAY	92	75	300
FRIDAY	87	70	300
SATURDAY	23	14	300

Lighting conditions in workplaces.

3.4 FIELD ANALYSIS

	Shown here is one of the largest pumps that are produced within this industry and the hole shown in the center is the only input and output for the worker performing the task, it can be shown that it is very narrow, they are only 24 inches in diameter.
	Here it is seen that getting inside the pump is complicated and you must have a thin complexion to be able to fulfill it and still complicated for the worker and has to make forced postures
	You can see the worker performing welding tasks inside the pump, you can see how smoke is generated that can be left inside the space, being harmful to the worker

<table>
<tr><td></td><td>In the smallest filter that is manufactured its access is of the same diameter, however, due to its position the postures made when entering are, in the same way, forced but different from the previous pump.</td></tr>
<tr><td></td><td>As you can see the space is too small to perform movements with the arms, and at the time of being welded the temperature can increase, which can affect the health of theworker.</td></tr>
<tr><td></td><td>This would be the view you have of the worker inside the container when he is carrying out his activities inside</td></tr>
</table>

3.2 YOSHITAKE QUESTIONNAIRE

The Subjective Fatigue Symptoms Test is a questionnaire that measures the types and magnitudes of fatigue experienced by workers. It addresses three dimensions of the subjective perception of work fatigue by asking 10 questions for the mental demand at work, 10 for the physical manifestations of fatigue and finally 10 items inquiring about mixed symptoms.

The questions are designed in such a way that they require a dichotomous answer (YES / NO) containing a different tabulation mode for men (6 positive answers) and women

(7 positive answers). This tool was successfully applied in different Latin American countries (Mexico, Cuba, Argentina, Venezuela and Brazil, among others). Used in conjunction with other inquiry techniques, it is valuable for studying the physical and cognitive demands of different types of work processes.
In the time already determined, they were taking samples in relation to the Yoshitake questionnaire, this in order to analyze the fatigue caused by welding in confined spaces. This sampling was carried out to two workers of the company who meet the characteristics to weld inside the filters that are manufactured in the company. Taking into consideration that; Worker 1 referred to as "WORKER A" carried out their activities in confined spaces on Wednesdays and Fridays, and Worker 2 referred to as "WORKER B" carried out their activities in confined spaces on Tuesdays and Thursdays of the investigation week.

Days Worked in Confined Spaces

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Table 2. Symptoms of Drowsiness and Monotony in WORKER A

A. SYMPTOMS OF DROWSINESS AND MONOTONY.	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Ans. in YES	A.F. of YES	Ans. in NO	A.F of NO
	EN	EX	EN	EX	EN	EX	EN	EX	EN	EX	EN	EX				
1. Do you feel heaviness in your head?	N	N	N	N	N	Y	N	N	N	Y	N	Y	3	3	9	9
2. Are you tired all over your body?	N	Y	N	N	N	Y	Y	Y	N	Y	N	N	5	8	7	16
3. Do your legs feel tired or heavy?	N	N	N	Y	N	Y	N	Y	N	Y	N	N	4	12	8	24
4. During this time have you been yawning (since the start of your work or since the last measurement)?	N	N	N	N	N	Y	N	Y	Y	Y	Y	Y	6	18	6	30
5. ¿Do you feel any discomfort in your brain (ie, bloated or have your ideas jumbled)?	N	Y	N	N	Y	Y	N	Y	Y	Y	Y	Y	8	26	4	34
6. Are you sleepy?	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	10	36	2	36
7. Do you feel tired in your eyes?	N	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	9	45	3	39
8. Is it difficult for you to make any movements (do you feel clumsy or numb)?	N	N	N	N	N	Y	N	N	N	N	N	Y	2	47	10	49
9. Do you feel insecure when standing (because you feel sleepy)?	N	Y	N	Y	N	Y	N	N	N	Y	N	Y	5	52	7	56
10. Do you feel like stretching?	N	N	N	N	N	Y	N	N	N	Y	N	N	2	54	10	66
												∑	**54**		**66**	

. **Tabla 3.** Symptoms of Difficulty Concentrating in WORKER A

B. SYMPTOMS OF DIFFICULTY WITH CONCENTRATION	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Ans. in YES	A.F. of YES	Ans. in NO	A.F of NO
	EN	EX	EN	EX	EN	EX	EN	EX	EN	EX	EN	EX				
1. Do you have any trouble thinking when doing your homework?	N	N	N	N	N	Y	N	N	N	N	Y	Y	3	3	9	9
2. Don't feel like talking because work is overwhelming you?	N	N	N	N	N	N	N	N	N	N	N	N	0	3	12	21
3. Does the task you do make you nervous or stressed?	N	N	N	N	N	N	N	N	N	N	N	N	0	3	12	33
4. Do you feel unable to concentrate and pay attention during your work?	N	N	N	N	N	N	N	N	N	N	N	N	0	3	12	45
5. Have you lost interest in things at work?	N	N	N	N	N	N	N	N	N	N	N	N	0	3	12	57
6. Do you forget things related to your work?	N	N	N	N	N	N	N	N	N	N	N	N	0	3	12	69
7. ¿Do you have a lack of confidence in yourself, such that you make mistakes in your work more often than usual?	N	N	N	N	N	N	N	N	N	N	N	N	0	3	12	81
8. Do you feel anxious or restless when doing your tasks?	N	N	N	N	Y	N	N	N	Y	Y	N	N	3	6	9	90

9. Do you have difficulty straightening your posture after you have done your homework?	N	Y	N	N	**N**	**Y**	Y	Y	**N**	**Y**	N	N	5	11	7	97
10. Do you feel that you lack patience to do the things of your work?	N	N	N	N	**N**	**N**	N	N	**N**	**N**	N	N	0	11	12	109
												∑	**11**		**109**	

.

Table 4. Bodily Symptoms or Projection of Damages in WORKER A

C. BODY SYMPTOMS OR PROJECTION OF DAMAGES	**Monday**		**Tuesday**		**Wednesday**		**Thursday**		**Friday**		**Saturday**		**Ans. in YES**	**A.F. of YES**	**Ans. in NO**	**A.F of NO**
	EN	**EX**	**EN**	**EX**	**EN**	**EX**	**EN**	**EX**	**EN**	**EX**	**EN**	**EX**				
1. Do you have a headache?	N	N	N	Y	**N**	**Y**	Y	N	**N**	**Y**	Y	Y	6	6	6	6
2. Do you feel tension in your shoulders?	N	Y	Y	N	**N**	**N**	N	N	**N**	**Y**	N	N	3	9	9	15
3. Do you have back pain?	N	N	N	N	**Y**	**N**	Y	Y	**N**	**Y**	Y	Y	6	15	6	21
4. Do you feel overwhelmed when you breathe?	N	Y	N	N	**N**	**N**	Y	Y	**N**	**N**	N	N	3	18	9	30
5. Are you thirsty?	Y	Y	Y	Y	**Y**	**Y**	Y	Y	**Y**	**Y**	Y	Y	12	30	0	30
6. Has your voice become hoarse?	N	N	N	N	**N**	**N**	N	N	**N**	**N**	N	N	0	30	12	42
7. Do you feel dizzy or lightheaded?	N	N	N	N	**N**	**Y**	N	N	**N**	**N**	N	N	1	31	11	53
8. Are you dazzled or blinking your eyes?	N	N	N	N	**N**	**Y**	Y	N	**N**	**Y**	N	N	3	34	9	62
9. Do you have tremors in your arms or legs?	N	N	N	N	**N**	**N**	N	N	**N**	**Y**	N	N	1	35	11	73
10. Do you feel unwell or ill (generally unwell)?	N	N	N	N	**N**	**N**	N	N	**N**	**N**	N	N	0	35	12	85
												∑	**35**		**85**	

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Table 5. Symptoms of Drowsiness and Monotony in WORKER B

A. SYMPTOMS OF DROWSINESS AND MONOTONY.	**Monday**		**Tuesday**		**Wednesday**		**Thursday**		**Friday**		**Saturday**		**Ans. in YES**	**A.F. of YES**	**Ans. in NO**	**A.F of NO**
	EN	**EX**	**EN**	**EX**	**EN**	**EX**	**EN**	**EX**	**EN**	**EX**	**EN**	**EX**				
1. Do you feel heaviness in your head?	N	N	**N**	**Y**	N	Y	**N**	**Y**	N	N	N	N	3	3	9	9
2. Are you tired all over your body?	N	N	**Y**	**Y**	N	Y	**N**	**Y**	N	N	N	N	4	7	8	17
3. Do your legs feel tired or heavy?	N	Y	**N**	**Y**	N	N	**N**	**Y**	N	Y	N	N	4	11	8	25
4. During this time have you been yawning (since the start of your work or since the last measurement)?	N	N	**N**	**N**	N	N	**Y**	**N**	N	N	N	N	1	12	11	36
5. ¿Do you feel any discomfort in your brain (ie, bloated or have your ideas jumbled)?	N	N	**N**	**N**	N	N	**N**	**N**	Y	N	N	N	1	13	11	47
6. Are you sleepy?	N	N	**N**	**N**	Y	Y	**N**	**Y**	Y	N	Y	Y	6	19	6	53
7. Do you feel tired in your eyes?	N	N	**N**	**Y**	N	Y	**N**	**Y**	N	N	N	Y	4	23	8	61
8. Is it difficult for you to make any movements (do you feel clumsy or numb)?	N	N	**N**	**N**	N	N	**N**	**Y**	N	N	N	N	1	24	11	72
9. Do you feel insecure when standing (because you feel sleepy)?	N	N	**N**	**Y**	N	N	**N**	**N**	N	N	N	N	1	25	11	83
10. Do you feel like stretching?	Y	N	**N**	**N**	N	N	**Y**	**N**	N	N	N	N	2	27	10	93
												∑	**27**		**93**	

. **Table 6.** Symptoms of Difficulty Concentrating in WORKER B

B. SYMPTOMS OF DIFFICULTY WITH CONCENTRATION	**Monday**		**Tuesday**		**Wednesday**		Thursday		**Friday**		**Saturday**		**Ans. in YES**	**A.F. of YES**	**Ans. in NO**	**A.F of NO**
	EN	**SX**	**EN**	**SX**	**EN**	**SX**	EN	SX	**EN**	**SX**	**EN**	**SX**				
1. Do you have any trouble thinking when doing your homework?	N	N	**N**	**N**	N	N	N	Y	Y	N	N	N	2	2	10	10
2. Don't feel like talking because work is overwhelming you?	N	N	**N**	**N**	N	N	N	N	N	N	N	N	0	2	12	22
3. Does the task you do make you nervous or stressed?	N	N	**N**	**N**	N	N	N	Y	N	N	N	N	1	3	11	33
4. Do you feel unable to concentrate and pay attention during your work?	N	N	**N**	**N**	Y	N	N	Y	N	N	N	N	2	5	10	43

5. Have you lost interest in things at work?	N	N	**N**	**N**	N	Y	N	N	N	Y	N	N	2	7	10	53
6. Do you forget things related to your work?	N	N	**N**	**N**	N	N	N	N	N	N	N	N	0	7	12	65
7. ¿Do you have a lack of confidence in yourself, such that you make mistakes in your work more often than usual?	N	N	**N**	**N**	N	N	N	N	N	N	N	N	0	7	12	77
8. Do you feel anxious or restless when doing your tasks?	N	N	**N**	**N**	N	N	N	N	N	N	N	N	0	7	12	89
9. Do you have difficulty straightening your posture after you have done your homework?	N	N	**N**	**Y**	Y	N	N	Y	Y	Y	N	N	5	12	7	96
10. Do you feel that you lack patience to do the things of your work?	N	N	**N**	**N**	N	N	N	N	Y	Y	N	N	2	14	10	106
												∑	**14**		**106**	

.

Table 7. Bodily Symptoms or Projection of Damages in WORKER B

C. BODY SYMPTOMS OR PROJECTION OF DAMAGES	**Monday**		**Tuesday**		**Wednesday**		**Thursday**		**Friday**		**Saturday**		**Ans. in YES**	**A.F. of YES**	**Ans. in NO**	**A.F of NO**
	EN	**SX**	**EN**	**SX**	**EN**	**SX**	**EN**	**SX**	**EN**	**SX**	**EN**	**SX**				
1. Do you have a headache?	N	N	**N**	**Y**	N	Y	**N**	**N**	N	Y	N	N	3	3	9	9
2. Do you feel tension in your shoulders?	N	N	**N**	**Y**	N	N	**N**	**Y**	N	N	N	Y	3	6	9	18
3. Do you have back pain?	N	N	**Y**	**Y**	Y	N	**N**	**Y**	N	N	N	N	4	10	8	26
4. Do you feel overwhelmed when you breathe?	N	Y	**N**	**Y**	N	N	**N**	**Y**	N		N	N	4	14	8	34
5. Are you thirsty?	Y	N	**Y**	**N**	N	N	**Y**	**Y**	Y	Y	N	Y	7	21	5	39
6. Has your voice become hoarse?	N	N	**N**	**N**	N	N	**N**	**N**	N	N	N	N	0	21	12	51
7. Do you feel dizzy or lightheaded?	N	Y	**N**	**Y**	N	N	**N**	**Y**	N	Y	N	Y	5	26	7	58
8. Are you dazzled or blinking your eyes?	N	Y	**N**	**Y**	N	N	**N**	**Y**	N	Y	N	N	4	30	8	66
9. Do you have tremors in your arms or legs?	N	N	**N**	**N**	N	N	**N**	**N**	N	Y	Y	N	2	32	10	76
10. Do you feel unwell or ill (generally unwell)?	N	N	**N**	**N**	N	Y	**N**	**N**	N	N	N	N	1	33	11	87
												∑	**33**		**87**	

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3.3 CORLETT AND BISHOP QUESTIONNAIRE

It consists of marking the parts of the body where the operator feels pain or discomfort and listing them in ascending order according to the degree of discomfort or pain. Therefore, questions such as the following are asked: What is the part of the body where you feel discomfort? What is the second part of the body where you feel discomfort or pain? And so on.

Days Worked in Confined Spaces

Table 8. Frequency In Dolence In Worker A

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
MON	**EN**																					
	EX	B		B	B					B	B				B	B	B	B	B	B	B	B
TUES	**EN**			B				B		B	B		B		B	B						
	EX																					
WEND	**EN**																					
	EX	B		B	B		B		B	B	B	B		B	B	B						
THURS	**EN**																					
	EX		B																			
FRID	**EN**			B			B					B										
	EX	B		B	A		A	B	B	A	A	A	B	B	A	A						
SATU	**EN**	B		B															B			B
	EX																		B			B

.

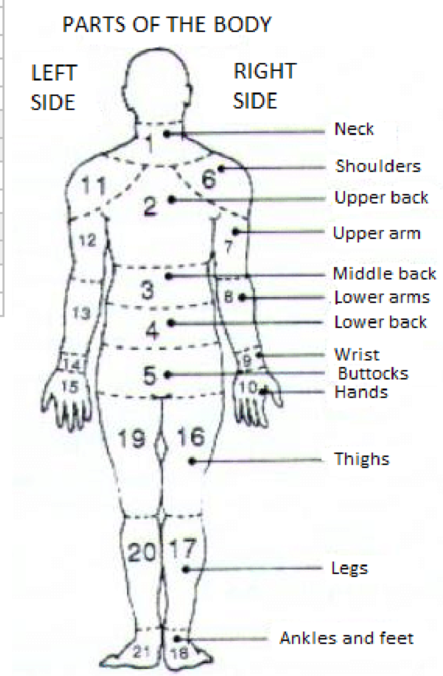


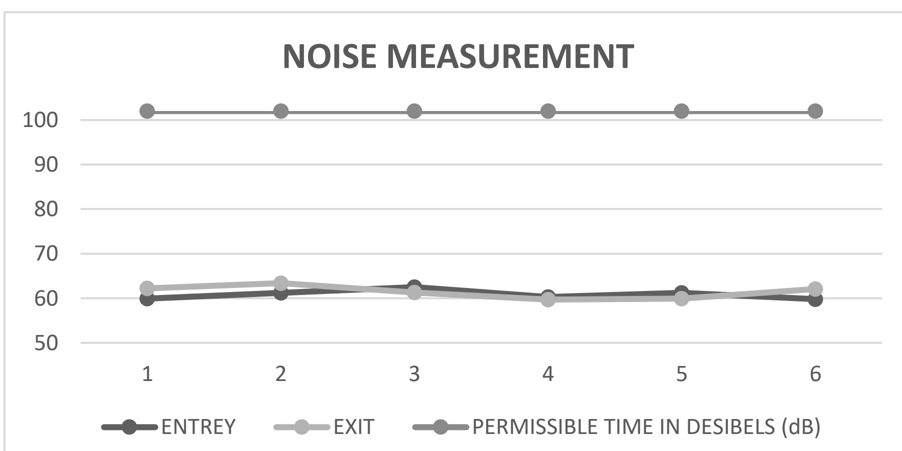
Table 9. Frequency In Dolence In Worker B

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
MON	**EN**																					
	EX	B		B	B					B	B				B	B	B	B		B	B	
TUES	**EN**							B		B	B		B		B	B						
	EX				B												B		B			
WEND	**EN**		B														B			B		
	EX	B		B	B		B		B	B	B	B		B	B	B						
THURS	**EN**				A																	
	EX			B						B	B				B	B	B		B			
FRID	**EN**						B					B					B		B	B		B
	EX	B					A	B	B			A	B	B				B	A		B	A
SATU	**EN**	B																				
	EX			B																		

B= Botheration
A= Aching

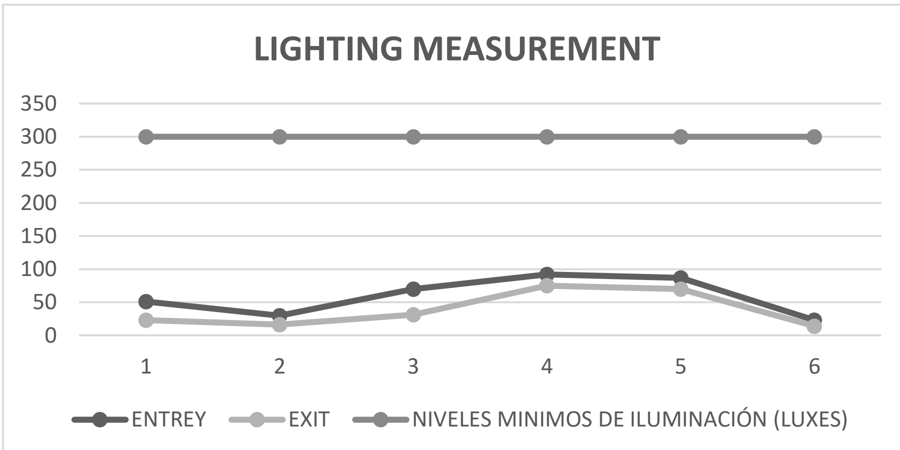
4 RESULTS.

4.1 ENVIRONMENTAL RESULTS.



The graph indicates that the sound levels to which the worker is exposed are maintained by a range of 59.7 to 63.4 decibels.

✓ the maximum permissible time indicated by the official Mexican standard 011 is 102 dB, which means that it is not so high as to cause any damage or pathological disease.



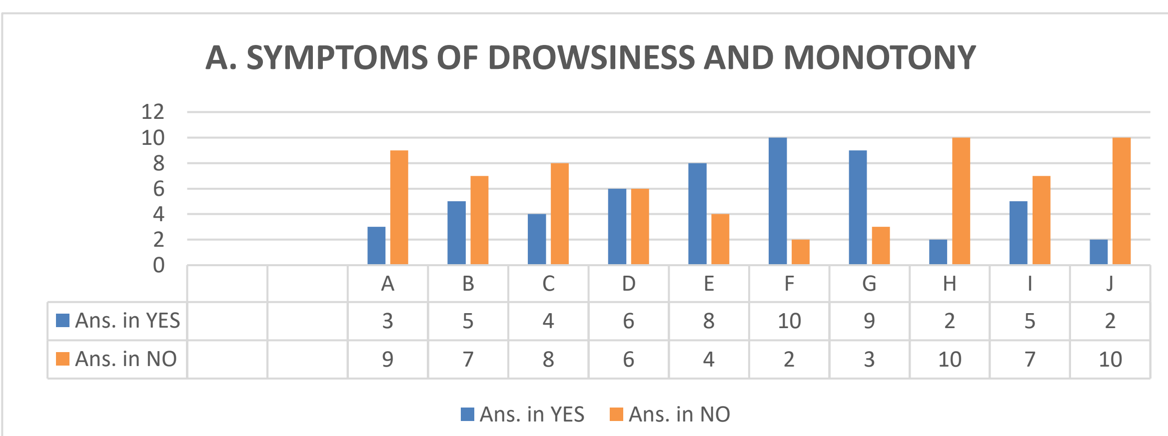
The graph of results shows that the calculated data do not exceed the limit of luxes allowed indicated by the official Mexican standard 025, in the work area where the person is located, being in a range of 14 to 92 luxes.

✓ The variability of the lighting does not cause difficulties in the worker such as seeing incorrectly or concentration problems.

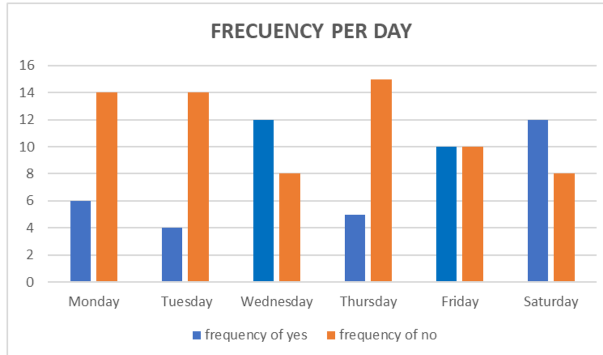
4.2 RESULTS PER WORKER.

4.2.1 YOSHITAKE QUESTIONNAIRE:

WORKER A



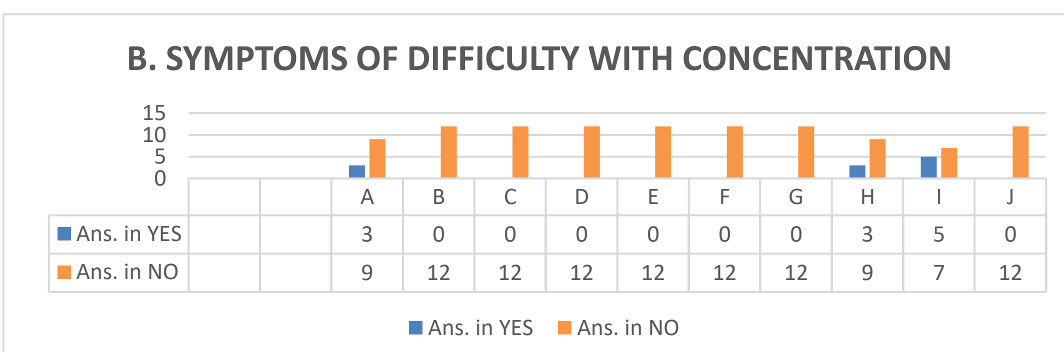
NOT WORKED IN CONFINED SPACES		
DAY	**FREQUENCY OF YES**	**FREQUENCY OF NO**
MONDAY	6	14
TUESDAY	4	14
THURSDAY	5	15
SATURDAY	12	8



A	1. Do you feel heaviness in your head?	**F**	6. Are you sleepy?
B	2. Are you tired all over your body?	**G**	7. Do you feel tired in your eyes?
C	3. Do your legs feel tired or heavy?	**H**	8. Is it difficult for you to make any movements (do you feel clumsy or numb)?
D	4. During this time have you been yawning (since the start of your work or since the last measurement)?	**I**	9. Do you feel insecure when standing (because you feel sleepy)?
E	5. ¿Do you feel any discomfort in your brain (ie, bloated or have your ideas jumbled)?	**J**	10. Do you feel like stretching?

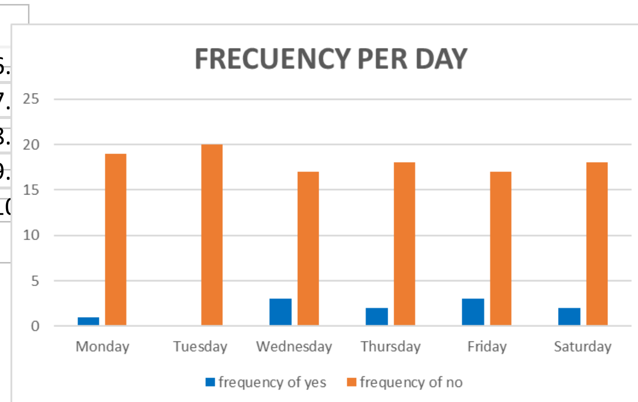
The result applied to demonstrate the symptoms of drowsiness and monotonous, we notice that the results show a difference between the days that he works inside the confined space and those that outside it, when he works in confined spaces, they are usually a little more mentally exhausted.

A	1. Do you have any trouble thinking when doing your homework?	**F**	6. Do you forget things related to your work?
B	2. Don't feel like talking because work is overwhelming you?	**G**	7. ¿Do you have a lack of confidence in yourself, such that you make mistakes in your work more often than usual?
C	3. Does the task you do make you nervous or stressed?	**H**	8. Do you feel anxious or restless when doing your tasks?
D	4. Do you feel unable to concentrate and pay attention during your work?	**I**	9. Do you have difficulty straightening your posture after you have done your homework?
E	5. Have you lost interest in things at work?	J	10. Do you feel that you lack patience to do the things of your work?

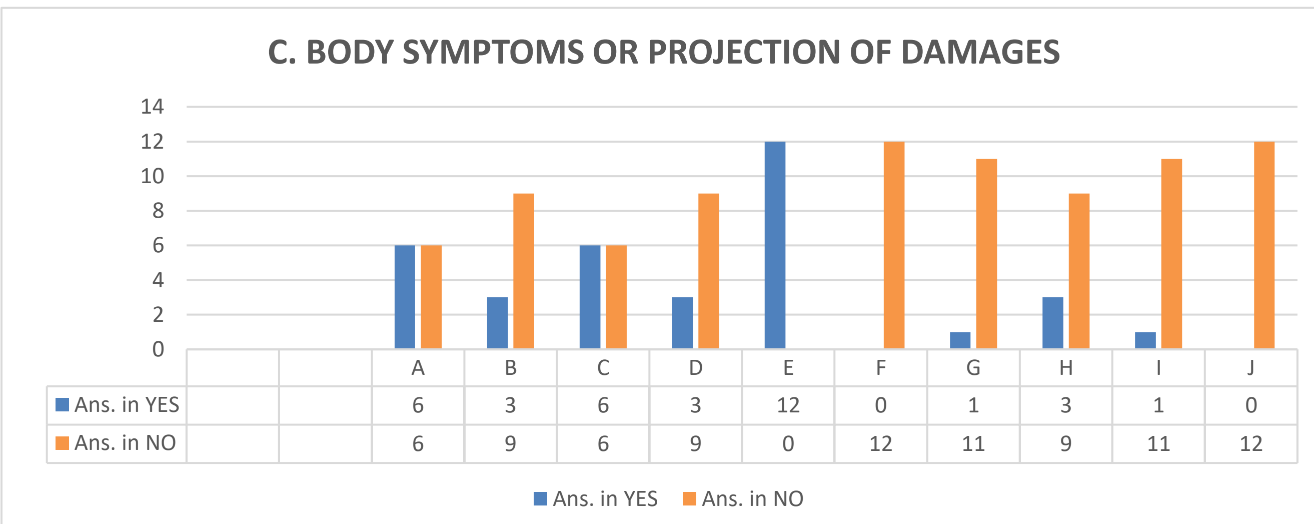


NOT WORKED IN CONFINED SPACES		
DAY	FREQUENCY OF YES	FREQUENCY OF NO
MONDAY	1	19
TUESDAY	0	20
THURSDAY	2	18
SATURDAY	2	18

A	1. Do you have a headache?	F	6.
B	2. Do you feel tension in your shoulders?	G	7.
C	3. Do you have back pain?	H	8.
D	4. Do you feel overwhelmed when you breathe?	I	9.
E	5. Are you thirsty?	J	10



Symptoms of difficulty in concentration are also found to vary within the days that they are working within confined jobs, as can be seen, the values that indicate fatigue are higher than the average of the days in which the work is outside. confined space.

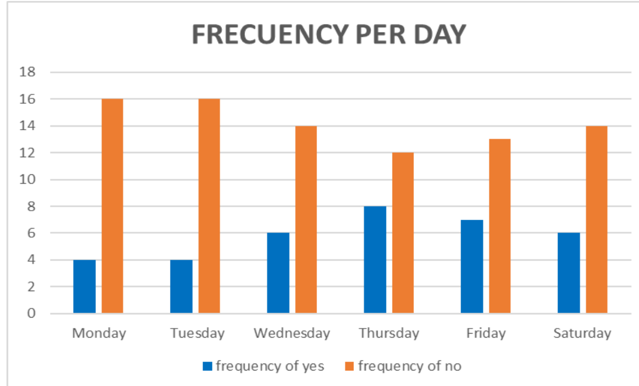


	A	B	C	D	E	F	G	H	I	J
Ans. in YES	6	3	6	3	12	0	1	3	1	0
Ans. in NO	6	9	6	9	0	12	11	9	11	12

WORKED IN CONFINED SPACES		
DAY	FREQUENCY OF YES	FREQUENCY OF NO
WEDNESDAY	3	17
FRIDAY	3	17

NOT WORKED IN CONFINED SPACES		
DAY	FREQUENCY OF YES	FREQUENCY OF NO
MONDAY	4	16
TUESDAY	4	16
THURSDAY	8	12
SATURDAY	6	14

WORKED IN CONFINED SPACES		
DAY	FREQUENCY OF YES	FREQUENCY OF NO
WEDNES DAY	6	14
FRIDAY	7	13



Body fatigue is also an aspect that is slightly affected when carrying out work in confined spaces, a slight increase in responses in favor of fatigue symptoms can be noted.

As can be seen in the results of "WORKER A" we can realize the conditions in which he works.

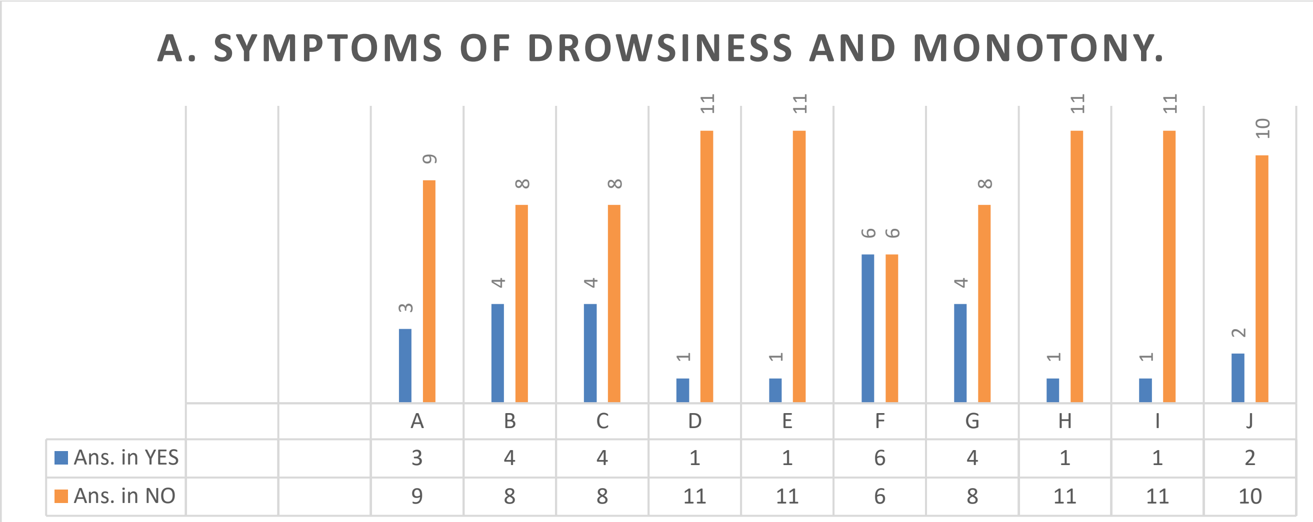
Table A shows us that he usually finds himself with some degree of tiredness, sleepiness and mentally exhausted.

Table B shows that he is still in a good capacity for concentration and that area is safe.

Finally, Table C indicates that the hydration of "worker A" is insufficient, because he is constantly thirsty and this can cause a headache.

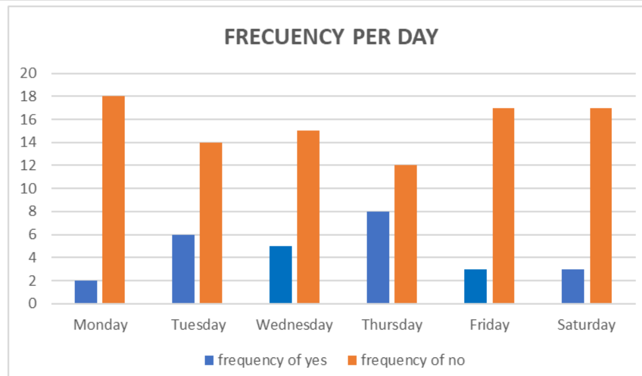
WORKER B

A	1. Do you feel heaviness in your head?	F	6. Are you sleepy?
B	2. Are you tired all over your body?	G	7. Do you feel tired in your eyes?
C	3. Do your legs feel tired or heavy?	H	8. Is it difficult for you to make any movements (do you feel clumsy or numb)?
D	4. During this time have you been yawning (since the start of your work or since the last measurement)?	I	9. Do you feel insecure when standing (because you feel sleepy)?
E	5. ¿Do you feel any discomfort in your brain (ie, bloated or have your ideas jumbled)?	J	10. Do you feel like stretching?



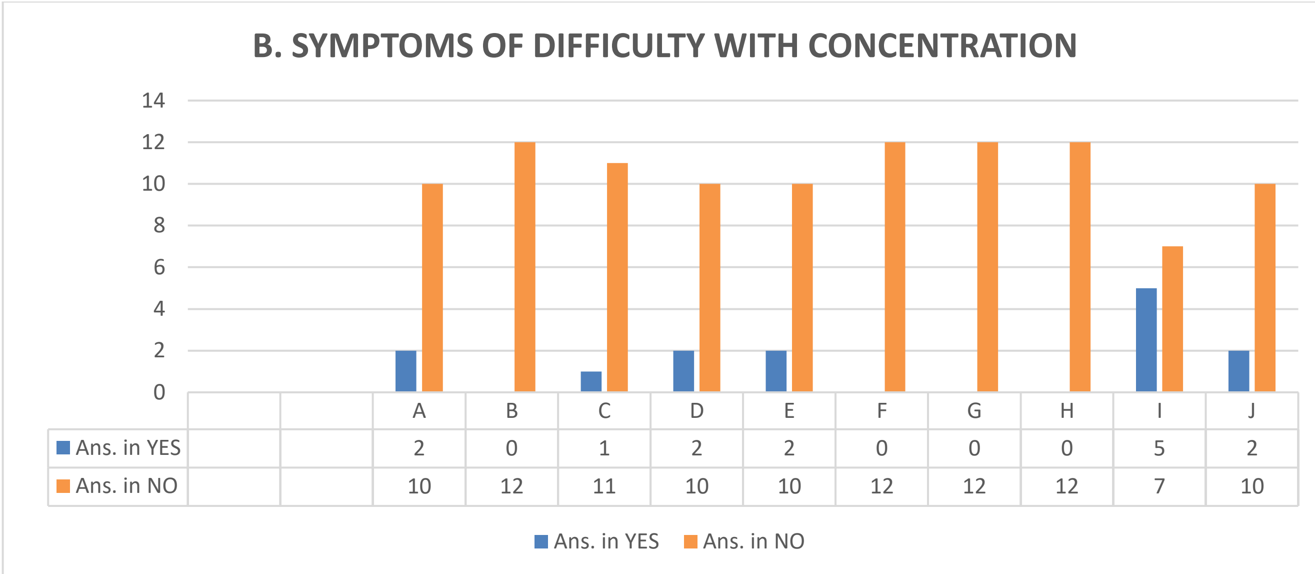
NOT WORKED IN CONFINED SPACES		
DAY	**FREQUENCY OF YES**	**FREQUENCY OF NO**
MONDAY	2	18
WEDNESDAY	5	15
FRIDAY	3	17
SATURDAY	3	17

WORKED IN CONFINED SPACES		
DAY	**FREQUENCY OF YES**	**FREQUENCY OF NO**
TUESDAY	6	14
THURSDAY	8	12



It can be observed in the results that the days in which the worker is in confined spaces has a greater metal load than in those outside the area, so it is recommended that the environmental factors to which he is exposed be reviewed to reduce the negative impact on mental exhaustion.

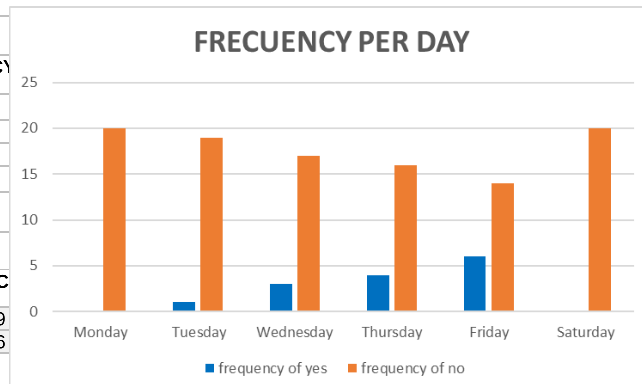
A	1. Do you have any trouble thinking when doing your homework?	**F**	6. Do you forget things related to your work?
B	2. Don't feel like talking because work is overwhelming you?	**G**	7. ¿Do you have a lack of confidence in yourself, such that you make mistakes in your work more often than usual?
C	3. Does the task you do make you nervous or stressed?	**H**	8. Do you feel anxious or restless when doing your tasks?
D	4. Do you feel unable to concentrate and pay attention during your work?	**I**	9. Do you have difficulty straightening your posture after you have done your homework?
E	5. Have you lost interest in things at work?	J	10. Do you feel that you lack patience to do the things of your work?



	A	B	C	D	E	F	G	H	I	J
Ans. in YES	2	0	1	2	2	0	0	0	5	2
Ans. in NO	10	12	11	10	10	12	12	12	7	10

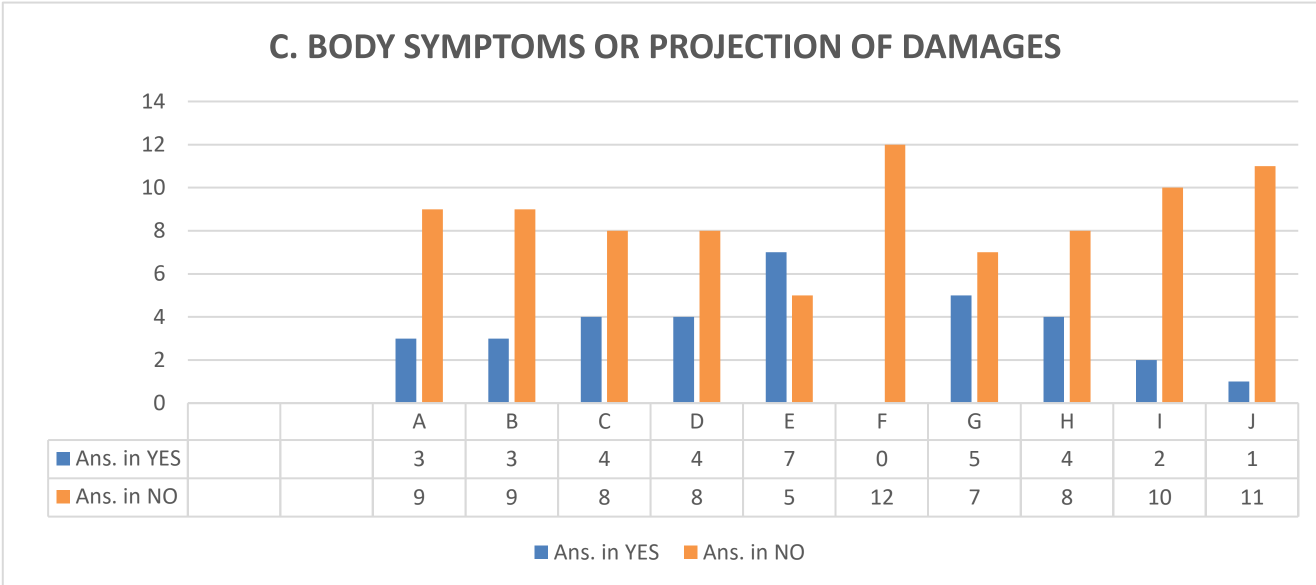
NOT WORKED IN CONFINED SPACES		
DAY	**FREQUENCY OF YES**	**FREQUENCY**
MONDAY	0	20
WEDNESDAY	3	17
FRIDAY	6	14
SATURDAY	0	20

WORKED IN CONFINED SPACES		
DAY	**FREQUENCY OF YES**	**FREQUENC**
TUESDAY	1	19
THURSDAY	4	16



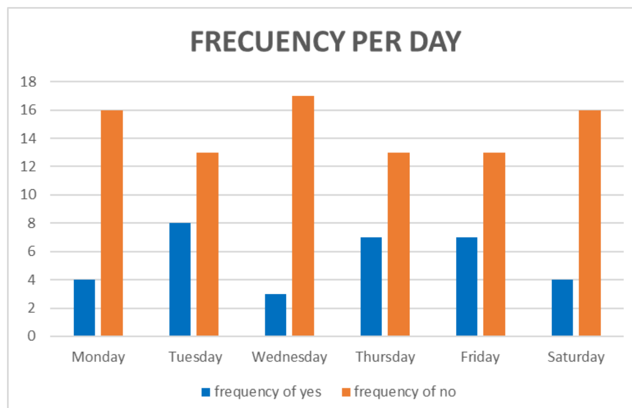
In section B we can conclude that there is not much impact on the change of roles, however, it is recommended to continue monitoring it in the area since in worker A there was variability and can present them in a future in worker B.

A	1. Do you have a headache?	**F**	6. Has your voice become hoarse?
B	2. Do you feel tension in your shoulders?	**G**	7. Do you feel dizzy or lightheaded?
C	3. Do you have back pain?	**H**	8. Are you dazzled or blinking your eyes?
D	4. Do you feel overwhelmed when you breathe?	**I**	9. Do you have tremors in your arms or legs?
E	5. Are you thirsty?	**J**	10. Do you feel unwell or ill (generally unwell)?



NOT WORKED IN CONFINED SPACES		
DAY	FREQUENCY OF YES	FREQUENCY OF NO
MONDAY	4	16
WEDNESDAY	3	17
FRIDAY	7	13
SATURDAY	4	16

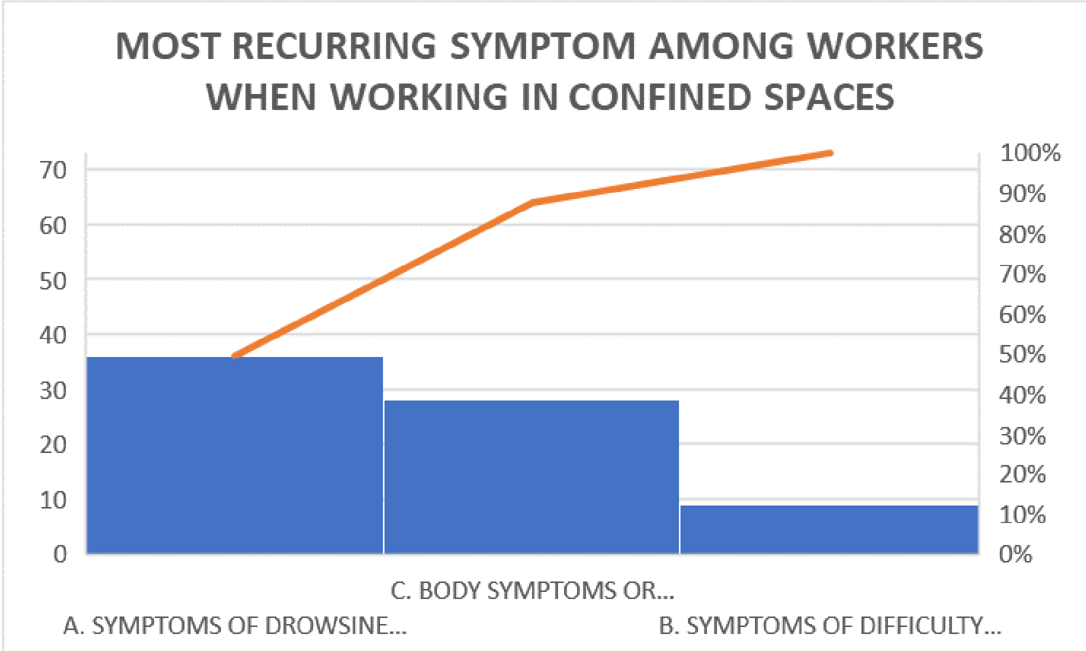
WORKED IN CONFINED SPACES		
DAY	FREQUENCY OF YES	FREQUENCY OF NO
TUESDAY	8	13
THURSDAY	7	13



In the body fatigue we could observe that if there is a great variability in the frequencies since it presents physical discomforts due to the postures in which it is in the worker.

In the case of "WORKER B" you can see reflected in graph A who is constantly sleepy during his work period.

In graph B it is seen that like the first worker he is within the normal in his concentration level. And finally in graph c it is shown that you are also constantly thirsting so you need more hydration



These symptoms although they do not look too harmful to health, with the passage of time if they can present any disease or deterioration in any area, in addition to that does not allow them to give 100% of their work capacity, for these two reasons is that it must be attended and solved as soon as possible.

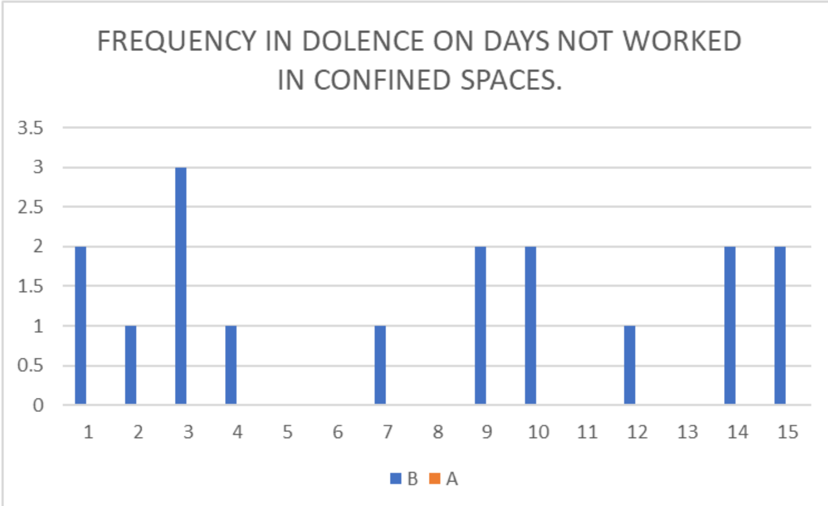
As observed in the results of the yoshitake questionnaire, it can be seen that mental exhaustion is not a factor that influences in such a transcendent way in the development of this work, although certain features of this type of exhaustion can be noticed in worker A, however not so relevant as to harm their health or their quality of work.

4.2.2 CUESTIONARIO CORLETT & BISHOP:

WORKER A

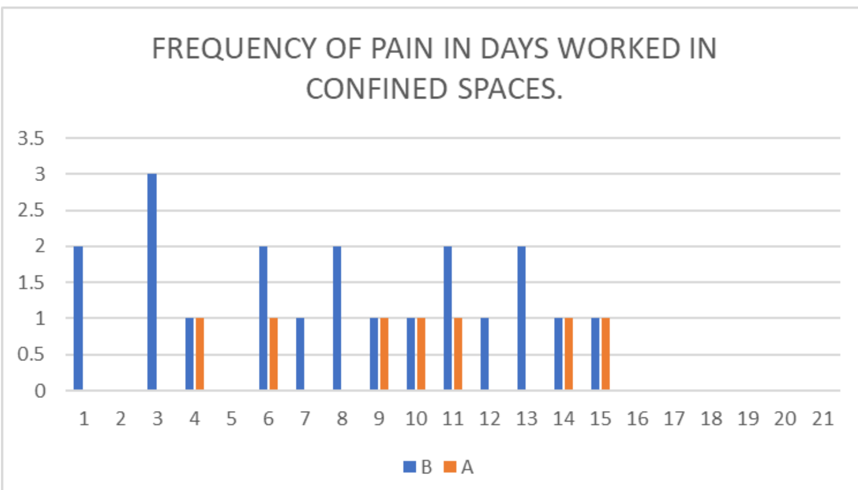
Days not to be worked in confined spaces (Monday, Tuesday, Thursday, Saturday).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
B	2	1	3	1	0	0	1	0	2	2	0	1	0	2	2	1	1	3	1	1	3
A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Days worked in confined spaces (Wednesday and Friday).

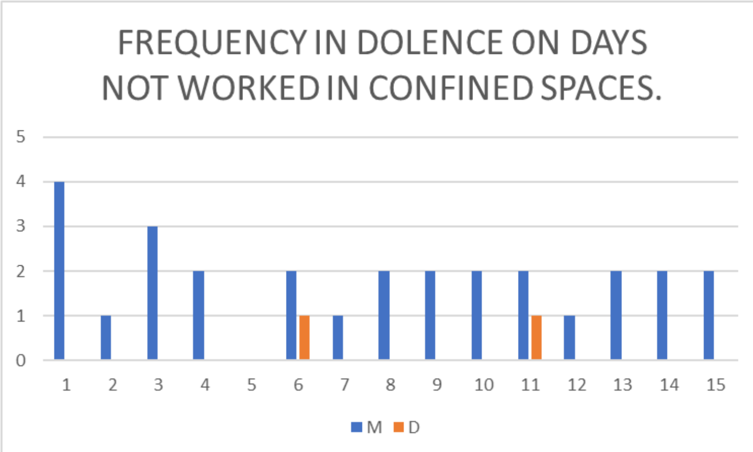
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
B	2	0	3	1	0	2	1	2	1	1	2	1	2	1	1	0	0	0	0	0	0
A	0	0	0	1	0	1	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0



WORKER B

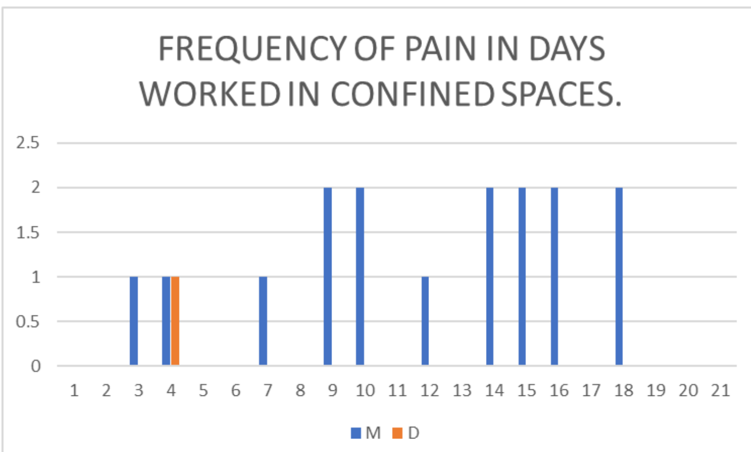
Days not to be worked in confined spaces (Monday, Wednesday, Friday, Saturday).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
B	4	1	3	2	0	2	1	2	2	2	2	1	2	2	2	3	2	1	3	2	1
A	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1



Days worked in confined spaces (Wednesday and Friday).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
B	0	0	1	1	0	0	1	0	2	2	0	1	0	2	2	2	0	2	0	0	0
A	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



It is notorious how the ailments in comparison to the god not worked in confined spaces of the two workers grow, the discomfort prevailing is in the middle of the back, knees and feet as a consequence of the postures in which the worker is checked. However, it is also important to highlight that the pain indices are very low, but it is important to give relevance to the postures in which the worker can be placed since it could cause chronic damage in an average time.

5 CONCLUSIONS.

By way of conclusion, we can say that the correct application of these methods based on studies, help us to have a perspective that we originally did not have of the work that was being done. This helps us define what are the red spots that can be caused in our health, which have to be treated immediately to prevent them from becoming permanent damage. The application of these studies can be of great help to promote the well-being and maximum physical performance of a worker within the company. It is important not only to consider the worked at our discretion, because we must also have an official format that endorses it as safe. It is important to preserve the physical integrity in good condition, because any damage can be irreplaceable and harm to a small or large extent the adult life of the sufferer.

CONTRIBUTION TO ERGONOMICS.

The purpose of this article is to provide readers with information about the different problems that arise in confined spaces, specifically in the welding area.
This particular area is usually forgotten and is not given the seriousness it really requires.

We manage to observe how complicated it is to work on it, the positions that the worker has to perform when executing the activity will be devastating for his future years, as well as the environment to which he is exposed: noise and lighting, which together, these problems will cause chronic diseases in the future.

This article seeks to create awareness in our branch giving it greater seriousness and focus to seek solutions, and thus, to be able to create workstations that facilitate the worker, remembering that the human being should not adapt to the environment but the environment to the worker.

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ANALYSIS OF THE ERGONOMIC CONDITIONS IN THE WORK STATIONS OF A MAQUILADORA THROUGH THE IMPLEMENTATION OF THE RULA METHOD.

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Resumen: El estudio ergonómico de los puestos de trabajo en las industrias permite evaluar las condiciones laborales y dar solución oportuna a las lesiones y enfermedades que se hacen presente en las áreas de trabajo; actualmente, existe una amplia variedad de metodologías para generar alternativas de solución. En esta investigación se utilizó el método RULA (Evaluación Rápida de las Extremidades Superiores) para obtener información que permitió generar las acciones correctivas pertinentes considerando cada una de las operaciones llevadas a cabo en el área, las posturas corporales, las cargas y tareas repetitivas. RULA evaluó las extremidades superiores (hombro/brazo, antebrazo/codo, muñeca), cuello, tronco y piernas. La investigación se limitó a las estaciones de trabajo del área de producción en las que se lleva a cabo el proceso de prensado de una empresa maquiladora de conectores y ensamble de tableros electrónicos para servicio de telecomunicación. Los resultados arrojaron una puntuación total de 6, lo que sugiere un nivel de acción "ampliar el estudio y modificar pronto".

Palabras clave: Lesiones, evaluación ergonómica, prevención, RULA

Relevancia para la Ergonomía: La exposición de los trabajadores a riesgos ergonómicos por posturas inadecuadas ocasiona trastornos, lesiones, accidentes y/o enfermedades que afectan la productividad dentro de las empresas ya que se pueden reflejar en días laborales perdidos, incapacidades, ausentismo, jubilaciones anticipadas, gastos por exámenes diagnósticos y tratamientos (Jiménez, 2014).

El estudio de las condiciones de trabajo permite detectar estas condiciones e implementar estrategias evaluando el grado de exposición (frecuencia/repetición), fuerzas y duración/carga estática para disminuir los problemas señalados y evitar exponer al trabajador.

Las estadísticas recientes relacionadas con los desórdenes músculo-esqueléticos de origen ocupacional, uno de los padecimientos laborales más frecuentes tanto en países industrializados como en vías de desarrollo, son realmente preocupantes no solo por los efectos que tienen en la salud del trabajador, sino también por el enorme impacto económico sobre los negocios y el costo social señalan Rodríguez, Y. & Guevara, C., (2011) y sugieren que la aplicación sistemática de la ergonomía ha sido reconocida como la forma más eficaz de combatirlos.

Abstract: The ergonomic study of workplaces in industries makes it possible to evaluate working conditions and to provide timely solutions to injuries and illnesses occurring in the work areas; nowadays, there is a wide range of methodologies to generate alternative solutions. In this research, the RULA (The Rapid Upper Limb Assessment) method was used to obtain information that allowed to generate the appropriate corrective actions considering each one of the operations carried out in the area, body postures, loads and repetitive tasks. RULA evaluated the upper limbs (shoulder/arm, forearm/elbow, wrist), neck, trunk and legs. The research was limited to the workstations in the production area where the pressing process of a company manufacturing connectors and assembly of telecommunication electronic panels is carried out. The results yielded a total score of 6, suggesting a level of action to “extend the study and modify soon.”

Keywords: Injuries, ergonomic assessment, prevention, RULA

Relevance to Ergonomics: Exposure of workers to ergonomic risks due to inappropriate postures causes disorders, injuries, accidents and/or illnesses that affect productivity within companies as they can be reflected in lost working days, incapacity, absenteeism, early retirement, expenses for diagnostic tests and treatments (Jiménez, 2014).

The study of working conditions makes it possible to detect these conditions and implement strategies evaluating the degree of exposure (frequency/repetition), forces and duration/static load to reduce the problems identified and avoid exposing the worker.

Recent statistics related to occupational musculoskeletal disorders, one of the most frequent occupational diseases in both industrialized and developing countries, are truly worrying. Not only for the effects they have on workers' health, but also for the enormous economic impact on business and the social cost, point out Rodríguez, Y. & Guevara, C., (2011) and suggest that the systematic application of ergonomics has been recognized as the most effective way to combat them.

1. INTRODUCTION

Ergonomic analysis of working conditions aims to adapt tasks, tools, as well as the general work environment to the skills and needs of the employee.
The RULA method aims to improve the ergonomic conditions of the workers of a company manufacturing connectors and assembly of telecommunication electronic panels.

According to the ILO (International Labor Organization), musculoskeletal disorders (MSD) constitute one of the main occupational health problems resulting from small and repeated injuries, such as: increase in the pace of work, the concentration of forces in the hands, wrists and shoulders, forced and sustained postures causing static stress on diverse muscles. (Franco, S., Salazar. M., Peña, M. & Aguilera, M., 2017).

According to the occupational health statistics of the Instituto Mexicano del Seguro Social (Mexican Institute of Social Insurance), occupational risks related to some type of musculoskeletal trauma amounted to 63 854 cases out of the 492 684 registered in 2020, which represents about 13%, and 1 681 out of the 8 274 registered were permanently incapacitated, representing 20% of them. Instituto Mexicano del Seguro Social (2020) (Mexican Institute of Social Insurance).

Objectives

General:

To analyze ergonomic conditions in the workstations from a maquiladora company through the implementation of the RULA method.

Specific:

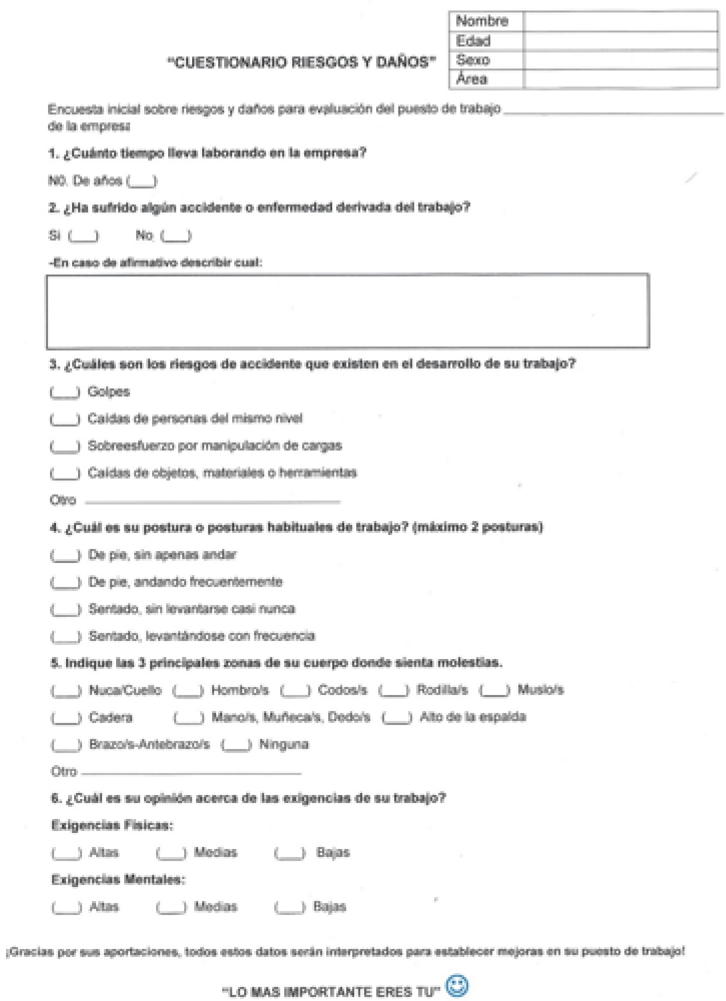
- Identify the ergonomic conditions at workstations in the production areas.
- Detecting hazardous conditions at workplaces throughout the application of the RULA method.
- Propose improvements to the ergonomic conditions of workstations in production areas.

2. METHODOLOGY

In order to perform the ergonomic analysis of the pressing area, it was necessary to diagnose the current situation of the workstations in order to detect potential risk factors. Subsequently, the RULA methodology was applied to assess the work postures, determine the level of intervention required and thus reduce the level of risk due to the postural load, i.e. for the ergonomic improvement of the area.

Diagnosis of ergonomic conditions in work stations.

A questionnaire was designed and applied to 102 workers in the press process, to determine if they are exposed to risks that may cause an injury or disease. The questionnaire questions are illustrated in Figure 1.



Nombre	
Edad	
Sexo	
Área	

"CUESTIONARIO RIESGOS Y DAÑOS"

Encuesta inicial sobre riesgos y daños para evaluación del puesto de trabajo de la empresa

1. ¿Cuánto tiempo lleva laborando en la empresa?

N0. De años (___)

2. ¿Ha sufrido algún accidente o enfermedad derivada del trabajo?

Si (___) No (___)

-En caso de afirmativo describir cual:

3. ¿Cuáles son los riesgos de accidente que existen en el desarrollo de su trabajo?

(___) Golpes
(___) Caídas de personas del mismo nivel
(___) Sobreesfuerzo por manipulación de cargas
(___) Caídas de objetos, materiales o herramientas
Otro __________

4. ¿Cuál es su postura o posturas habituales de trabajo? (máximo 2 posturas)

(___) De pie, sin apenas andar
(___) De pie, andando frecuentemente
(___) Sentado, sin levantarse casi nunca
(___) Sentado, levantándose con frecuencia

5. Indique las 3 principales zonas de su cuerpo donde sienta molestias.

(___) Nuca/Cuello (___) Hombro/s (___) Codos/s (___) Rodilla/s (___) Muslo/s
(___) Cadera (___) Mano/s, Muñeca/s, Dedo/s (___) Alto de la espalda
(___) Brazo/s-Antebrazo/s (___) Ninguna
Otro __________

6. ¿Cuál es su opinión acerca de las exigencias de su trabajo?

Exigencias Físicas:

(___) Altas (___) Medias (___) Bajas

Exigencias Mentales:

(___) Altas (___) Medias (___) Bajas

¡Gracias por sus aportaciones, todos estos datos serán interpretados para establecer mejoras en su puesto de trabajo!

"LO MAS IMPORTANTE ERES TU"

Figure 1. Questionnaire "Risks and damages"

Risk factors were searched using the Nursing Department's disease or accident records. Employees were also consulted and operations and jobs were observed first-hand. Subsequently, a Pareto Chart was used to detect the risk factors causing injuries and diseases in workers with the highest incidence according to the data recorded in figure 1.

Risk Factors	No. of Defects	Relative %	Accumulated %
Machinery	60	34	34
Incorrect postures	57	32	66
Furniture	30	17	83
Workload	20	11	94
Raw material	10	6	100
Total	**177**	**100**	

Figure 1. Potential risk factors

We collaborated with a team of experts in the field to make an Ishikawa diagram that allowed us to identify the root cause of occupational injuries and diseases. See Figure 10.

Application of the RULA method.

Information was collected through the study of time, videos and photographs from the studied area to apply the RULA method and determine the individual and not joint postures or sequences of postures to be evaluated considering the work cycles of each position. The scores of each part or segment of the body were obtained, the final score and level of action were determined being proportional to the risk involved in carrying out the task. High values indicate a higher risk of musculoskeletal injuries. See Figure 2.

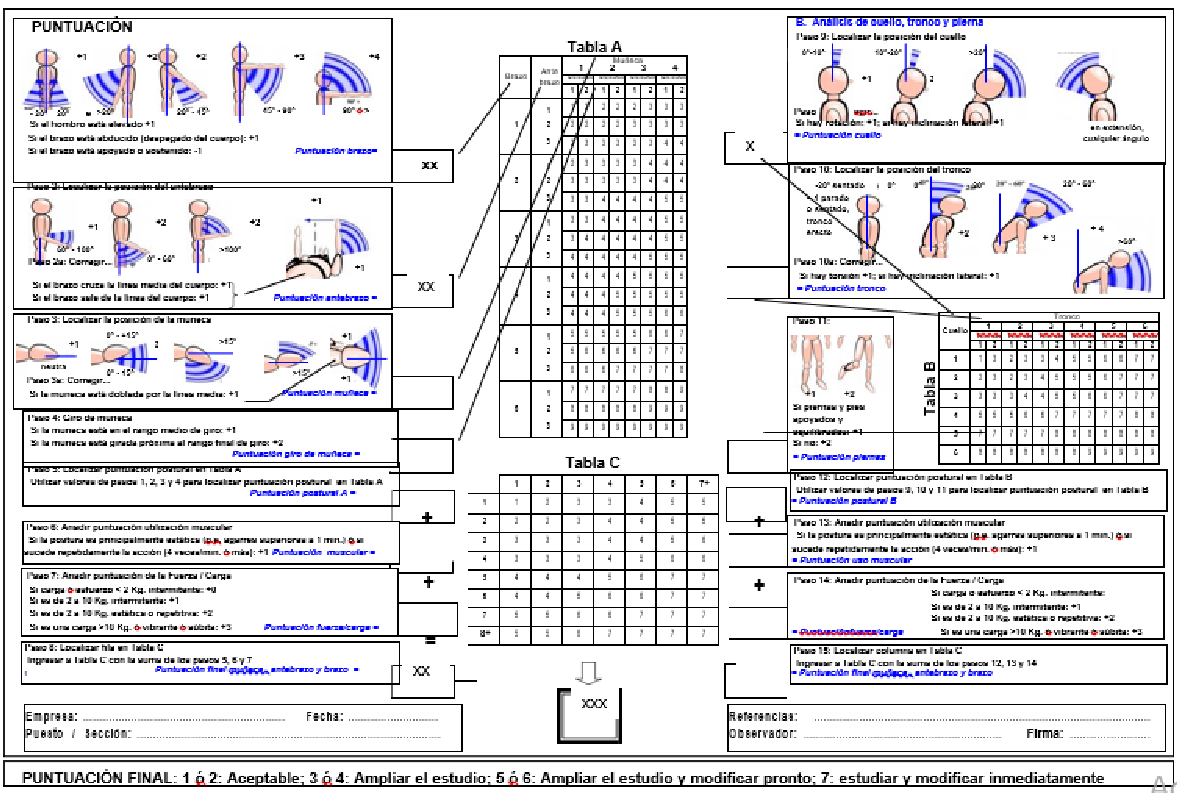


Figure 2. Ergonomic evaluation format of the RULA method

On the basis of the data obtained, corrective actions leading to the improvement of ergonomic conditions were proposed.

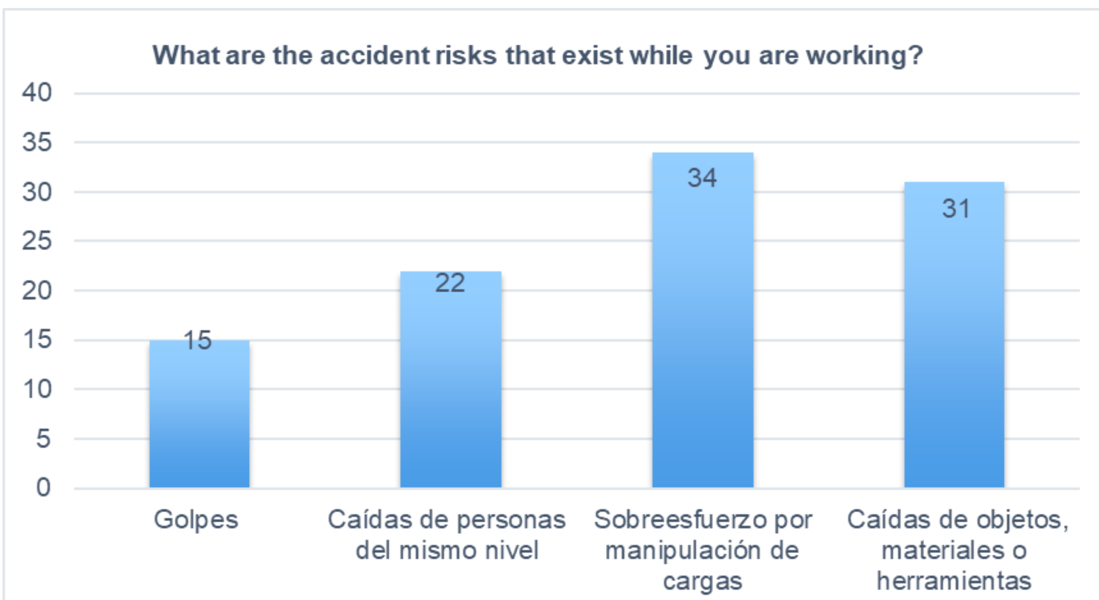
3. RESULTS

The results from the survey are shown in Figures 3-8. 60.78% of the workers have suffered an accident or disease resulting from their work activities, the predominant risks being overwork due to handling loads and falling objects, materials or tools.

The most common posture is sitting without standing up. The main areas in the body that feel discomfort are the hand, wrist and finger. In addition, workers consider that the physical and mental demands of their activities to be average.

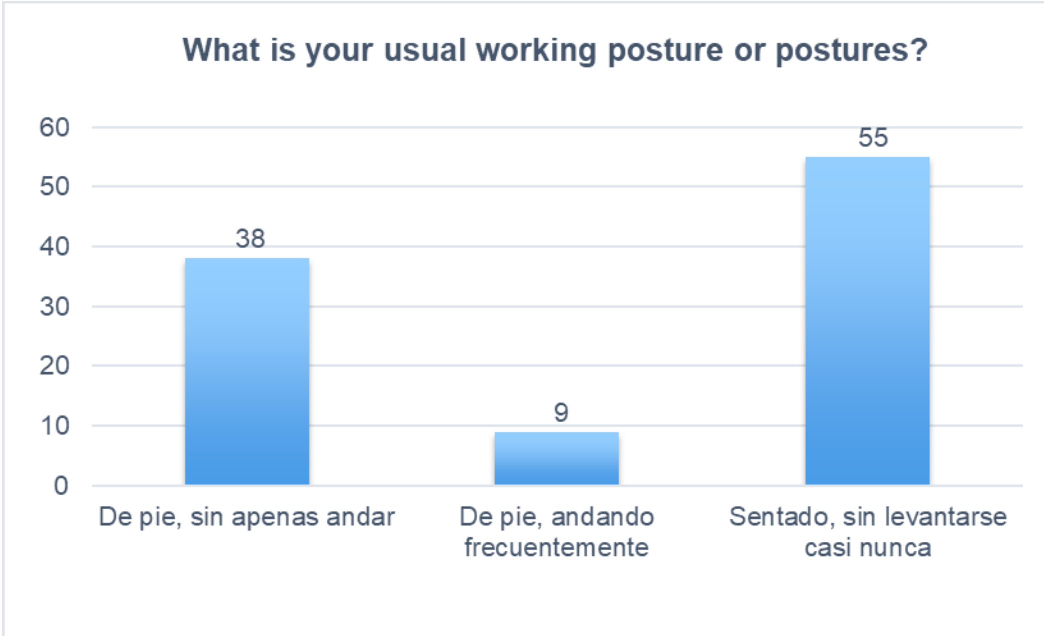
*Yes *No

Figure 3. Question 1



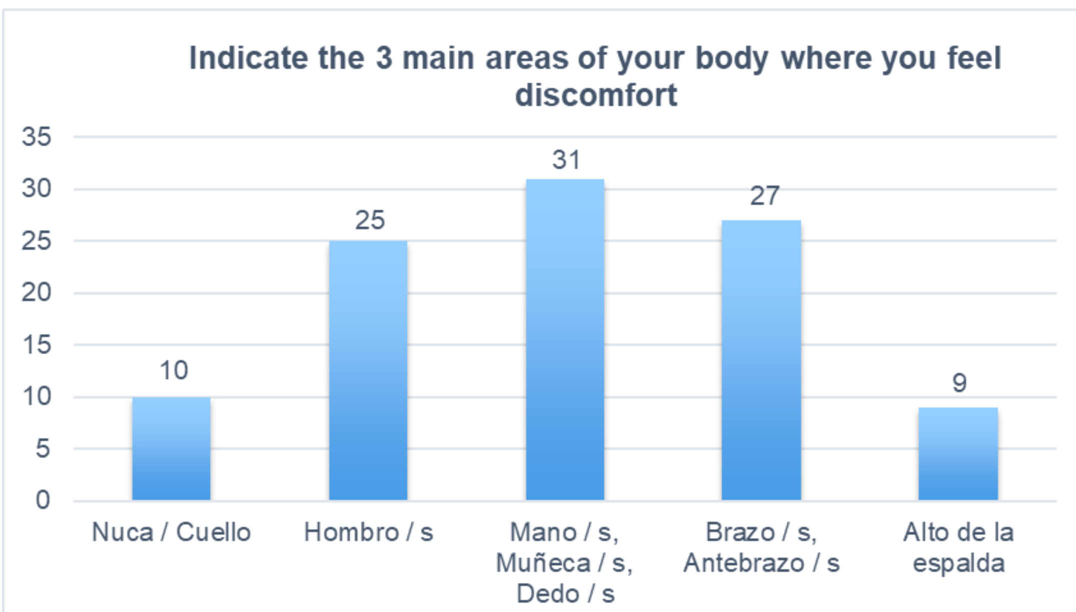
*Hits *People falling from the same level *Overexerting due to the handling loads *Objects, materials or tools falling

Figure 4. Question 2



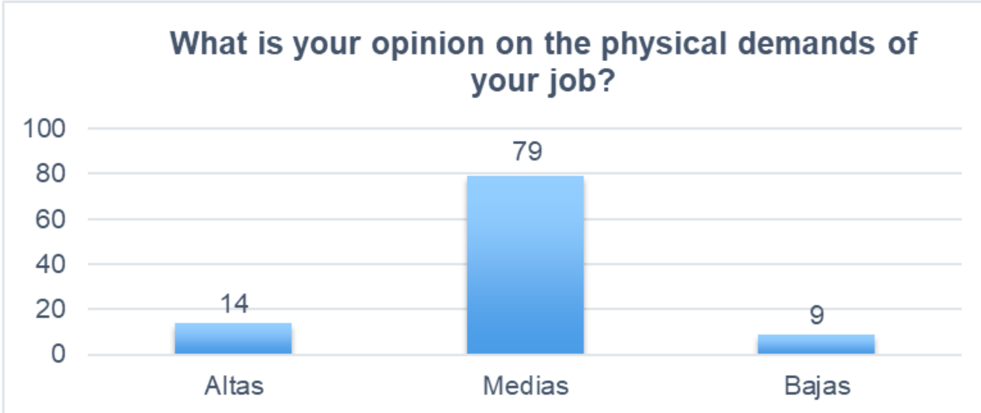
*Standing, barely walking *Standing, walking frequently *Sitting, barely getting up

Figure 5. Question 3



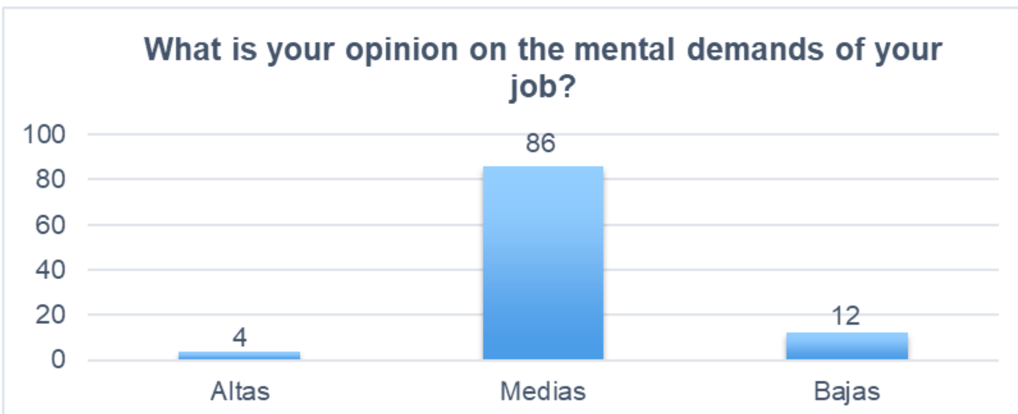
*Nape / neck *Shoulder / s *Hand / s, Wrist/s, Finger / s *Arm / s, Forearm / s *Upper back

Figure 6. Question 4



*High *Medium *Low

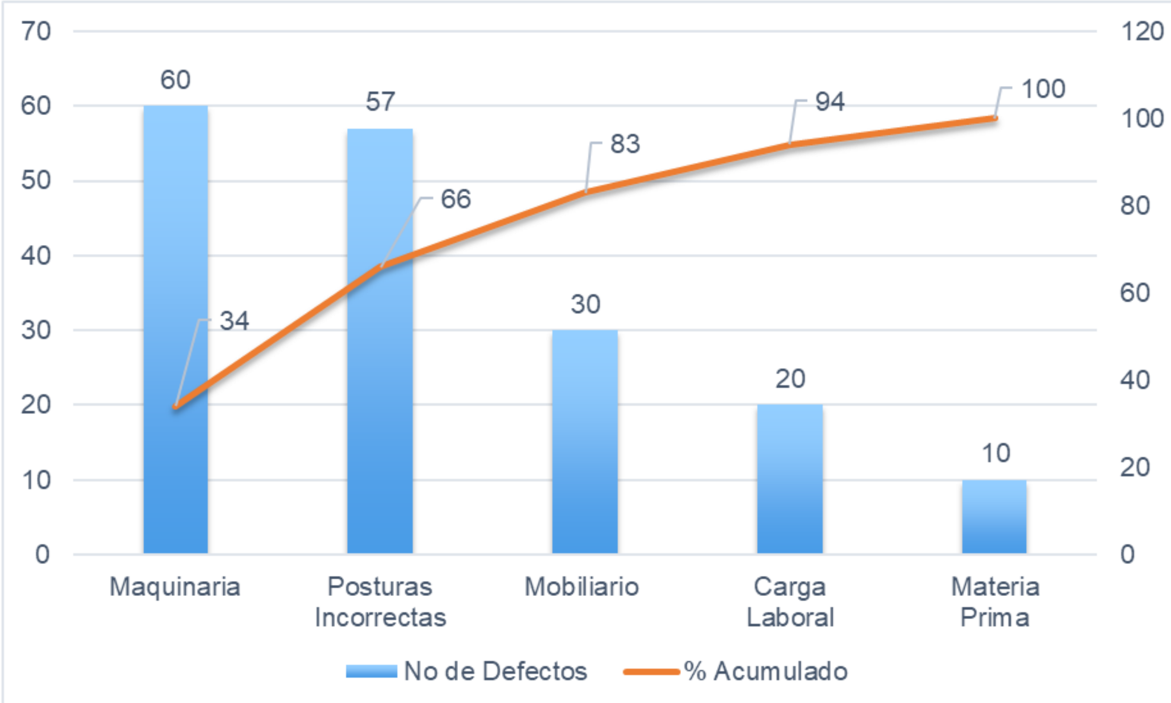
Figure 7. Question 5



High *Medium *Low

Figure 8. Question 6

In the analysis of the press process using the Pareto Chart (see Figure 9), it was observed that 20% of the risk factors (machinery, incorrect postures and furniture) represent 83% of the risks in the employee, causing injuries and diseases in different parts of the body.



*Machinery *Incorrect postures *Furniture *Workload *Raw material*
*No.of Defects *Accumulated %

Figure 9. Pareto Chart

The Ishikawa diagram (Figure 10) shows the root cause of the injury and disease problem is the machinery, specifically the manual press, which is unsuitable for the process.

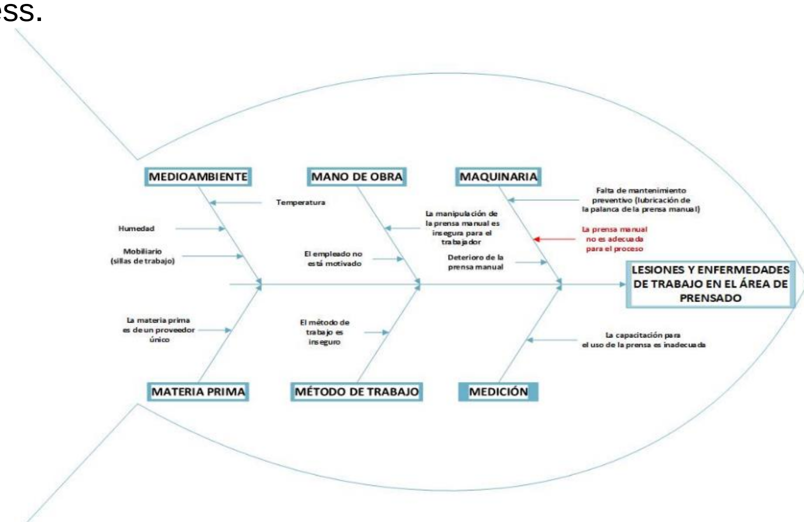
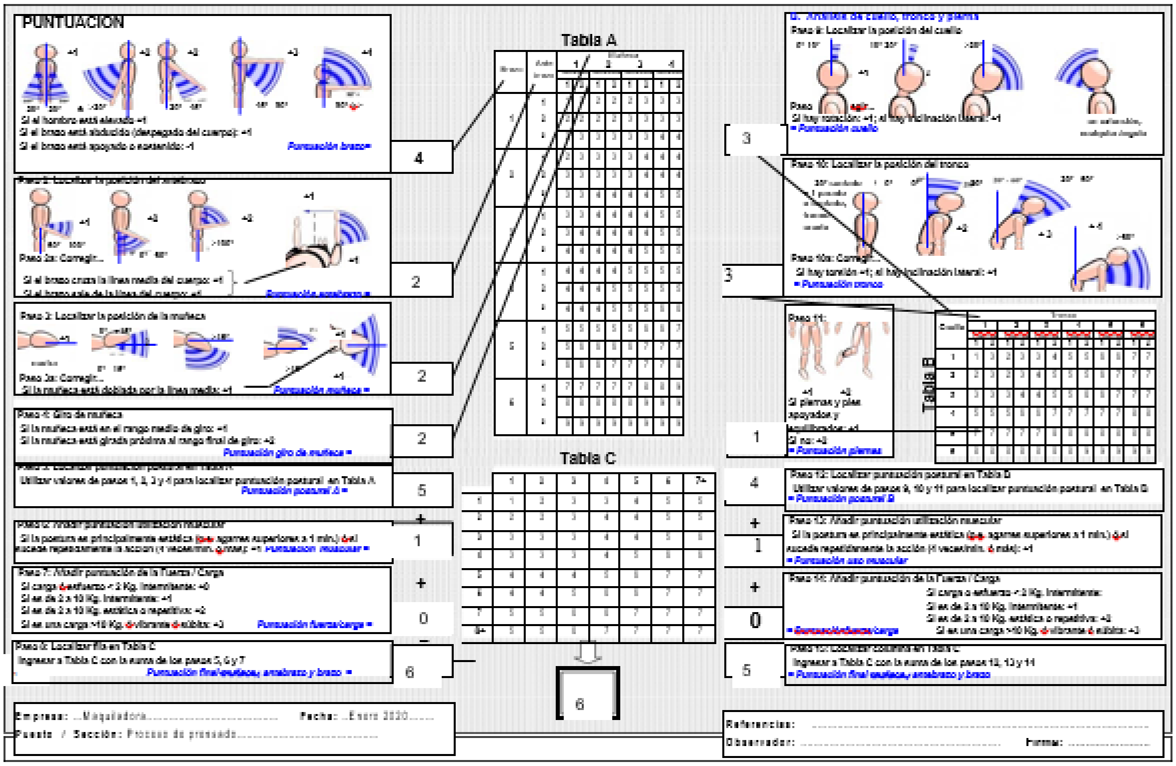


Figure 10. Ishikawa Diagram

The result from the RULA method is “extend the study and modify soon” with a total of 6 points. (See Figure 11).



PUNTUACION 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 11. Ergonomic evaluation format of the RULA method applied to production areas.

It was observed that when performing the operations on the manual press the operator exposes their shoulders / elbows / forearm, while elevating the shoulder to grab the lever, performing one repetition per minute, applying force to carry out the press causing musculoskeletal damage.

Considering the repetitive and constant effort when performing the critical activity, they presented ailments in their limbs. The proposals are as follows:

- Automate one of the presses.
- Ergonomic exercise routines in small 5 minutes res periods.
- Awareness from the staff from that area.
- Acquisition of ergonomic furniture.

4. DISCUSSION/CONCLUSIONS

According to Obando F., & Maldonado, C. (2019) it is estimated that worldwide between 30% and 50% of workers are exposed to risks that generate musculoskeletal injuries impacting on the productivity of organizations and therefore on the economy of industry. Ergonomic analysis and assessment is a fundamental element in determining corrective actions aimed at reducing risks and diseases inside a work area by guaranteeing healthy and productive workers.

It is important to implement ergonomic principles at workspaces; however, according to Franco, S. et al (2017), it is not enough to have a good workplace, but also to be trained on the importance of maintaining a proper posture, since workers are also affected by bad postures.

Obando F., et al., (2019) based on Gómez, L.; Rivera, S.; Granado, M. and Suárez, O. (2017) and Asensio, S.; Bastante, M. and Diego, J. (2012) point out that it is important to consider variables such as weight distribution, load or force applied in a specific area of the body , repetitive movements, load elevations, postures forced and static, mental requirement, and the environment because they increase the chance of suffering an injury over time.

This method provided relevant information about the work postures in the area, which allowed the identification of corrective measures to improve the physical health of the worker.

The proposed actions were implemented in the company in such a way as to automate the manual press, adapt ergonomic furniture, perform 5-minute exercise routines and train the staff with an emphasis on prevention and based on the assigned tasks.

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REDISTRIBUTION OF PRODUCTION AREA IN A WOOD PALLET MANUFACTURING COMPANY THROUGH RISK ANALYSIS, REGULATIONS AND ERGONOMIC PRINCIPLES.

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Resumen La adaptación a los cambios de los procesos productivos, tiene como reto, el análisis integral de todos los factores que intervienen, uno de ellos es la evaluación de las estaciones de trabajo en las áreas producción, en la cuales, se realizan las operaciones directas de la transformación de las materias primas al producto terminado. El estudio que se presenta se realizó en una empresa dedicada a proveer soluciones integrales en tarimas y embalajes de madera, el objetivo general fue evaluar las estaciones de trabajo y proponer un diseño de área de producción que cumpla con las condiciones óptimas para que el trabajador aumente su desempeño y disminuya el riesgo laboral.

Palabras clave: Principios ergonómicos, riesgos, estaciones de trabajo, distribución de área.

Relevancia para la ergonomía: Siendo la ergonomía la disciplina que se encarga del diseño de lugares de trabajo, la investigación realizada representa un análisis importante dentro de la empresa que propicia un mejoramiento de las condiciones de los espacios para los trabajadores y da pauta a trabajar con conocimiento de la normatividad aplicable.

Abstract: The adaptation to changes in production processes, has as a challenge, the integral analysis of all the factors involved, one of them is the evaluation of the workstations in the production areas, in which, the direct operations of the transformation of raw materials to the finished product are performed. The study presented here was conducted in a company dedicated to provide integral solutions in wooden pallets and packaging, the overall objective was to evaluate the workstations and propose a design of production area that meets the optimal conditions for the worker to increase their performance and reduce occupational risk.

Keywords. Ergonomic principles, risks, workstations, area distribution

Relevance to Ergonomics: Ergonomics being the discipline that deals with the design of workplaces, the research conducted represents an important analysis within the company that favors an improvement in the conditions of the spaces for workers and gives guideline to work with knowledge of the applicable regulations.

1. INTRODUCTION

A productive process encompasses a set of activities by which materials undergo a transformation process, to be destined for sale and consumption by the final consumer. (Nuño, 2017). Within a productive process it is important to identify that the execution of the activities respects aspects such as the principles of the economy of movements that according to (Niebel and Freivalds, 2012) are based on an elementary understanding of human psychology and should be of great utility in the application of the analysis of methods with the operator in mind. Industrial and manufacturing engineers continually develop guidelines for the design of safer, more efficient and effective manufacturing stations. (Meyers, 2000).

The ergonomic aspects that involve the environmental, hygiene and safety at work, are fundamental to provide workers with conditions that improve their performance.

In this project, an analysis of the operations of the pallet production area called ABB in a wood pallet manufacturing company is carried out. The flow of operations was identified, the percentages of production contributed by each operator in a given time, analyzing the work areas, to subsequently make proposals for the necessary changes for a better functioning of the area, taking care of the integrity of the workers. A redesign of the production area is presented taking into account the current area and the necessary spaces for the worker considering the available space in the new warehouse and the necessary changes for the arrangement of the production area. Following the results of this project, significant changes are estimated for the improvement of the ABB production area.

2. OBJETIVES

2.1 General objective

Evaluar las de estaciones de trabajo y diseñar un área de producción que cumpla con las condiciones óptimas para el trabajador que aumente su desempeño y disminuya el riesgo laboral en una empresa fabricante de tarimas de madera.

2.2 Specific objectives

- Determinar el diagnóstico situacional del funcionamiento en el área de producción.
- Identificar las áreas de oportunidad para mejorar el área de trabajo.
- Desarrollar las propuestas de diseño de las estaciones de trabajo bajo los principios ergonómicos y normatividad aplicable.
- Proponer el diseño de la distribución del área de producción cumpliendo con el flujo del proceso.

3. METHODOLOGY

A case study that only applies to the planning and design area of the ABB production area of the company Proeser de México was carried out through the analysis and evaluation of seven workstations included in this area. A mixed approach was used, determining the performance indicators based on numerical data from the records of material handling and calculations of the company's areas, as well as qualitative indicators regarding compliance with ergonomic principles and the characteristics that the design of the workstations must comply with. The time of development of the research was from August to December 2020. The information analyzed was based on direct observation of the processes, interviews with personnel and data provided by the company.

The research was conducted according to the following procedure:

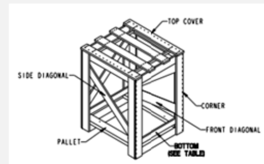
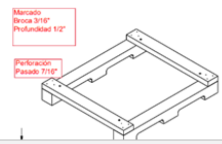
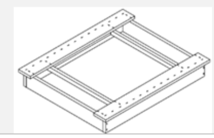
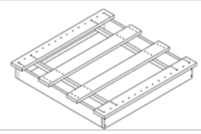
1. Identification of the operation of the production area.
2. Obtaining performance indicators.
3. Identification of ergonomic principles for each area.
4. Study of risks.
5. Determination of specific rules applicable to the work area.
6. Workstation design.
7. Material handling analysis.
8. Determination of space requirements.
9. Area layout design.

4. RESULTS

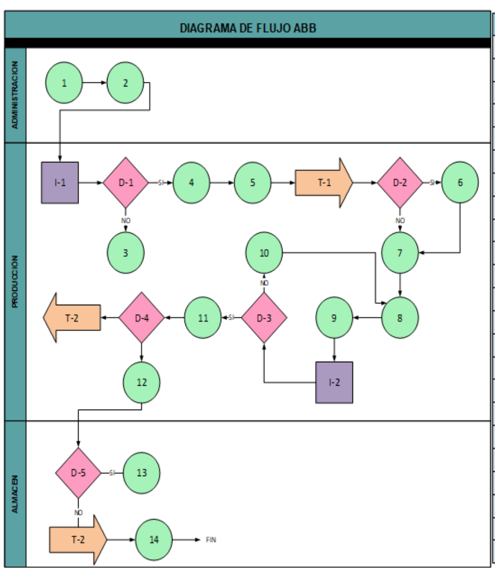
4.1 Identification of the production area operation.

The company supplies wooden pallets as special products to a wide variety of companies of different industries. Table 1 shows some examples of its products.

Table 1. Products manufactured in the study area

Part number	Image
Crate completo	
Pallet	
Top cover P001	
Top cover P002	

Daily monitoring of the production process was carried out to identify activities, transports, decision making and inspections, thus creating the ABB flow diagram shown in Figure 1.



COD.	DESCRIPTION
1	upervisor verifies with warehouse inventory level of cut material.
2	Supervisor requisitions material from the cutting area.
I-1	Cut material is inspected from warehouse and cutting area.
D-1	Cut material meets specifications.
3	No: returned to cutting area.
4	Yes: stays in production area.
5	The operator prepares his work tools.
T-1	The operator mules the material to his work station.
D-2	Does the material need extra cutting?
6	Yes: The operator performs the necessary cutting at the station 7 guillotine.
7	No: The operator mule transports the material to his work station.
8	The operator makes the product required by the customer order indicated by the supervisor.
9	The operator stacks the finished product.
I-2	Finished product is inspected by quality manager.
D-3	Product meets customer specifications.
10	Yes: Product is sealed.
11.	No: Product is rejected and sent for rework.
D-4	Does the product need heat treatment?
T-2	Yes: The finished product is transported to the oven area.
12	No: inventory level in racks is checked.
D-5	There is space in racks
13	Yes: material is placed on racks
14	The product is placed in the warehouse.

Figure 1. Process flow diagram.

4.2 Identification of ergonomic principles for each workstation.

The company's workers are exposed to long working days where they perform repetitive movements that directly affect the operator and the productivity of the product. After observing the current workstations for several consecutive days and having interviewed the worker in the form of a conversation about how he felt at the end of the day, how long he had been working in that area and what areas of opportunity he saw for his station, in addition to the way of working in each station, the ergonomic principles that were not being complied with were identified. Table 2 shows the results.

Figure 2. Images of the workstations.

Table 2. Identification of ergonomic principles in each of the stations studied.

Ergonomic principles	Worksatations						
	1	2	3	4	5	6	7
1. Keep everything within reach		X	X				
2. Use elbow height as a referenc			X	X		X	X
3. The grip shape reduces effort							
4. Find the correct position for each task							X
5. Reduce excessive repetitions.	X	X	X	X	X	X	X
6. Minimize fatigue	X	X	X	X	X	X	X
7. Minimize direct pressure..	X	X	X	X	X	X	
8. Adjust and change posture	X	X	X	X	X	X	
9. Provide space and access.	X	X	X	X	X	X	X
10. Maintain a comfortable environment.	X	X	X	X	X	X	X

11. Highlight clearly to improve comprehension.							
12. Improve work organization.							

4.3 Risk identification.

The Risk Evaluation (RE) procedure, conceived as an analytical and preventive instrument, responds to the need to regulate activities involving the use, handling, transportation and storage of substances and activities considered highly hazardous to which workers may be exposed (SEMARNAT, 2020). A workplace is defined as an area of the workplace, whether built or not, in which workers must remain or to which they may have access because of their work.

The risk factors to which the worker may be exposed depend on the activity performed and where it is performed. The identification, hierarchy and criteria for each area are identified by the evaluator, who files accidents and incidents occurring in the operation of the facilities or similar processes, briefly describing the event, the causes, the area involved, the level of impact and, if applicable, the actions taken to address them. According to the regulations of the Secretary of Labor and Social Welfare, the severity of the damage caused by a risk is shown in Table 3. Table 4 shows the risks identified.

Table 3. Damage severity.

Severity		**Definition**
Category	**Name**	
I	MINOR	Without damage or with damage involving temporary incapacity of the worker of three days or less.
II	MODERATE	May involve temporary incapacity of the worker for more than three days.
III	CRITICAL	May involve partial permanent disability of the worker.
IV	FATAL	May involve total permanent disability or death of the worker.

Table 4. Identification of risks in the area.

Risk	**Category**	**Recommendation**
Impact or penetration due to nail or staple trajectory deviation.	I, II	Personnel should receive training on the proper use of work equipment (work guns) and wear personal protective equipment at all times, in addition to receiving training on the importance of its use and the risks it can reduce.

Risk of constant vibration in hands	III	Rotate activities to prevent the worker from being exposed to constant vibrations for long periods of time, such as wearing anti-vibration gloves to minimize exposure.
Embedding of wood splinters	I	Wear personal protective equipment (gloves) to avoid this type of situation in case it still happens, you can go to the department of safety and hygiene where it will be followed up for extraction and prevent maturation in the affected area, and thus the operator can continue with their work activities.
Repetitive movements	I, II, III	Rotate personnel in order to reduce the ergonomic impact due to the constant repetition of the movements carried out during the workday; if this recommendation is not followed up, operators may suffer from musculoskeletal disorders.
Forced postures	I, II, III	Receive training on the concept and damage caused by performing their work in forced postures for long periods of time.
Exposure to inhalation of small wood particles.	II, III	All machines that can produce dust during operation (saws, drills, guillotines, tableting machines, sanders, etc.) must have a localized dust extraction system that prevents dust from accumulating in the atmosphere and on the floor of the work area.
Injury to eyes due to detachment of wood particles	I, II	Wear their personal PPE at all times (glasses) to prevent this type of incident, so the worker receives training on the importance of PPE and what could happen if they ignore its use.
Blow to the foot due to falling raw material	I, II, III	Wear safety shoes provided by the company at all times, in addition to being attentive when walking through areas where there are pallets on pallets.
Cutting or mutilation of limbs by guillotine	I, II, III	Receive training on the proper handling of the equipment before starting to use it. It is also recommended not to place hands under the moving blade, not to cut more than two bars at a time and to keep the equipment turned off if it is not being used.
Shock due to falling material that is not well supported	I, II, III, IV	Use caution when placing the pallets and be attentive when walking in the production area to avoid accidents such as hitting the pallets.
Cut by edges of work tables	I	Secure the edges of the work tables with an anti-cutting material that also allows the

		operator to have a support on which he can lean if required, taking care not to damage the worker and thus also comply with ergonomic principle number 7. Minimize pressure.
Risk of entrapment due to falling racks	II, III, IV	The racks must have a previous study of their useful life which guarantees that they are in good condition, as well as the maximum weight they can hold to avoid exceeding the limits and thus avoid risks.
Forklift strike	II, III, IV	The forklift operator must comply with the established 10 km per hour and at all times be attentive to the road, use a reverse alarm and be trained to operate the forklift. The aisles must comply with the corresponding measures for the use of the forklift, which consists of the width of the aisles in one direction must be at least the width of the loaded vehicle plus 1 meter. In case of circulation in both directions, it shall not be less than the width of the vehicles plus 1.40 meters. The minimum width of the secondary aisles shall be 1 meter.
Risk due to fire	I, II, III, IV	Personnel receive training on the use and operation of the fire extinguishers that are strategically located in ABB's work area. In addition, personnel are prohibited from smoking or performing any function that generates flames in work areas.
Cut by machete handling	II, III	Workers must be attentive at all times when performing their activities, so they must be cautious when using cutting tools, and they must wear anti-cutting gloves while performing their activities.
Injuries from falling down ramp	II, III	The area must have signs indicating the risk of falling down the ramp and personnel must not use them when leaving or passing through the area without related activities.
Electrical risk	I, II, III,IV	Personnel should receive training on the state of electrical circuits, their risks and the identification of pipelines.
Injuries due to mule mishandling	I, II, III,IV	Mules are used in the kiln area to move the pallets to be treated by the necessary heat treatment; they are moved to be sorted and checked for quality before being released.
Blow due to hammer manipulation	I, II	The kiln personnel must know how to use the mules, the correct height of the pallets so that they do not exceed them and any of them

		could fall, causing accidents, and they must verify that there are no personnel around them to avoid injuring a person.

4.4 Determination of specific standards applicable in the work area.

After touring the specific area and working with the company's health and safety department, the most relevant applicable regulations in the area were identified in order to gather information on the conditions of the workers. The identification of the application of the standards is presented in Table 5.

Table 5. Identification of NOM's application

Applicable Mexican Official Standard	Non-compliance items
Nom-002-STPS-2010- Fire prevention and control	7.5, 7.5.1, 7.5.2, 7.5.3, 8, 8.1, 8.2, 9, 9.1, 9.2, 9.3, 10, 10.1, 10.2, 10.3
Nom-006-stps-2014 Material handling and storage	7.1, 7.2, 8.1, 8.2, 8.4, 8.5, 9.6, 9.7
Nom-025-stps-2008 Illumination	8.1, 8.2, 9, 9.1, 9.1.1, 9.1.2, 11
Nom-017-stps-2008 Personal protection equipment	Complies in all sections

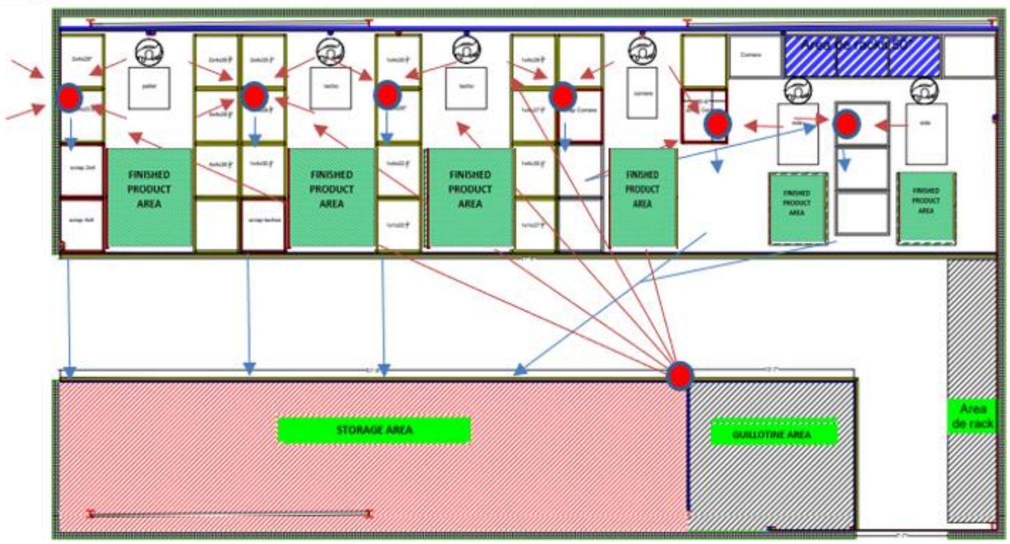
4.5 Workstation design.

According to the distribution of the workstations and the analysis of the ergonomic principles, the following improvement proposals were made:

1. table perimeter reinforced with pad support, that to minimize the work pressure besides making the area safer since the edges are made of iron which is also an unsafe condition for the worker.
2. Change the tables for others that have hydraulic legs since adjustability makes it easier to adjust the workstation to your needs. Adjusting helps to maintain better heights and reaches avoiding pressures and uncomfortable postures.
3. It is proposed a table with tool support such as nail gun, hammer, machete, drill since the operator only places them on the table as shown in the image.
4. Ergonomic anti-fatigue mat, since workers spend long working days standing it is necessary to have one, also allowing imperceptible movements in the muscles of the thighs, calves and feet which causes the blood to flow more easily avoiding the heart is forced and automatically decreases energy consumption, allowing substantially reduce fatigue and its effects.
5. The station should have at least 2 feet on the sides of the table for operator mobility.
6. Since the lights are too high and do not provide the necessary visibility, they should be closer to the workstation to provide the necessary illumination.
7. The vibrating equipment they use should be replaced by anti-vibration elements or anti-vibration gloves.

4.6 Materials handling análisis

According to the flow diagram seen in the first activity, the scheme of material movements in the area was made visually, where it is observed that the station that has more interaction is station 7, however this is without an assigned operator so that the manager of the other stations has to perform this extra activity thus taking away production time, so it is advisable to assign a plant operator for that station.



Activity	Identification color
Sourcing of material that needed extra cutting	
Finished product	
Operator	

Figure 3. Material handling flow in the area.

Table 6. Inter-station parts requirement.

DE	A								
	E1	E2	E3	E4	E5	E6	E7	Rack	Shipping area
E1		0	0	0	0	400	400	250	0
E2	0		0	0	0	0	0	400	0
E3	0	0		0	0	0	0	450	0
E4	0	0	0		600	880	0	0	0
E5	0	0	0	0		0	0	600	0
E6	0	0	0	0	0		0	200	0
E7	100	260	430	800	0	0		0	0
Rack	0	0	0	0	0	0	0		900
Shipping area	0	0	0	0	0	0	0	0	

4.7 Determination of space requirements.

The spaces required in the area, the total number of machines, equipment and work tables were calculated, and it was identified which of them are mobile and which are static according to Guerchet's method; Table 7 shows the results.

Table 7. Guerchet method calculations.

PROESER
WOODEN SHIPPING SOLUTIONS

PROESER DE MEXICO SA. DE CV.

MÈTODO GUERCHET- ABB

Nº de lados	Maquinaria /Equipo	Cantidad	Medidas(Pulgadas)			Superficies Estaticas (Ss)	Superficie Gravitacional (Sg)	Superficie de Evolucion comun (Se)	Total
			Largo	Ancho	Alto				
4	Mesa de trabajo 1	1	44,01	44,68	30,31	1966,3668	7865,4672	491,5917	10323,4257
4	Mesa de trabaja 2	1	43,97	45,47	32,67	1999,3159	7997,2636	499,828975	10496,40848
4	Mesa de trabajo 3	1	39,96	40,94	31,49	1635,9624	6543,8496	408,9906	8588,8026
4	Mesa de trabajo 4	1	48,62	28,07	29,4	1364,7634	5459,0536	341,19085	7165,00785
4	Mesa de trabajo 5	1	48,465	60	31,1	2907,9	11631,6	726,975	15266,475
4	Mesa de trabajo 6	1	48,42	60,15	32,04	2912,463	11649,852	728,11575	15290,43075
3	Mesa complemeto 1	1	22,24	12,79	29,52	284,4496	853,3488	56,88992	1194,68832
3	Estante complemento 2	1	47,79	15,82	37,2	756,0378	2268,1134	151,20756	3175,35876
3	Mesa complemeto 3	1	46,57	15,74	45,01	733,0118	2199,0354	146,60236	3078,64956
3	Mesa complemento 4	2	24,01	14,33	26,49	688,1266	2064,3798	137,62532	2890,13172
3	Racks complemento 5	1	62,99	29,92	86,61	1884,6608	5653,9824	376,93216	7915,57536
3	Rackas azules complemento 6	2	48,03	24,01	111,02	2306,4006	6919,2018	461,28012	9686,88252
4	Guillotina	1	28,54	49,21	58,66	1404,4534	5617,8136	351,11335	7373,38035
3	Mula	2	62,2	22	48,03	2736,8	8210,4	547,36	11494,56
4	Montacargas mitsubichi	1	135	24	83	3240	12960	810	17010
3	Bultos de material	26	50	42	40	54600	163800	10920	229320

K	0,05	In2	360269,777
		Ft2	2501,87185

After performing the necessary measurements and calculations taking into account the equations shown above, the method resulted in a space requirement of 2500.87 tf2 for the ABB area, in order to have the necessary space for each operation.

4.8 Area layout design.

For the design of the area it was taken into account to leave space for the worker to move around while performing his activities, also taking into account that the finished material will no longer be agglomerated in the area since it will be moved on mules to the shipping area at the time of forming the 10 products, which will give the worker the advantage of working in a clearer area.

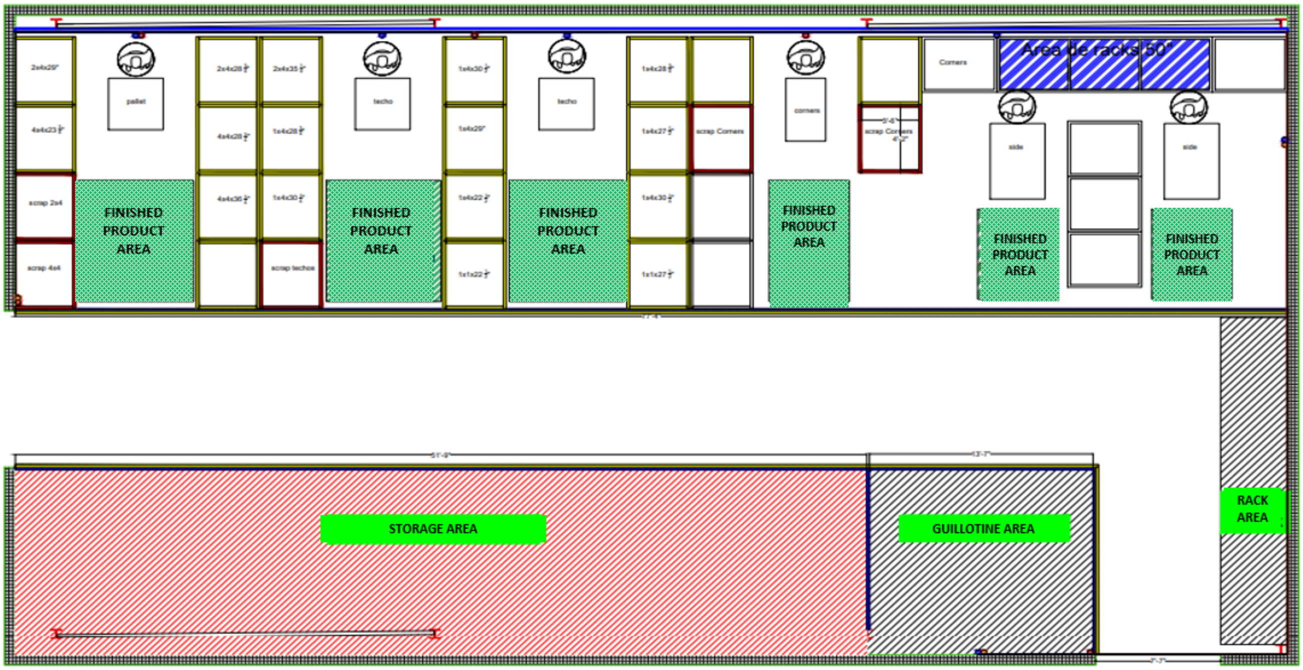


Figure 4. Distribution Actual.

The current area has a space of 547 ft2 while the area assigned to the new warehouse will have a space of 1519.78 ft2. The redesign will no longer take into account the area of racks or guillotine since that will be extra area that will supply the ABB area.

This design is referred to the space given in the new warehouse, as mentioned above the space required indicated by the Guerchet method is not the one that will be provided in the new space, however, one of the 7 stations of the current area will not be located in that space as well as the racks that had station 6 will no longer be in the space of the station since there will be a space for materials. This is favorable for the new ABB area, one of the stations with less space in the previous area was where the side was created and it was also the largest product of ABB, but in the new design it will be given almost double the previous space.

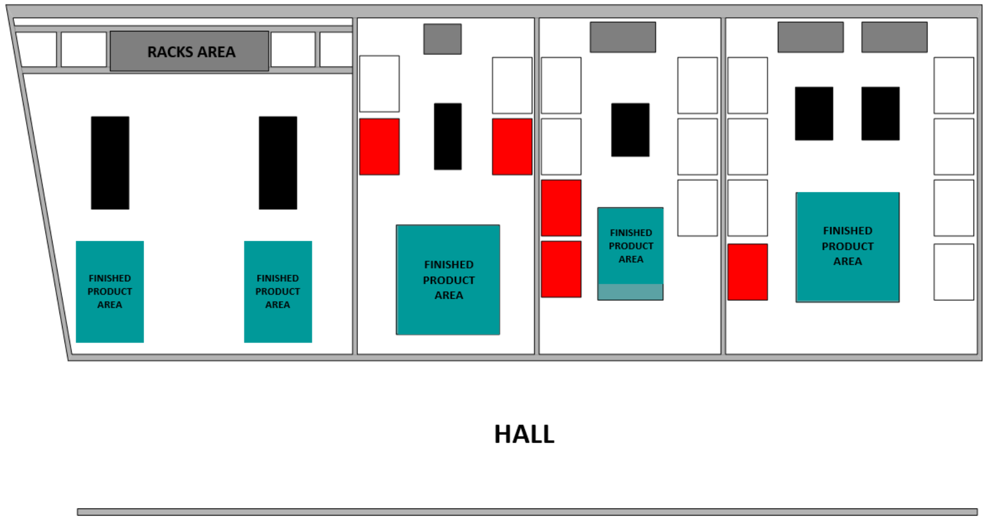


Figure 5. Proposed area distribution.

5. DISCUSSION/CONCLUSIONS

With the development of the aforementioned activities we obtained the representation of the flow of activities which allowed the development of the material flow analysis which has a lot of interaction, so it is necessary to have enough space and the current area did not have the necessary space for an efficient transfer process which at first glance was noticed by the constant agglomeration of materials, Therefore, the space requirement method was carried out, which indicated the amount of space necessary for the correct operation of the area. When constructing a new building, the space for ABB was established, even though it was not the space required by the method, it is favorable since it has a considerable increase, as well as the points to improve each work station and thus increase the performance of the operators.

The redesign of the area according to the authorized space was done leaving better spaces for the worker, and taking into account that the finished product will be moved to the shipping area when the stirrup is finished, the agglomeration of material will be avoided and thus the obstruction of aisles for the workers.

The STPS norms taken into account for the investigation were of greater significance for the area, which after analyzing, it was noted the insufficiency of the area with respect to safety and health at work.

After analyzing the ergonomic principles of the workstations, it is concluded that if the company takes into account the recommendations given in this research, the worker would considerably reduce the ergonomic damage.

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TOWARDS A HYBRID HAND EXOSKELETON BRAIN CONTROLLED ASSISTIVE TECHNOLOGY FOR INDUSTRIAL ENVIRONMENTS, APPLICATIONS OR TASKS

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Resumen: El control de sistemas robóticos avanzados con señales cerebrales promete mejoras sustanciales en el control intuitivo de los movimientos de la mano (Soekadar et al., 2019). El principal desafío para integrar tales sistemas en entornos industriales se relaciona con la confiabilidad del control cerebral, particularmente cuando las señales cerebrales se registran de manera no invasiva (Abdulkader et al., 2015). Utilizando un exoesqueleto de cerebro/mano neuronal (B / NHE) híbrido, no invasivo, basado en EEG-EMG, sugerimos que la combinación de un enfoque de asistencia y rehabilitación puede promover la tecnología de interfaz cerebro-computadora (BCI). En tal escenario, la tecnología de asistencia neuronal/cerebral no solo tendría un impacto inmediato en el espacio de trabajo, sino que también fomentaría la ergonomía al estimular la neuroplasticidad funcional y estructural (Wang et al., 2010).

Palabras clave: Interfaz cerebro-computadora, bioseñales, biomecatrónica, exoesqueletos, implementación humana.

Relevancia para la ergonomía: Este artículo contribuye con un enfoque moderno para la implementación de la mano humana en industria manufacturera, tanto como tecnología de asistencia laboral como un sistema para prevenir los riesgos para la salud relacionados con los fenómenos de fatiga y estrés musculoesquelético.

Abstract: Controlling advanced robotic systems with brain signals promises substantial improvements in intuitive control of hand movements (Soekadar et al., 2019). The main challenge to integrate such systems in industrial environments relates to the reliability of brain-control, particularly when brain signals are recorded non-invasively (Abdulkader et al., 2015). Using a non-invasive, hybrid EEG-EMG-based brain/neural hand exoskeleton (B/NHE), we suggest that combining an assistive and rehabilitative approach may further promote brain-computer interface (BCI) technology. In such a scenario, brain/neural-assistive technology would not

only have an immediate impact on the workspace, but would also foster ergonomics by stimulating functional and structural neuroplasticity (Wang et al., 2010).

Keywords: Brain interface, biosignals, biomechatronics, exoskeletons, human implementation

Relevance to Ergonomics: This article contributes with a modern approach for hand human implementation in industrial manufacturing activities, both as labor assistance technology and as a system to prevent health risks related to fatigue phenomena and musculoskeletal stress.

1. INTRODUCTION

In 2017, Tapia et al. conducted an ergonomic risk analysis in an industrial automotive company in Mexico. The study was subject to only workers who use their upper limbs to carry out their activities. The results showed that the ergonomic risk factor related to strength is present in 35% in the development of MSD in the upper extremities, being the second most impressive factor, followed by posture with 51% (Tapia et al., 2017). In 2011 the Mexican Institute of Social Security (IMSS) filed 147 cases of carpal tunnel syndrome, which increased to 540 and 636 cases in 2015 and 2016 respectively (Macorra et al., 2019) (STPS, 2017). Regarding shoulder injuries, an increase from 140 to 516 cases was documented in the same time interval, which represents an increase of more than three times in this period (Macorra et al., 2019). Therefore, it is very important to study and improve the interaction of the hands with the industrial environments.

Exoskeletons are wearable robotic machines originally studied for human body powered assistance in heavy-duty and/or repetitive tasks (Cempini et al., 2015). Assistive technologies gained relevance in industrial and military application, leading to a number of prototypes, patents, and commercial products (De Santis et al., 2008).

2. OBJECTIVES

To design and integrate a basic BCI technology system for industrial environments in order to achieve labor assistance in manufacturing tasks through brain wave control of a hand exoskeleton.

- To design a brain-computer interface (BCI) system.
- To design a hand exoskeleton capable of replicating flexion/extension (F/E) finger movements.
- To construct a biomechatronic coupling BCI-exoskeleton.
- To verify integration and operation of the proposed prototype as assistive technology.

3. DELIMITATION

Industrial, mechatronics and biomedical engineering converge in a synergic way to design a hybrid system capable of capturing electromagnetic analog signals from a human user's brain in the 4 to 30 Hz range and also its respective digital signal conversion (EEG EMOTIV EPOC+), as well as processing the digital information from de brain waves (CyKit V3 and OpenVibe), identify patterns to be interpreted as virtual mechanical instructions or as operation commands for a biomechanical motion, then send and receive the command to the electronic interpreter (Raspberry/dspic30f4013) to order the electromechanic execution on the effector device of the hand exoskeleton and finally to verify the response of the system.

The purpose of this research is to propose a system as biomechatronic technology for labor assistance, based on the NOM-241-SSA1-2012 standard and with the competencies acquired in the joint programs of the Master in Industrial Engineering and Master in Electronic Engineering of the Hermosillo campus of the National Technological Institute of Mexico, the aim of this work is to acquire and process brain signals to control the dynamics of an exoskeleton in the hands of workers in industrial manufacturing activities, in whom the risks related to fatigue phenomena, musculoskeletal stress and health effects could be prevented during regular occupational tasks, among others.

Our design and integration processes are executed in the facilities of the ergonomics laboratory of the DEPI (División de Estudios de Posgrado e Investigación) at the TecNM/ITH campus during the 2020 to 2022 period. And for the on-site performance tests, these are contemplated to be done in local company in the automotive industry.

4. METHODOLOGY

4.1 VDI-2206 method

The present design is based on the mechatronics systems methodology VDI-2206 (Ingenieure, 2004), which is a flexible procedure model seen as a process that represents the sequence of steps as a project development cycle. The main phases are summarized next:

- Requirements: needs, limitations and performance parameters that the system will have.
- System design: the general specifications obtained in the first phase are taken into account and the system is divided into modules, generating solutions for each element.
- Domain-specific design: the mechanical, electrical and software components of the complete system are taken into account, each element considered like modules.
- System integration: the integration of all modules in a whole system is carried out, ensuring that the interaction in the set is as desired.

- Verification/Validation and analysis: in this work it consists of functional tests and verification.

The methodology used can be seen schematically in figure 1.

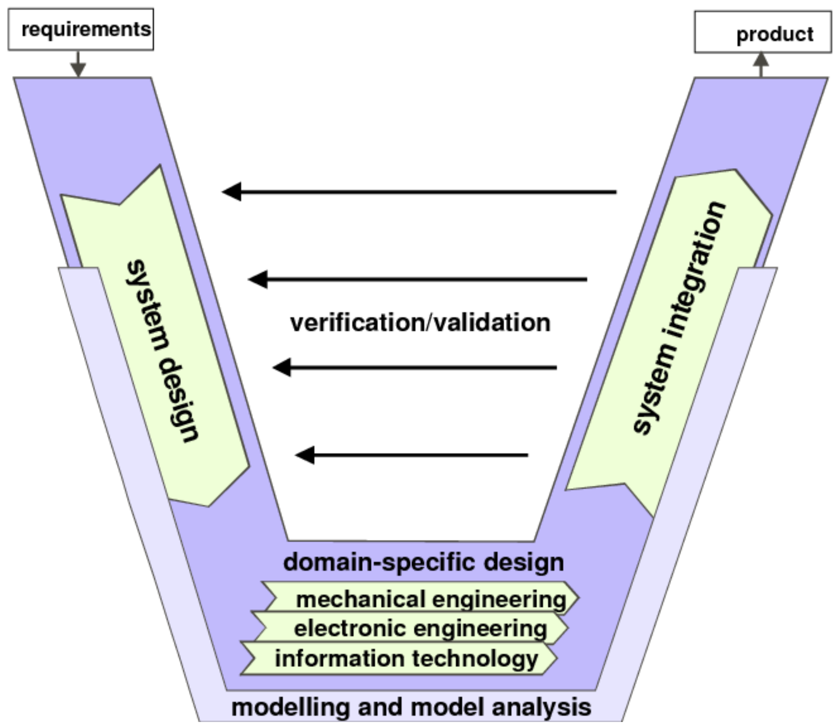

Figure 1.- VDI-2206 method schematics in a V-shape (Tapia et al., 2017).

4.2 Enhanced Functional Flow Block Diagram (EFFBD)

Representation set that shows the flow of control through sequencing of functions and constructs as well as the data interactions overlaid to present a more complete picture, although without specifying specific durations of time between each function. Functional events are represented through blocks and can be performed in parallel or take an alternative route (NASA, 2007).

4.3 Icam DEFinition for Function Modeling (IDEF0)

This functional modeling method is designed to model the decisions, actions, and activities of a system. It starts from the definition of rules and techniques that meet the requirements and functions for the design of the implementation of the mechanisms, activities and operations that support the integration of the system (S. of Commerce, 1993). The structure of the components of the IDEF0 model are made up of boxes (activities, processes or transformations), arrows (transmit data), rules and diagrams.

5. RESULTS

5.1 Requirements

According to the proposed methodology, defining the requirements of a system involves quantifying characteristics such as difficulty, risk and/or importance; that is why we list in detail the measurements, components, materials, etc. to meet the needs or desires previously raised and obtain a convincing functional biomechatronic design.

Table 1.- Requirements

I.	**EEG dimensions**
	Height: 9 cm
	Width: 15 cm
	Length: 15 cm
II.	**Exoskeleton hand dimensions**
	Height: 5 cm
	Width: 12 cm
	Length: 20 cm
III.	**Ergonomic design**
	Safe and comfortable attachment to the body
	Strategic placement for increased comfort
	Lightweight and portable for versatile applications
	Low power consumption to prevent heating
IV.	**Communication**
	Wireless communication to node
V.	**Monitoring**
	Read and filter brain signals in real time
	Feature detection and classification
VI.	**Controller Circuit**
	DSPIC30F4013
	12V DC Motor
	Optical Encoder
	11.1V Li-Po Battery
	LM2596 DC-DC Step Down Converter Module
	PC817 Optocoupler
	IFR4905 Mosfet
	IFRZ44N Mosfet
	TIP120 Transistor
	2N3055 Transistor
	Multiple Capacitance Capacitors
	Multiple Resistance Resistors

As can be seen in Table 1, in order to integrate the objectives and obtain a product, it is necessary to cover aspects such as the ergonomic design of the system, the selection of materials and electronic devices for the manufacture of components, the communication and the Human-Machine interaction.

5.2 System design

To present in detail the integration process of the functional architecture of the system and based on the IDEF0 model, we show in figure 2 the graphical representations of node 1, related specially with acquire and process the brainwaves information; which includes the structuring of the activities, processes and operations that perform the functions of Data acquisition, Wireless communication, Noise attenuation, Signal filtering, Feature recognition and Feature classification.

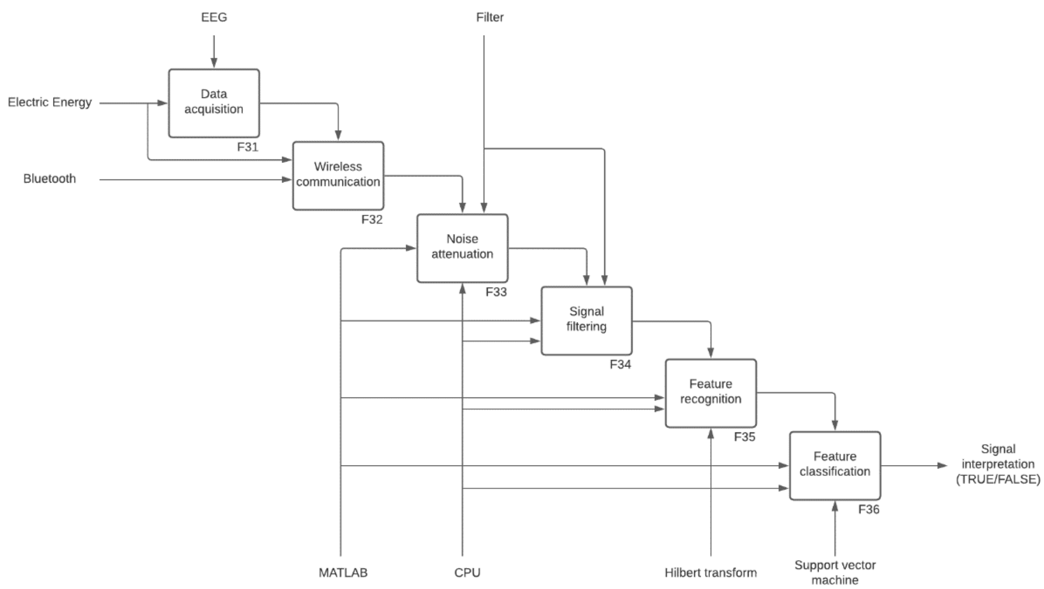

Figure 2.- Node: acquisition and digital process of brainwave information.

Similarly, in figure 3 we can see the node 2, which has the focus and task of executing the desired mechanical action, and which contains the functions considered about Step down circuit, that of the Microcontroller, the H-bridge circuit and finally on the DC motor.

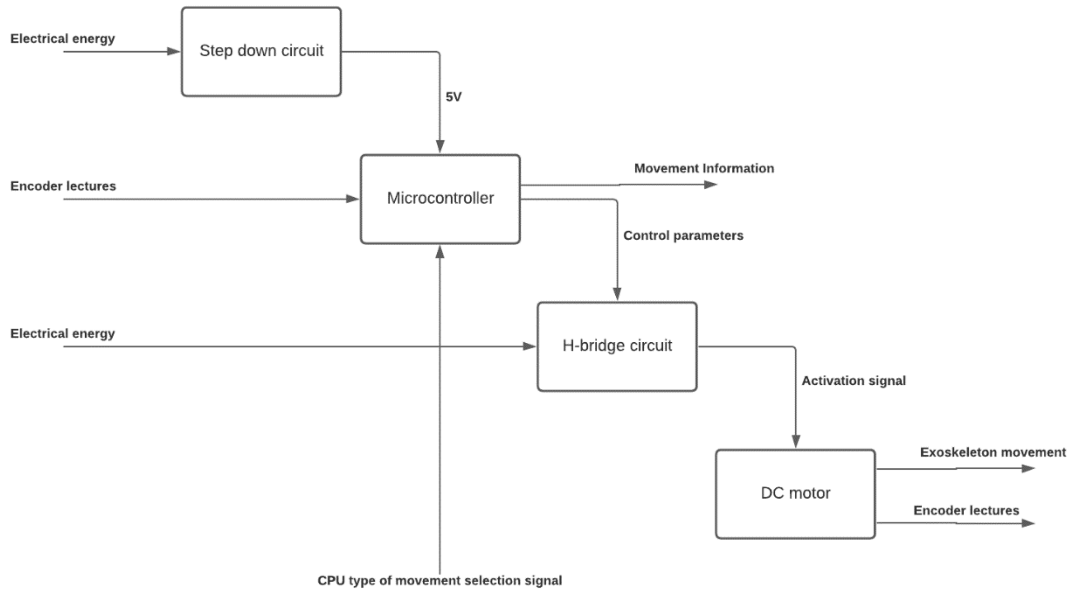

Figure 3.- Node 2: receive instruction and execute the mechanical action.

5.3 Modular division

The first module consists of a BCI system that will act as a tool for capturing EEG signals from the brain, specifically theta, alpha and beta waves, which were used by Shi, et al. (2018) to detect visual stimulation evoked potentials. In terms of hardware, this module requires an EEG and a computer capable of wireless communication via Bluetooth®. The EPOC + EMOTIV® EEG was chosen and a computer with a Core i5 processor and 12 Gb of RAM is available. Regarding software, two open source tools are required: CyKit V3 and OpenVibe.

The system design for obtaining EEG data consists of four steps and these are illustrated in Figure 4. It starts with the obtaining of EEG data from a study subject and its subsequent transmission via Bluetooth to the computer. Communication with the device in question is enabled through the CyKit V3 software. The last stage is done in the OpenVibe software, which participates in the signal’s treatment and analysis.

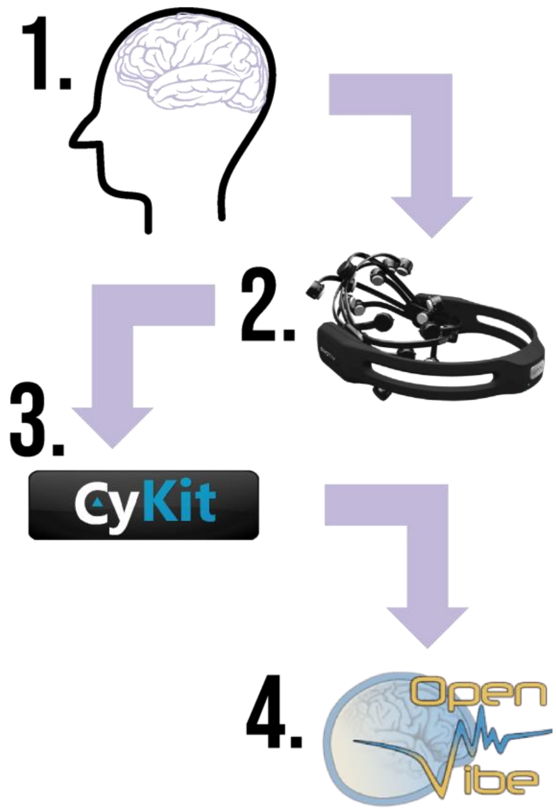

Figure 4.- Workflow for Module I - BCI: 1. Study subject; 2. EEG (EPOC + EMOTIV®); 3. Communication software (Cykit V3); and 4. Processing (OpenVibe).

For the specific domain design, two stages are contemplated and these can be seen in Figure 5: signal treatment and analysis. Signal treatment was achieved by applying digital filters. For noise attenuation, low-pass and high-pass filters were implemented to reduce noise from the device's battery (0.5 Hz high-pass) and possible interference with the high frequency power supply (120 Hz band rejection). Subsequently, the signals are combined and treated using band-pass filters with ranges subject to the brain wave to be obtained. These waves are classified according to their frequency band: delta (0-4 Hz), theta (4-7 Hz), alpha (8-12 Hz), beta (12-30 Hz) and gamma (30-50 Hz).

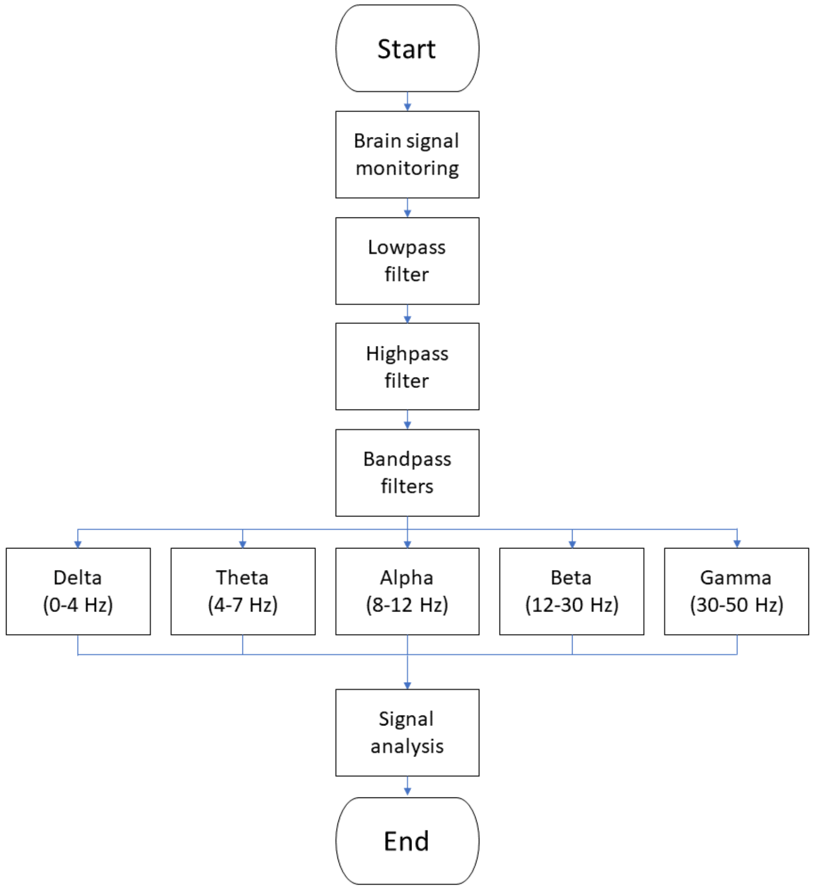

Figure 5. Signal treatment (noise attenuation and filtering).

Following the signal treatment stage, EEG data is interpreted in the analysis stage and the process is shown in Figure 6. In order to achieve this, two techniques are implemented: Hilbert transform for signal features identification; and support vector machines for signal classification. The first technique is used to detect the desired signal that will initiate the next module. The second technique is used to classify the signal according to its magnitude into one of two categories: 1. Inactive, and 2. Active.

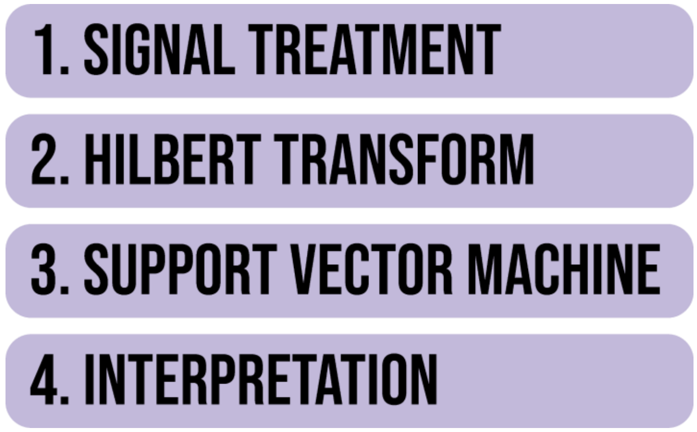

Figure 6. Workflow for signal processing in Module I - BCI: 1. Signal treatment; 2. Hilbert transform; 3. Support vector machine; 4. Interpretation.

Another result involves the design of the hand exoskeleton mechanical system with bowden cable as the one shown in Figure 5. The system is created using 3D printed parts and nylon cables. It is going to be actuated by a 12v DC motor controlling the Flexion/Extension (F/E) movements of the fingers. This system is originally designed for EMG signals and now it is contributing with the hybrid exoskeleton action system.

Figure 7. Hand exoskeleton as a reference for the design process.

As Figure 8 shows the design that was created in the software Solidworks. This design is comparable to the one in Figure 7 and can be manufactured using 3D printing technologies such as fused deposition modeling (FDM), stereolithography (SLA) or digital light processing (DLP) which are actually the most common technologies.

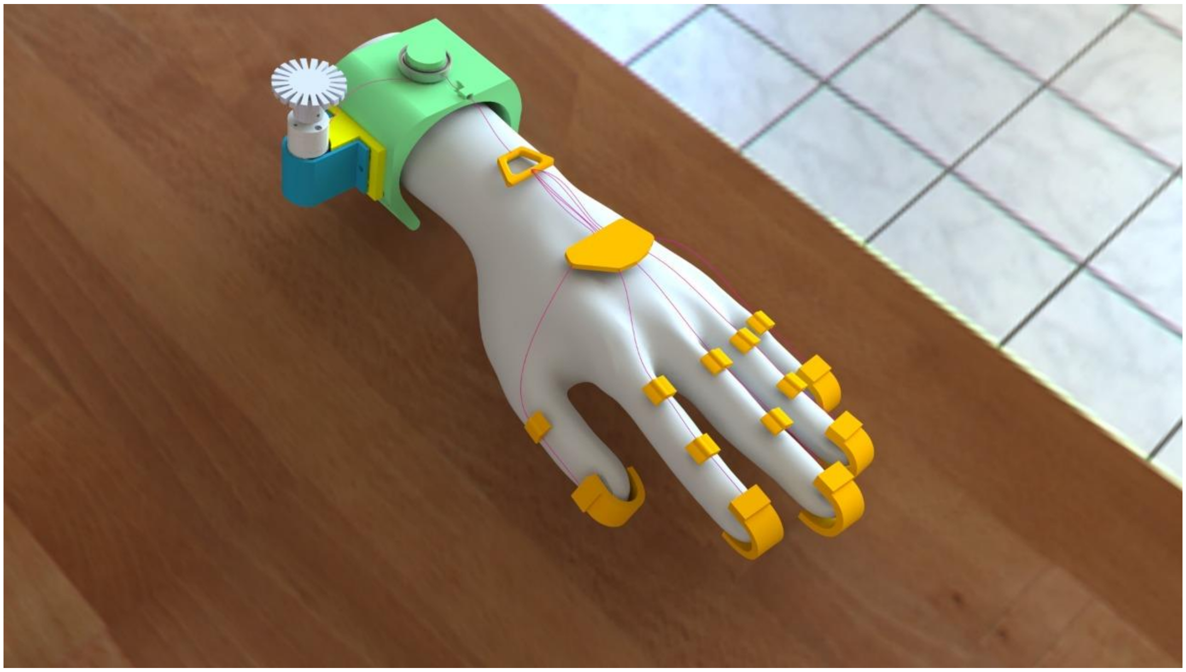

Figure 8.- Final design concept for hand exoskeleton used for the hybrid exoskeleton action system.

Once the mechanical design was developed, a controller for the movement of the exoskeleton operated with the 12V DC motor was created as shown in Figure 9. To do this, a DSPic microcontroller connected to a PC is used by implementing a TTL-USB communication protocol. This microcontroller circuit receives signals from the sensors (myoelectric sensor and encoder) to make decisions regarding the type of signal sent to the H-bridge to drive the exoskeleton. These activation signals depend on the type of signal received by the controller and can be actuated or stopped, up to an angle programmed by reading the Encoder.

The H bridge is developed with MOSFET transistors to ensure fast response of change between the activation and stop signal. This allows the system to comply with rapid alternation without raising the temperature, which allows constant work to be carried out without considerable losses.

The power supply circuit of the system is an arrangement of transistors that allows maintaining a constant voltage of 12V, even when there are small voltage drops in the battery, ensuring that the power supply of this circuit will not be a problem with the input noise.

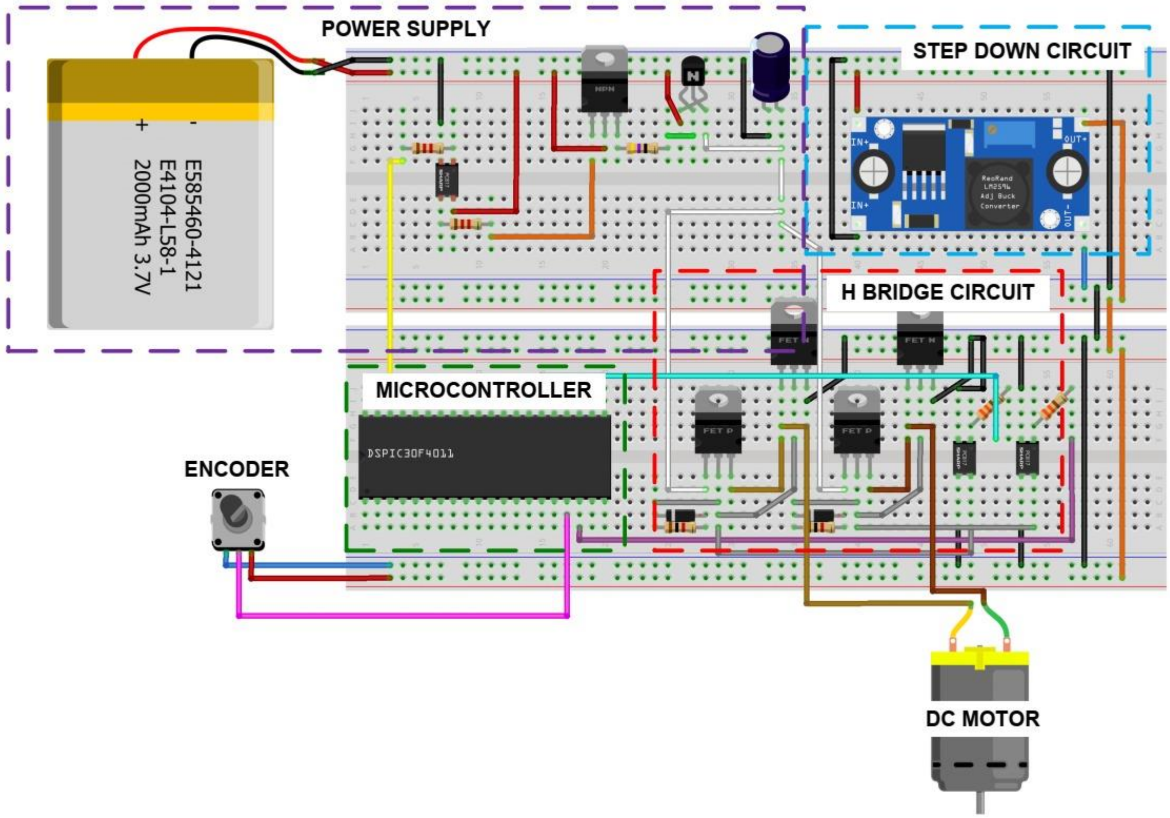

Figure 9.- Controller circuit breadboard connection.

6. CONCLUSIONS

Most of the proposed objectives were achieved: the design of a functional brain-computer interface (BCI) was shown in the diagrams based on the IDEF0 model. The expectation of designing a hand exoskeleton capable of flexing/extending the movement of the fingers was made and successfully simulated in SolidWorks. Then this document is presented as a biomechatronic coupling BCI-exoskeleton. Even though we are well aware that the whole biomechatronic system integration/verification is missing due to the recent coronavirus covid-19 pandemics the in-situ work at ergonomics lab. Then based on our partial results and the success of some other similar BCI projects we are convinced this project can be integrated in a hybrid brain/neural activation hand exoskeleton for industrial environments in order to achieve further labor assistance in manufacturing tasks.

6.1 Relevance for ergonomics

This article contributes with a modern approach for hand human implementation in industrial manufacturing activities, both as labor assistance technology and as a system to prevent health risks related to fatigue phenomena and musculoskeletal stress.

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ERGONOMIC CONTRIBUTION IN WORKSTATIONS, FOR THE SEWING OF DISPOSABLE MEDICAL MATERIAL.

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Resumen: Las operaciones de cosido de batas desechable para la protección personal, establecidas en las líneas de producción en "Industrias APSON S.A. de C.V" perteneciente a la industria maquiladora y manufacturera localizada en el Noreste del estado de Sonora, mantienen un conjunto de actividades secuencialmente operativas que llevan consigo una gran demanda de energía, trabajo y concentración por parte del operador que realiza sus actividades en dichas estaciones de trabajo. Las principales exigencias de estas estaciones de trabajo se concentran en las posturas inadecuadas donde se desarrolla la tarea, los tiempos de ciclo cortos, el manejo manual de cargas inadecuado y el estrés por contacto. Estas exigencias en su conjunto incrementan la posibilidad de que el trabajador desarrolle un Desorden Músculo Esquelético y a su vez se ve afectado el rendimiento productivo de la estación de trabajo.

El trabajo investigativo contempla la aplicación de los principios de la biomecánica ocupacional y las directrices ergonómicas para rediseñar los puestos de trabajo en operaciones de cosido de batas desechable en las líneas de producción en la industria maquiladora y manufacturera localizada en el Noreste del estado de Sonora.

El incremento acelerado en la demanda de los productos de protección personal en específico el de las batas desechables, hacen necesario que los sistemas productivos de este tipo de artículos se vean sustancialmente mejorados en su productividad y a su vez la empresa desarrolle una mayor competitividad. Para lograr lo anterior se requiere que el recurso humano dedicado a la producción cuente con las condiciones necesarias y suficientemente ergonómicas, que les permita desarrollar sus actividades con la mayor eficiencia posible y con el menor impacto negativo del trabajo sobre el trabajador.

El trabajo enmarca el rediseño de la estación de trabajo de cosido de bata desechable, contemplando las directrices ergonómicas, lo que da como resultado una disminución en la posibilidad de que el operador desarrolle un desorden músculo esquelético y a su vez se mejora la productividad de la entidad empresarial.

Palabras clave: Ensamble manual, rediseño ergonómico.

Relevancia para la ergonomía: El incremento acelerado en la demanda de un producto, afecta directamente las condiciones de trabajo, llevando consigo un alto riesgo de que el trabajador desarrolle un Desorden Músculo Esquelético en un periodo corto de tiempo. Por lo que es de vital importancia la aplicación de las normas, procedimientos y directrices de la ergonomía en este tipo de situaciones. El presente trabajo desarrolló la aplicación de la ergonomía en una estación de trabajo donde se incrementó drásticamente la demanda y se obtuvieron resultados en la disminución del riesgo para el trabajador y un incremento en la productividad de la estación de trabajo. Lo que se contempla como una aportación esencial a la ciencia ergonómica.

Abstract: The sewing operations of disposable gowns for personal protection, established in the production lines on "Industrias APSON SA de CV" belonging to the maquiladora and manufacturing industry located in the Northeast of the state of Sonora, maintain a set of sequentially operative activities that convey with them a peak demand for energy, work, and concentration for the operator who carries out his actions on these workstations. The fundamental demands of these workstations are concentrated in the inadequate postures where the task is developed, the short cycle times, the inadequate manual handling of loads, and the stress by contact. Collectively, these demands increase the possibility of the worker developing Musculoskeletal Disorders and in turn, the productive performance of the workstation is affected.

This investigative work contemplates the application of the principles of occupational biomechanics and ergonomic guidelines to redesign the jobs in sewing operations of disposable gowns in the production lines on the maquiladora and manufacturing industry located in the Northeast of the state of Sonora.

The accelerated increase in the demand for personal protection products, specifically disposable gowns, makes it necessary for the production systems of this type of item to be substantially improved in their productivity, and at the same time, the company develops greater competitiveness. To achieve the above, it is required that the human resource dedicated to production develops the necessary and sufficient ergonomic conditions, which allows them to carry out their activities with the highest possible efficiency and the least negative impact of work on the employee.

This work frames the redesign of the disposable gown sewing workstation, considering the ergonomic guidelines, which results in a decrease in the possibility that the operator develops a Musculoskeletal Disorder and in turn improves the productivity of the entity business.

Key Words: Manual assembly, ergonomic redesign.

Relevance to ergonomics: The accelerated increase in the demand for a product directly affects working conditions, carrying with it the possibility of the worker developing a Musculoskeletal Disorder. For this reason, the application of ergonomics is of vital importance. This work developed the ergonomic redesign of a workstation where the demand was drastically increased, and results were obtained in reducing risks for the worker and an increase in the productivity of the workstation. What is considered as an essential contribution to ergonomic science.

1. INTRODUCTION

Mexico faces one of the most complex public health problems in recent years, due to the exponential expansion in the national territory of the pandemic caused by the SARS-CoV 2 virus (COVID-19) (Rodríguez Nava et al., 2020). For this, the Mexican health sector has implemented some critical strategies to contain the pandemic in our territory, declaring phase three of maximum alert: the mobility of people is reduced as significantly as possible; social distancing; strict prevention measures; cancelation of massive activities. These strategies are focused on containing the pandemic; one of the particular actions for this containment being the use of disposable protective clothing.

In addition to the above, constant evolution is observed in the industry that sustains a revolution in the production paradigm. The introduction of current technologies, rapid changes in the market, and production strategies have influenced work content and the need for worker training (López Alonso et al., 2011). These trends have given rise to increased risks and diseases, highlighting Musculoskeletal Disorders (MSDs) of occupational origin, which are a common health problem and the main cause of occupational disability (Castro-Castro et al., 2018).

Industrias Apson S.A. de C.V. represents a company with a regional identity, located in the city of Agua Prieta, Sonora, belonging to a strategic organization called the Maquiladora Industry and Export Manufacturing of the Northwest of the State of Sonora. This company is a manufacturer and supplier of products used in operating rooms and necessary for the prevention of infections. Industrias Apson S.A. de C.V. manufactures a full line of masks for facial protection in surgical procedures and a broad line of disposable protective clothing including isolation gowns, medical gowns, laboratory gowns, warming jackets, coveralls, dental gowns, and ice packs.

The company's mission is to combat preventable infections and help save lives through partnerships with healthcare professionals by providing the right products, education, and support that deliver genuine solutions. Being the production lines belonging to the company Industrias Apson S.A. de C.V., the object of study of the present investigation. The company's strategic location allows fast and secure access to market-leading products during pandemics and spikes in demand caused by unusual or severe flu seasons. This has bluntly mitigated the spread of the SARS-CoV 2 virus (COVID-19).

The intersection that occurs between the vertiginous advance in industrial technologies and the increase in the demand of the products used for the containment of the pandemic, result in the need to increase the company's production volumes, so it becomes necessary to delve into the conditions that may influence and favor the reduction of the time necessary to carry out the operation at the workstation, that is, the cycle time, as well as the associated costs. In the design and measurement of work in linear flows, characteristic of the industry under study, the process maintains an interdependent relationship between the configuration of the work area and the workforce, specifically in the man-machine-work environment trinomial. (Kar & Hedge, 2020). A particular situation of this is the workstations where personal protective clothing sewing activities (disposable gown) are carried out, which present characteristics like high repeatability, monotony, high degree of concentration, low locomotion, and short cycle times. (Pinto Retamal, 2015).

The fact that the trinomial man-machine-work environment supports the company's ability to produce articles with the quality, quantity, flexibility, and cost specifications that the market demands, is precisely what bases the need to find a synergy between the anatomical and physiological capacities of the operators and the functional structure of the station or work area (Báez et al., 2013). This synergy maintains a set of significant variables, focusing on the positions in which the worker interacts with the workstation to complete the process of transforming raw material into a finished product. When the postures in which the worker performs his work, from the anatomical and physiological point of view, are not adequate, the worker develops a gradual growth in his fatigue (Cuautle Gutiérrez et al., 2021). This situation develops a negative impact of the work on the operator who performs such functions, which is an ascending perspective that carries with it the possibility of Musculoskeletal Disorders (MSD), affecting the quality of life of the worker and the productivity of the business exercise (López Torres et al., 2014).

The Musculoskeletal Disorders of work origin involved in the sewing stations of the disposable gown have exceeded the plans, programs, and improvement and productivity actions implemented. This situation has been observed mainly because of increases in incident reports, staff turnover, annoyances expressed by the worker, and an absolute increase in visits to the doctor by staff who perform their functions in these areas. This is mainly because the implicit requirements in the actions and tasks framed in the sewing workstations of the face protection mask have a negative impact on the worker, mainly in the spine and upper limbs, since the actions directly involved in the operation consist of making a very precise stitch used for the final assembly of the product. The implicit distribution in the machinery of this task does not allow the work to be carried out within the range of biomechanical comfort; consequently, in the production lines, there are a series of problems that negatively impact the biomechanics of the work to be executed (Vázquez, 2012).

The present research involves the application of the main ergonomic guidelines for the redesign of the sewing station of personal protective gowns, a situation that in its global perspective will present a substantial improvement in the intrinsic machine-man relationship and reduce the negative impact of the exogenous variable environment. With the actions described above, support for improvements is generated that has a positive impact on productivity, efficiency, and improvement in the quality of life of operators.

2. OBJECTIVES

2.1 General objective

To contribute to the reduction of musculoskeletal disorders through the ergonomic redesign of work stations 59, sewing of disposable gowns.

2.2 Specific objectives

- To evaluate the theoretical and scientific aspects related to the work performed in the sewing of disposable products for body protection.
- To redesign the sewing operation of disposable body protection gowns by applying ergonomic guidelines.
- To validate the increase in the productive performance of the worker from the designed procedure.

3. DELIMITATIONS

The following is established as the object of study: the work stations, which develop the operative practice of sewing disposable body protection gowns, within the maquiladora industry in the northeast of the state of Sonora, Mexico.

4. METHODOLOGY

The investigative methodological strategy that is developed in the present work is divided into two moments: the first focuses on the research tools used and the second on the pragmatic investigative methodological action that is presented. The research structure used in this work is the mixed method of research, so both qualitative and quantitative tools will be used.

In the qualitative part, non-participant observation is established as a strategy. In it, a set of observations are made to the workers during the performance of their activity, mainly to define the time it takes to regain their physical strength and to ensure that accumulated fatigue does not occur.

In the quantitative stratum, the ergonomic evaluation method called the ART tool is applied; this method provides enough information to be able to determine the level of ergonomic risk to which the worker is exposed.

Statistics. A statistical comparison will be carried out to define the substantial improvement in the workstation, where the ergonomic redesign of the disposable gown sewing was executed, thereby determining if the redesign had a positive impact on the reduction of work risk for the operator.

The second moment is established in three steps that are developed below:

1. In the first point, a diagnosis of the current situation is carried out, which assesses the development of operational activity in the workstation for sewing disposable body protection gowns and the negative impact on the

worker's quality of life. We frame this situation from the application of the ART tool method in order to define the degree of risk in which the workstation is.

2. Once the diagnosis has been developed, an analysis-synthesis process is carried out, which assesses the synergistic relationship between the workstation and the operator, and the necessary and sufficient conditions are established to develop the ergonomic redesign procedure that includes: the main guidelines for ergonomics, biomechanics, and standardization of micro-movements.

The third point to be developed establishes the application of the procedure designed in workstation 59, sewing disposable body protection gowns and defining a comparison of the ergonomic evaluations carried out with the ART tool method, before and after the application.

5. RESULTS

As the first aspect to be developed in the investigative work, a diagnosis was performed on the operating conditions at station 59, disposable gown sewing, for such situations, it is necessary to carry out a direct observation procedure on the workstation, as well as obtaining a set of video recordings that support the observations congruently, and it is possible to establish an accurate and reliable diagnosis.

In figure 1 the workstation 59 is shown, sewing of disposable gowns, in the operability of this workstation a set of complex activities are observed from the ergonomic perspective depending on its design, the points of greatest severity are the referents to the distance between the workstation and the points of obtaining the raw material, the height of the workstation, the type of pedal actuator of the sewing machine, and the seat. Points that together result in a productive cycle time of 14.3 seconds per piece.

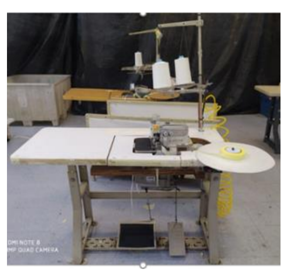

Figure 1: Workstation 59, disposable gown sewing.

Figure 2 shows the operational flow diagram of workstation 59 and the calculation of the productive cycle time of the operation.

PROCESS FLOW DIAGRAM								
Fecha Realización: 12 de abril de 2021		Ficha Número: 1						
Diagrama No. 1	Página 1 de 1	**RESUMEN**						
Proceso: Cuello		Actividad	Actual		Propuesto		Economía	
			Cant	Tiempo	Cant	Tiempo	Cant	Tiempo
Actividad: Costura		Operación	6	14.3				
		Transporte						
Tipo de diagrama: de flujo	Material( )	Espera						
	Operario( )	Inspección						
Método: Presente	Actual( )	Almacenamiento						
	Propuesto( )	Distancia Total						
Área / Sección: Modulo 59		Tiempo Total						
Elaborado por:		Aprobado por:						

Descripción						Dist.	T (S)	Observaciones
Agarrar la bata de la operación							2	
Acomodar la bata en la máquina							2.3	
Cocer el bandil alrededor del cuello de la bata							2	
Medir el bandil conforme a lo establecido							3	
Cortar el bandil a la medida establecida							3	
Enviarla a la siguiente operación							2	
TOTAL							14.3	

Figure 2: Workstation 59 process diagram, disposable gown sewing.

To carry out a greater depth in the analysis and ergonomic evaluation of the workstation, the ergonomic evaluation method ART tool was applied, considering the movements are highly repetitive, they are concentrated in the upper limbs of the body and are considered as micro-movements, coupled with the use of force and handling of the fingers.

Figure 3 shows the results of the application of the ART tool ergonomic evaluation method. The scores obtained by the evaluation method establish an urgent additional research requirement.

Following the methodology proposed in the present investigation, the next step is to define the ergonomic principles applicable to the type of workstation in which the study is immersed and proceed to develop the redesign of the workstation. The primary focus that remains in the redesign process is to reduce the forced postures in which the operator carries out its activity.

It is substantial to establish that one of the most complex problems denoted by the ergonomic evaluation defined with the ART-tool, is the exposure time in which the operator performs the disposable gown sewing activity. For this activity, the daily scheduled work time is 8.5 hours, with two break times, framed as follows: the first of 15 minutes, 3 hours after starting the workday, and the second of 30 minutes, in which a productive break is carried out for the operator to take lunch. Even with the conditions described above, the total hours worked are greater than the limit established by the evaluation method, being then, that the time factor is potentiated by 1.5 times, which results in a high value in reference to the risk associated with the worker that performs its work on these workstations.

Figure 3: Results of the application of the ergonomic evaluation method ART - tool at workstation 59, disposable gown sewing.

Table 1 shows the ergonomic principles, standards, and procedures taken into account to develop the action of the ergonomic redesign of the workstation 59, disposable gown sewing.

Table 1: Ergonomic principles and actions for the redesign of the workstation.

Principio ergonómico:	Acción en el rediseño ergonómico de la estación de trabajo 59
Adaptar el trabajo a las áreas de confort del trabajador, en acorde a las medidas antropométricas al percentil noventa.	La mesa de trabajo considera una altura de entre 4 y 5 cm. por encima del codo del operador y una inclinación de 5 grados.
Disminuir la repetitividad de movimientos. Minimizar los movimientos innecesarios.	Se acortan las distancias para tomar la materia prima.
Disminuir la amplitud de los ángulos de movimiento para conservar ángulos de confort.	Se incluye en el rediseño de la estación de trabajo una banda transportadora, lo que disminuye los ángulos en la obtención de la materia prima.
Las alturas del asiento y respaldo de la silla deben ser ajustables. Las características específicas de la silla son determinadas por la tarea.	El rediseño considera la incorporación de una silla ergonómica con ajuste en las alturas y descansabrazos.
La altura de trabajo depende de la tarea a realizar. Evitar trabajar con las manos por detrás del cuerpo. Reducir la distancia entre la postura neutra del trabajador y la postura en la que desarrolla la tarea.	La mesa de trabajo contempla un espacio de ajuste en las alturas y una inclinación para una mejor operabilidad.
Disminuir la carga estática. Ofrecer variación en tareas y actividades.	La aplicación de las mejoras en la estación de trabajo rediseñada contempla un conjunto de micro descansos y una jornada máxima de 8 horas.

With the actions shown previously, the bases are established to carry out the redesign of the workstation 59. The diagram of the redesign is shown in Figure 4.

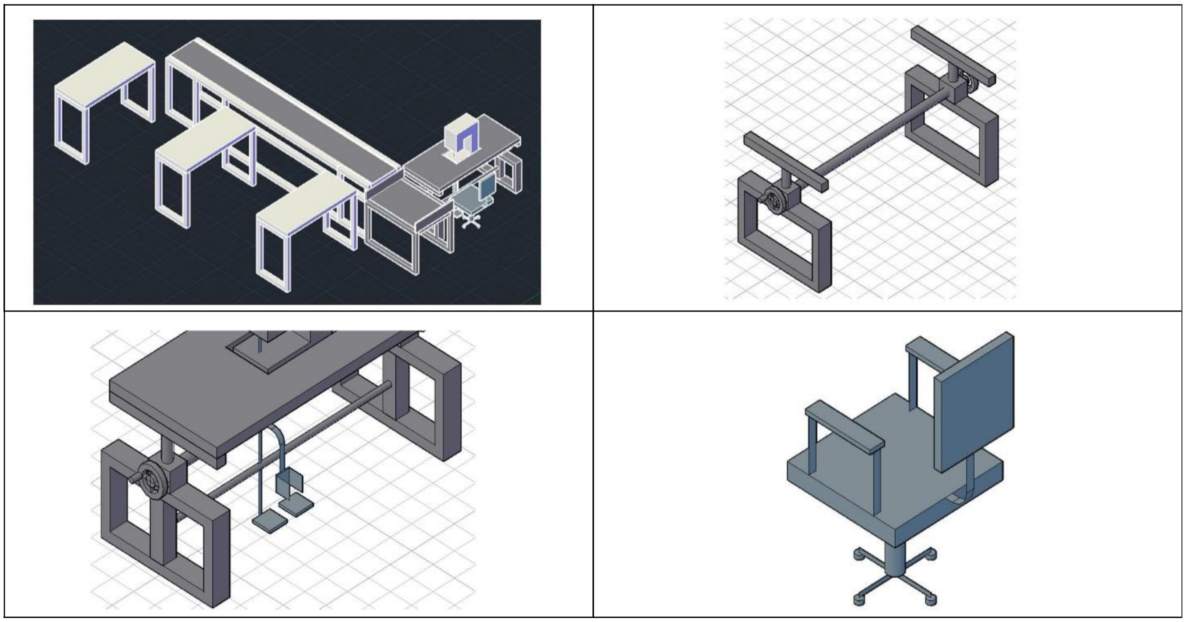

Figure 4: Ergonomic redesign of workstation 59, disposable gown sewing.

The workstation where the operator interacts throughout the working day is detailed in figure 5; in this, each of the ergonomic guidelines mentioned above are contemplated.

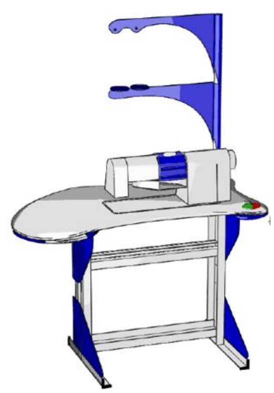

Figure 5: Workstation, disposable gown sewing, redesigned.

For the fulfillment of the third point of the proposed methodology, we proceed to the conformation and application of the redesigned workstation, in the productive processes of the company. In turn, the redesigned workstation is established; a process of training and coupling of personnel to the new workstation is carried out.

This situation is of utmost importance since to validate the improvement or not of the operation based on the redesign, the staff must develop the necessary skills to reach the production standards established by the company.

Through non-participant observation, it is recognized that the worker achieves his production standard and a coupling to the workstation is achieved. Based on this, the ergonomic evaluation of the workstation is carried out again with the ART tool method, thereby maintaining enough information to make a comparison in the ergonomic evaluations, before and after the redesign.

Figure 6 shows the ergonomic evaluation after redesign; it is crucially important to denote in this evaluation that the total work time has decreased from 8.5 to 8 hours, which has a very favorable impact on the worker's condition in that the increase in its fatigue is slower than in the previous workstation. It is emphasized that the volume of products made during the working day achieves the standard established by the company, and, at its best, the level of production increased in all the workstations where the ergonomic redesign was applied.

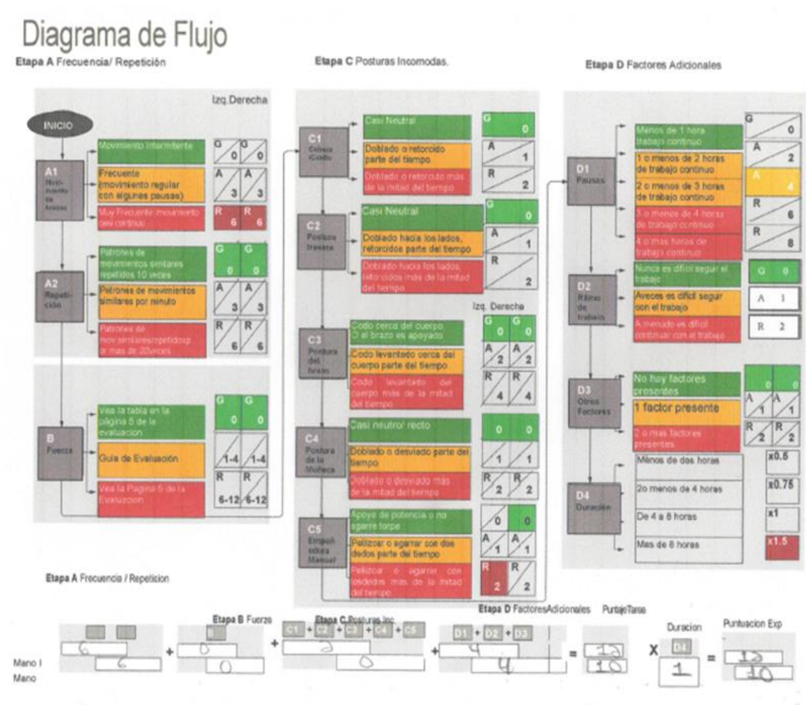

Figure 6: Ergonomic evaluation of the workstation with the ART tool method, after the redesign.

To carry out the validation of the ergonomic redesign in the gown sewing workstation, the application of this redesign was carried out in the production lines under the study of the research. In each of the redesigned workstations, significantly similar data was obtained, however, it is not statistically possible to obtain the values of central tendency and variability, since the particularities of each station cause the redesign to generate different impacts on the comparative parameters of the validation.

Consequently, the validation is based on the analysis of the impact of the redesign on each of the workstations, taking as a positive acceptance criterion the fact that all the redesigned stations were improved in the three aspects compared in the validation. Associated risk level, operating cycle time, and production volume.

Table 2 shows a comparison of workstation 59, before and after the ergonomic redesign was applied. It establishes the differences obtained in terms of worker risk level, operating cycle time, and level of parts produced.

Table 2: Comparison of results before and after the ergonomic redesign of the sewing workstation of disposable gowns.

	Estación de trabajo antes del rediseño ergonómico	Estación de trabajo rediseñada	Diferencia
Riesgo de trabajo: Valorado con ART – TOOL.	49.5 y 28.5 En los dos casos se requiere investigación adicional con urgencia	12 y 10 En los dos casos investigación adicional	Se disminuyo un nivel de riesgo en acuerdo con ART – TOLL.
Tiempo de ciclo operativo	14.3 segundo por pieza	12.7 segundos por pieza	1.8 segundos menos.
Piezas producidas	En 8.5 horas de trabajo se producían 2139 piezas.	En 8 horas de trabajo se producen 2267 piezas.	128 piezas y 30 minutos menos de labor.

Los resultados globales de la aplicación del rediseño ergonómico de la estación de trabajo cosido de batas desechables muestran un impacto positivo en las tres variables definidas en el comparativo. Nivel de riesgo, tiempo de ciclo operativo y volumen de producción. Lo que contempla en su proyección una menor posibilidad de que los operadores dedicados a este tipo de actividad desarrollen un Desorden Musculo Esquelético, el tiempo de ciclo operativo utilizado para realizar la actividad se vio disminuido y por ende el volumen de producción se incrementó.

6. CONCLUSIONS

The analysis of the specialized literature specifies with particular emphasis that the application of ergonomics is of vital importance and an urgent practice to be carried out when market conditions change and demand increases dramatically. In particular, workstations where there is peak demand for concentration, monotony, short cycle times, high times in uncomfortable working postures, must be kept under constant observation and with journals that include: ergonomic risk assessments of the workstation, opinions of the worker on ailments presented in the working day, absenteeism in the work area, and visits of the operator to the doctor.

The present investigation was developed in the workstations dedicated to the production of disposable medical material, especially to the fabrication of personal protective gowns. In these stations, the following points were considered for their analysis: the positions in which the worker carries out his activity, the force to be applied, and the duration of the working day, as this station is very demanding of concentration and monotonous.

In an interaction between the conditions described above and the rules, standards, and guidelines of occupational ergonomics, in the present investigation, a redesign of the workstation under study was carried out. This redesign was implemented in the production lines, based on a staff training process regarding the mechanisms and demands inquired by the new workstation, which allowed coupling of the staff to the workstation.

The validation of the redesign was carried out from the comparison of three variables considered in the study: the level of ergonomic risk associated with the workstation, the operating cycle time, and the production volume. This comparison was carried out by taking the data of each variable before and after the redesign of the workstation.

The results of the comparison in each of the redesigned workstations demonstrate a substantial improvement in each variable analyzed. As a whole, it is observed that ergonomic risk levels are reduced between one and two in accordance with what is stipulated by the Art tool ergonomic evaluation method, in cycle times there is a decrease between 10 and 15 percentage points, which is reflected in production volumes, reaching a prominent increase between 6 and 10 percent.

It is crucially significant to note that the operating hours in which the workers worked before the redesign stipulated 8.5 hours of work, time in which the operator, with two breaks, reached the production standard defined by the company. With the ergonomic redesign of the workstation, the total time of the working day is 8 hours, which allows the operator to comfortably reach the production standard.

The investigative work assesses the importance of applying the ergonomic guidelines in the workstations dedicated to the sewing of disposable gowns when defining the observable improvements in the operational results of the entity. However, the greatest emphasis given in the assessment is on reducing the ergonomic risks that occur in this type of workstation, which in its final projection impacts an improvement in the worker's quality of life.

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HEAT STRAIN IN CONSTRUCTION WORKERS

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Resumen: Una de las ocupaciones más peligrosas es el sector de la construcción (Wang et al., 2015). Los cambios en la tecnología y el desarrollo industrial y en general la modernidad habían llevado a los seres humanos a la exposición a factores relacionados con la física, química, entre otros centrados en la ergonomía, como el calor y la temperatura (Amiri et al., 2015). El estrés por calor es un factor que es un problema de salud en lugares donde las temperaturas excesivas y donde las personas trabajan sin ninguna precaución. Muchas ocupaciones al aire libre están relacionadas con el estrés térmico, como la construcción, el acero, la petroquímica, el vidrio, la agricultura y las industrias textiles; en este sector el equilibrio térmico humano es flojo y el estrés térmico está presente (Dehghan et al., 2015; Farhang Dehghan et al., 2015). El estrés por calor es un problema importante de seguridad y productividad que puede conducir a enfermedades por calor (Al-Bouwarthan et al., 2019). Varios estudios han propuesto métodos para evaluar el estrés térmico (Zare et al., 2020) que se basan en condiciones ambientales como la Temperatura Global de la Bombilla Húmeda (WBGT), el límite de trabajo térmico (TWL) y tablas de índice de calor como Humidex (Kakaei et al., 2019). Se seleccionó el cuestionario Heat Strain Score Index (HSSI) para comprender las respuestas perceptivas de los trabajadores de la construcción a la tensión térmica. El estudio se realizó en la ciudad de Hermosillo, Sonora, México. Esta escala incluye cuestiones subjetivas relacionadas con el estrés por calor como la sensación térmica y de humedad, la intensidad del sufrimiento de calor, sudoración, de sed. En este estudio participaron quince trabajadores de la construcción durante un período de 5 semanas continuas. El cuestionario fue respondido por los trabajadores, de lunes a sábado en cada semana. El propósito de este estudio fue evaluar la percepción emocional de la tensión térmica en los trabajadores de la construcción. Los resultados generales revelan que los trabajadores de la construcción refieren un alto índice de tensión térmica. Se realizaron dos análisis de varianza para la media de HSSI con factores de semana y día. Los resultados revelan que la media del índice HSSI difiere entre los días y es igual para las semanas. El histograma de HSSI revela una distribución normal de medias. La media de HSSI representa un alto valor del índice HSSI para los trabajadores de la construcción.

Palabras clave: calor, strain, construcción, trabajadores, evaluación.

Relevancia para la ergonomía: Este estudio nos muestra el potencial de la intervención ergonómica en actividades de construcción y diseño de estaciones de trabajo para mejorar la forma de realizar la tarea, lo que podría conducir a mejorar las condiciones de trabajo a altas temperaturas.

Abstract:. One of the most hazardous occupations is the construction working sector (Wang et al., 2015). The changes in technology and industrial development and in general the modernity had conducted to humans in the exposure to factors related to physical, chemical among other focused in ergonomics, such heat and temperature (Amiri et al., 2015). Heat stress is a factor which is a health problem in places where excessive temperatures and where people work without any precaution. Many outdoor occupations are related to heat stress, such construction, steel, petrochemical, glass, agriculture and textile industries; in this sector human thermal balance is loose and the heat stress is present (Dehghan et al., 2015; Farhang Dehghan et al., 2015). Heat stress is an important safety and productivity issue that can lead to heat illness (Al-Bouwarthan et al., 2019). Several studies have proposed methods for assessing heat stress evaluation (Zare et al., 2020) which rely on environmental conditions such as Wet Bulb Global Temperature (WBGT), thermal work limit (TWL) and heat index tables such as Humidex (Kakaei et al., 2019). It was selected the Heat Strain Score Index (HSSI) questionnaire to understand the perceptual responses of construction workers to heat strain. The study was carried out in the city of Hermosillo, Sonora, México. This scale includes subjective questions relating to heat stress such as thermal and humidity sensation, intensity of suffering from heat, sweating, of thirst. This study involved fifteen construction workers for a period of 5 continuous weeks. The questionnaire was self-answered by workers from Monday to Saturday in each week. The purpose of this study is to assess the emotional perception of heat strain in construction workers. General results reveal that construction workers refer a high heat strain index. ANOVA Tests for the effects weeks and days, reveals that HSSI index mean differs between the days and is equal for the weeks. HSSI histogram reveal a normal distribution of means. Mean of HSSI represent a high value of HSSI.

Keywords. Heat, strain, construction, workers, assessment.

Relevance to Ergonomics: This study shows us the potential scope for the ergonomics intervention in construction activities and workstation design to improve the way of performing the task, which could lead to improve working conditions under high temperatures.

1. INTRODUCTION

One of the most hazardous occupations is the construction working sector (Wang et al., 2015). The changes in technology and industrial development and in general the modernity had conducted to humans in the exposure to factors related to physical, chemical among other focused in ergonomics, such heat and temperature (Amiri et al., 2015). Heat stress is a factor which is a health problem in places where excessive temperatures and where people work without any precaution. Many outdoor occupations are related to heat stress, such construction, steel, petrochemical, glass, agriculture, and textile industries; in this sector human thermal balance is loose and the heat stress is present (Dehghan et al., 2015; Farhang Dehghan et al., 2015).

Efforts have been realized to reduce occupational injuries and fatalities in the construction industry (Kong et al., 2018). Ergonomic risk factors such as repetitive movements and lifting, awkward postures are a concern in the construction industry (Antwi-Afari et al., 2017 a). Besides these ergonomics risks, the construction operations are developed with manual tasks under very high climatic conditions that elevate the metabolism rate and increase body heat. When the amount of heat cannot be dissipated, a safety concern arises and could lead to health complications (Jia et al., 2019).

According to Petitti et al. (2013), about 17.1% of death in the construction sector are related to heat factors, in the state of Arizona, USA. About 36.8% of occupational heat-related deaths occurred in the construction industry in the United States (Gubernot et al., 2015). This condition is observed all over the world, we can find the same situations in the Middle East (Al-Bouwarthan, Quinn, Kriebel and Wegman (2019), Africa (Nunfam et al., 2019). Many factors and climatic conditions such as humidity affect the health illnesses in this sector, as well as global warming and heat waves which potentially will increase shortly. All these conditions encourage the need for assessments of heat stress at job sites.

Heat stress exposure could have different responses from workers, some of them are more susceptible to it than others (Pradhan et al., 2013). The exposition to heat stress implies environmental external stress, then the body attempts to maintain heat balance through thermoregulatory mechanisms such body core temperature, skin temperature and heart rate. Exposure to high temperature can cause health problems such heat stroke, cramps, and heat syncope (Inaba et Mirbod, 2007)). Those symptoms of heat exposure could increase the risk of accidents and decrease the work productivity (Gotshall et al., 2001). It has been demonstrated that the perceived quality of the physical environment which includes temperature has an impact on workers attitudes and work satisfaction (Lee et al., 2005). The continuous interaction between workers and their surroundings produces physiological strain in them, that could lead to discomfort and have effects on productivity, as well as on health of workers. (Parsons KC, 2000). Heat strain is a physiological response to heat stress, which involves the core and skin temperatures and heart rate (Givoni and Golman, 2006).

Heat stress is defined as the sum of the metabolic and environmental heat minus the heat dissipated from the body (Jacklitsch et al., 2016). Heat stress has received much attention in construction workers (Varghese et al., 2020).

Heat stress is an important safety and productivity issue that can lead to heat illness (Al-Bouwarthan et al., 2019). Several studies have proposed methods for assessing heat stress evaluation (Zare et al., 2020) which rely on environmental conditions such as Wet Bulb Global Temperature (WBGT), thermal work limit (TWL) and heat index tables such as Humidex (Kakaei et al., 2019).

It was selected the Heat Strain Score Index (HSSI) questionnaire to understand the perceptual responses of construction workers to heat strain. The study was carried out in the city of Hermosillo, Sonora, México. This scale includes subjective questions relating to heat stress such as thermal and humidity sensation, intensity of suffering from heat, sweating, of thirst. This study involved fifteen construction workers for a period of 5 continuous weeks. The questionnaire was self-answered by workers from Monday to Saturday in each week. The purpose of this study is to assess the emotional perception of heat strain in construction workers.

2. OBJETIVES

The following research objective was outlined:

To assess the observational perception of heat strain in construction workers in the city of Hermosillo, Sonora, México.

To understand how heat perception evolves through the days and the weeks of study.

3. METHODOLOGY

3.1 Study design and participants

A cross-sectional study was performed during five-week period in the city of Hermosillo, Sonora among construction workers from five construction sites. The size of the participant in this study is (N=15). Participants were excluded if they were currently undergoing medical treatment. Approval of the study was obtained from the Ethics Committee from Construction companies. Participants received information of the study goals and after this, workers who agreed to participate, signed a consent term. Participants were free to withdraw from the study at any time and were provided with their individual study results. Data were collected during six days of the week.

3.2 Procedure

A HSSI questionnaire was supplied to each participant every day during the period of study, the questionnaire was self-answered.

3.3 Data analysis

Data processing and analysis regarding to sociodemographic information of participants and HSSIQ is briefly described below:

3.3.1 Sociodemographic information of participants

Average and standard deviation of workers age, height and weight was calculated.

3.3.2 HSSIQ data analysis

Two tasks were considered during the study: the material handling that involved loading and unloading wheelbarrow with concrete mix and the roofing preparation which involves tasks such as hammering, attaching, and adjusting multiple elements. The HSSI questionnaire was answered after the first four hours of total day work. HSSI index was calculated for each day of the week and worker. An ANOVA test was performed to compare HSSI means through the days and through the weeks. HSSI indexes were calculated to define the heat strain risk zones.

3.3.3 HSSI Index mean analysis

An ANOVA test with a=0.05 was performed to know how the HSSI index developed through the days and through the weeks. It was applied to HSSI means the Duncan multiple range test to know the subsets of means.

3.3.4 HSSI index Frequency and histogram

Overall results of HSSI displayed through a histogram to know the general performance of index over the weeks.

4. RESULTS

4.1 Sociodemographic information of participants

This study included 24 construction workers, from which nine participants (37.5%) were excluded due to participation withdrawal (N = 7) or medical treatment (N = 2), resulting in a study sample of 15 participants (age 32.78 ± 3.85 years, men height 1.71 ± 5.37 cm and weight of 75.6 ± 5.36 kg).

4.2 HSSI Index mean ANOVA analysis

According to ANOVA test for the mean of HSSI, effect weeks (Table 1), significance level of test was 0.308 and p-value is 0.05, which tell us there is sufficient evidence to say that HSSI mean is equal through the weeks. It was found that self-reported HSSI Index mean is equal through the weeks, this result could be explained due the fact that the questionnaire was answered in the same period of day for all weeks and all workers were under the same conditions. It is interesting point out that, results reveal personal subjective perception of heat strain. The answers for questionnaire were homogeneous through the study.

Table 1 Variance Test of the mean of HSSI, Effect: Weeks

Mean of HSSI, Effect: Weeks					
Source	Sum of squares	df	Mean Square	F	Sig.
Between weeks	28.137	4	7.034	1.204	0.308
Within weeks	2599.200	445	5.841		
Total	2627.337	449			

Table 2 shows the results of ANOVA test for mean of HSSI, effect days. According to results, significance level for this test is 0.007 and p-value 0.05, there is sufficient evidence to say that HSSI mean is different between the days.

Table 2 Variance Test of the mean of HSSI, Effect: Days

Mean of HSSI, Effect: Days					
Source	Sum of squares	df	Mean Square	F	Sig.
Between weeks	92.879	4	18.756	3.254	0.007

Within weeks	2534.458	445	5.708	
Total	2627.337	449		

A post hoc test was made using the Duncan Multiple range (Table 3) test for the HSSI mean, results reveal two data subsets: HSSI mean is equal for days 1,2,4, 6 and for the second subset, HSSI mean is equal for days 2,3, and 5.

Table 3 Duncan Multiple Range Test for HSSI mean

Day	N	Subset for alpha = 0.05	
		1	2
1	75	19.518	
6	75	19.518	
4	75	19.623	
2	75	20.189	20.189
5	75		20.439
3	75		20.636

4.3 HSSI index Frequency and histogram

Figure 1 shows the histogram of HSSI, mean is 19.988, standard deviation is 2.419, which reveals a high value of HSSI, and according to value scale of HSSI, this means that there is danger level of Heat strain in construction workers.

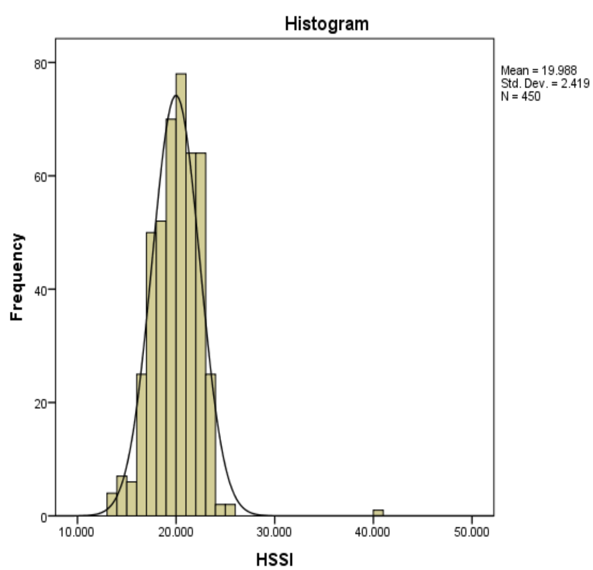

Figure 1 HSSI Index Histogram

5. DISCUSSION/CONCLUSIONS

Besides the results obtained from HSSI index, there are several factors that affect and individual response to heat strain, such as individual habit, acclimatation state and fitness level. In the other side, when environmental temperatures are higher, the body gains heat strain. Although physical activity, environmental conditions such as humidity, wet temperature and dry temperature define level of strain and physiological response, if workers do not use protection against heat exposure, this could be considered a risk to the health and comfort at workplaces.

The HSSI questionnaire is subject to various interpretations involving random and systematic bias that can affect the results of the heat strain assessment. This deficiency encourages the need for a more objective way of evaluating the heat strain. Study was limited to low sample size, due to the inconveniences of pandemics during the last and present year. General results reveal that construction workers refer a high heat strain index. ANOVA Tests for the effects weeks and days, reveals that HSSI index mean differs between the days and is equal for the weeks. HSSI histogram reveal a normal distribution of means. Mean of HSSI represent a high value of HSSI. Heat strain has been assessed in different environments with the purpose of controlling heat stress to get human thermal comfort (Aliabadi et al. 2014, Mohan et a., 2014). The Governmental Industrial Hygienist (ACGIH) and the International Organization for Standardization (ISO) have developed heat stress guidelines and standards (Sheffield et al. 2013). Forty-five indices have been developed under the auspicious of ISO (Dehghan et al., 2015; Monazzam et al., 2015; Vatani et al., 2016). Wet bulb globe temperature and effective temperature are experimental indices developed because of laboratory-based studies, which considers environmental variables. (Clantary and Sadeghi Aliabadi, 2005). HSSI index and index of thermal stress (ITS) are rational indices which has been derived from equations. Another rational index that could be a good option to perform the study was the Universal Thermal Climate Index (UTCI) which assess the heat strain in outdoor spaces. This index assesses the heat in outdoor places and its calculi are based on climatic variables, it has been used to promote urban plans and it is focused on the effect of climatic variables on heat stress ((Broede et al., 2013). Its major advantage is the sensitivity to variations in environmental variables such average radiation temperature, temperature, humidity, and air velocity (Blazejczyk et al., 2012; Kampmann et al., 2012). This parameter could be a good candidate to be applied in this city, however, the study performed in this investigation had as a purpose, to understand the evolution of heat strain perception thought the weeks and the days of study.

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PREVALENCE OF MUSCULOSKELETAL SYMPTOMPS AND RISK FACTORS AMONG SCULPTORS

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Resumen: La salud ocupacional es una preocupación a nivel mundial. México es un país en desarrollo donde hay varias pequeñas empresas dedicadas a actividades de trabajo artesanal. Algunas de estas empresas son propiedad y gestionadas por profesionales del arte tales escultores. Según Loewenson (2002), en los países desarrollados existe un escaso conocimiento de la salud ocupacional. Los síntomas musculoesqueléticos (SM) se han convertido en un problema de salud tanto en países desarrollados como en desarrollo (Jadhav et al., 2019). Mrunalini y Logeswari (2016) indican que los escultores pertenecen a un sector de trabajo informal que sufre de problemas musculoesqueléticos y que, por su naturaleza, no son considerados dentro de los esquemas de salud y protección ocupacional.

Meena et al. (2011) realizaron estudios en trabajadores artesanales reportando que en estas tareas los principales problemas de salud están asociados con molestias en el cuello, hombros, codos, muñecas, espalda baja y alta, así como en rodillas y tobillos. Los datos sobre la incidencia de SM son difíciles de obtener en los países subdesarrollados para el sector laboral de los escultores dada la informalidad de este (Mukhopadhyay y Srivastava, 2010), (Niu, 2010), (Khan y Singh, 2015), (Meena et al., 2015) (Nankongnab et al., 2015). La literatura sobre la prevalencia de síntomas musculoesqueléticos y factores de riesgo entre los escultores es escasa. Para abordar esta brecha de investigación, este estudio tiene como objetivo investigar los SM por segmento corporal y los factores de riesgo asociados, en escultores de quince pequeñas empresas de arte en la ciudad de Hermosillo, Sonora, México, a través del cuestionario adaptado y traducido Cornell Musculoskeletal Discomfort (ACMDQ) y REBA (Rapid Entire Body Assessment). Se delinearon los siguientes objetivos de investigación: Evaluar la prevalencia de síntomas musculoesqueléticos en escultores a través del Cornell Musculoskeletal Discomfort Questionnaire (ACMDQ) adaptado. Evaluar los factores de riesgo ergonómicos en las tareas de escultor a través de Rapid Entire Body Assessment (REBA). Establecer la correlación entre los SM y las puntuaciones REBA. Se realizó un estudio transversal durante cinco semanas en la ciudad de Hermosillo, Sonora, entre escultores que trabajan en quince pequeñas empresas de arte. Se encontró que el 83% de los trabajadores experimentaron incomodidad al menos 1-2 veces en una semana, y el 15% reportó incomodidad en varias veces en un día. La gravedad del malestar fue de 65% para moderado a muy incómodo (68%). La intervención con trabajo fue 58% en modo leve y a interferencia sustancial fue 34%. Se encontró que hay un bajo coeficiente de Pearson en el proceso para correlacionar los índices CMQD y REBA. La prevalencia de SM se encontró alta, y los segmentos corporales más afectados fueron la parte baja de la espalda, el cuello y los hombros. Los resultados indican que todos los segmentos del cuerpo de los trabajadores de escultura se ven afectados durante su tarea. Los resultados sugieren la necesidad de formación y entrenamiento, que sin duda sería eficaz para reducir algunos de los factores de riesgo y la severidad de los SM.

Palabras clave: síntoma, musculoesquelético, evaluación, escultores.

Relevancia para la ergonomía: Este estudio nos muestra el potencial de la intervención ergonómica en el diseño de estaciones de trabajo para mejorar la forma de realizar la tarea en un sector laboral poco estudiado como es el de los profesionales de la escultura, lo que podría conducir a mejorar las condiciones de trabajo y reducir los riesgos ergonómicos.

Abstract : One serious concern at workplace around the world, is Occupational health. México is a developing country where there are several small enterprises dedicated to handicraft working activities. Some of these enterprises are owned and managed by art professionals such sculptors. According to Loewenson (2002), in developed countries there is a poor knowledge of occupational health. Musculoskeletal symptoms (MS) have become a health concern in both developed and developing countries (Jadhav et al., 2019). Mrunalini and Logeswari (2016) indicate that sculptors belong to an informal labour sector that suffers from musculoskeletal problems and that, given their nature, they are not considered within occupational health and protection schemes. Meena et al. (2011) conducted studies in artisanal workers reporting that in these tasks the main health problems are associated with discomfort in the neck, shoulders, elbows, wrists, lower and upper back, as well as in knees and ankles. Data on the incidence of DM are difficult to obtain in the underdeveloped countries for the sculptors' labor sector given the informality of this (Mukhopadhyay and Srivastava, 2010), (Niu, 2010), (Khan and Singh, 2015), (Meena et al., 2015) (Nankongnab et al., 2015). The literature on the prevalence of musculoskeletal symptoms and risk factors among sculptors is scant.

To address this research gap, this study aims to investigate the MS by body segment and risk factors in sculptors from fifteen small art business in the city of Hermosillo, Sonora in México, through the adapted and translated Cornell musculoskeletal Discomfort questionnaire (ACMDQ) and REBA (Rapid Entire Body Assessment). The following research objectives were outlined: To assess the prevalence of musculoskeletal symptoms in sculptors through the adapted Cornell Musculoskeletal Discomfort Questionnaire (ACMDQ). To assess the ergonomic risk factors in sculptor tasks through Rapid Entire Body Assessment (REBA). To establish the correlation between the self-reported MS and the REBA scores. A cross-sectional study was performed during five-week period in the city of Hermosillo, Sonora among sculptors who work in fifteen small art business. It was found that 83% of the workers experienced discomfort a least 1-2 times in a week, and 15% reported discomfort in several times in a day. The severity of discomfort was 65% for moderate to very uncomfortable (68%). Intervention with work was 58% in slightly mode and to substantial interference was 34%. It was found that there is a low Pearson Coefficient in the process to correlate CMQD and REBA indexes. The prevalence of MS was found high, and the most affected body segments were the lower back, neck, and shoulders. Findings indicate that all body segments of workers are affected during their task. It is evident the need for training, which certainly would be effective in reducing some of risk factors and severity of MS.

Keywords. Musculoskeletal, symptom, prevalence, sculptor.

Relevance to Ergonomics: This study shows us the potential scope for the ergonomics intervention in workstation design to improve the way of performing the task, which could lead to improve working conditions and reduce ergonomics risks.

1. INTRODUCTION

One serious concern at workplace around the world, is Occupational health. México is a developing country where there are several small enterprises dedicated to handicraft working activities. Some of these enterprises are owned and managed by art professionals such sculptors. According to Loewenson (2002), in developed countries there is a poor knowledge of occupational health. Therefore, Sain and Meena (2016) consider that improving the working conditions have an impact on quality of life of the workers.

Musculoskeletal symptoms (MS) have become a health concern in both developed and developing countries (Jadhav et al., 2019). Oakman et al. (2019)

indicate that MS have impact on individuals around across the world. MS can affect the individual's life as well as physical and mental well-being (Woolf et al., 2012). According to the Bureau of Labor in U.S. MS and risk factors are related to 31.8% of all injuries (Goode, 2019). Prevention of MS is a factor on increasing and ensuring occupational health on workers (Kogi et al.,2003).

Mrunalini and Logeswari (2016) indicate that sculptors belong to an informal labour sector that suffers from musculoskeletal problems and that, given their nature, they are not considered within occupational health and protection schemes. Meena et al. (2011) conducted studies in artisanal workers reporting that in these tasks the main health problems are associated with discomfort in the neck, shoulders, elbows, wrists, lower and upper back, as well as in knees and ankles.

Gangopadhyay et al. (2003), AhmadWani and Jaiswal (2011), point out that workers in the informal sectors perform tasks in which there are risk factors for MS, such as the repetition of movements, load handling, as well as non-neutral postures, all of which cause stress that can lead to muscular and skeletal injuries. Much work has been focused on occupational health in handicraft sector such carpet, shoemaking, and textile. The epidemiological literature on work-related MS is extensive and the importance of occupational ergonomic factors for their occurrence has been demonstrated. However, the informal labor sector that houses sculptors is one of those that has had not only little information about the prevalence of musculoskeletal disorders, but a limited intervention of ergonomics (Mrunalini and Logeswari, 2016). Melzer and Iguti (2010) reported that among sculptors there is a prevalence of 38.5% of musculoskeletal pain, with the most affected parts being the legs (35%), and the back (33%), followed by the neck (9%), shoulders (9%), hands and wrists (9%), elbows (3.5%) and chest region (1.5%).

According to Shakerian et al. (2016) MS prevail in certain industrial jobs and in certain occupations, high-risk sectors include nursing, air transportation, mining, food industry, leather tanning, heavy and light manufacturing. Sahu et al. (2013) indicate in the profession of sculpture there are risk factors of DM similar to those observed in tasks of construction workers, health workers, stevedores, stockists, among others, all of which predispose the possibility of musculoskeletal disorders. Data on the incidence of DM are difficult to obtain in the underdeveloped countries for the sculptors' labor sector given the informality of this (Mukhopadhyay and Srivastava, 2010), (Niu, 2010), (Khan and Singh, 2015), (Meena et al., 2015) (Nankongnab et al., 2015). In our country the situation is similar, since in the IMSS(Instituto Mexicano de Seguridad Social) the affiliated workers correspond to the sectors of construction, transformation, transport and communications (http://www.imss.gob.mx/prensa/archivo//2021107/296, consulted in September 21, 2021) The literature on the prevalence of musculoskeletal symptoms and risk factors among sculptors is scant. To address this research gap, this study aims to investigate the MS by body segment and risk factors in sculptors from fifteen small art business in the city of Hermosillo, Sonora in México, through the adapted and translated Cornell musculoskeletal Discomfort questionnaire (ACMDQ) and REBA (Rapid Entire Body Assessment).

2. OBJETIVES

The following research objectives were outlined:

To assess the prevalence of musculoskeletal symptoms in sculptors through the adapted Cornell Musculoskeletal Discomfort Questionnaire (ACMDQ).

To assess the ergonomic risk factors in sculptor tasks through Rapid Entire Body Assessment (REBA).

To establish the correlation between the self-reported MS and the REBA scores.

3. METHODOLOGY

3.1 Study design and participants

A cross-sectional study was performed during five-week period in the city of Hermosillo, Sonora among sculptors who work in fifteen small art business. The size of the participant in this study is (N=75). Participants were excluded if they were pregnant or were currently undergoing medical treatment. Data were collected during the afternoon period. Approval of the study was obtained from the Ethics Committee at the Hermosillo Association of Plastic Artists. Participants received information of the study goals and after this, sculptors who agreed to participate, signed a consent term. Participants were free to withdraw from the study at any time and were provided with their individual study results.

3.2 Procedure

Following informed consent, to gather information about short- and long-term MS symptoms, participants were provided with adapted Cornell Musculoskeletal Discomfort Questionnaire and MS data was collected among workers in terms of frequency, severity, and interference with work. English version of questionnaire was translated to Spanish. The reliability of the questionnaire was tested using Kappa coefficients of 0.81-0.92. Participants were assisted in filling the questionnaire. The ACMDQ was composed of four sections: sociodemographic information, frequency, severity, and interference with work. The weights of each last three sections were assigned according to the ACMDQ scoring (Table 1). The score assigned to each section was calculated using the following equation:

$$\mathrm{F = S = I} = \sum_{\mathrm{I}=0}^{\mathrm{n}} \mathrm{niWi}$$

Where:
F= Frequency score
S= Severity score
I= Interference score
n_i= total number of samples with specific MS
W_i=Weight of corresponding symptoms

Total discomfort score: F*S*I

The multiplication of frequency, severity, and interference scores is the total discomfort score of the specific worker's body segment.

Table 1 Weightage for frequency, severity, and interference

Frequency	Severity	Interference
0.0 = Never	1= Slightly uncomfortable	1= Not interfered
1.5= 1-2 times per week	2= Moderate uncomfortable	2= Slightly interfered
3.5 = 3-4 times per week	3= Very uncomfortable	3= Substantially interfered
5.0= once in a day		
10= several times every day		

The REBA method (Hignett and Mc Atamney, 2000) was used through a direct observational technique for evaluating the working posture at the workplace. Nagaraj et al. (2019) consider REBA is an observational method to assess the body segments for postural and biomechanical loading. According to Hignett and Mc Atamney (2000), REBA is applicable to unpredictable working postures, like those of sculptors. It was selected the posture of ceramic mix kneading, as a critical activity based on their perceived severity due to awkward back posture during execution and frequency. The kneading activity implies movement of both hands with awkward working postures where neck and trunk are inclined.

3.3 Data analysis

Data processing and analysis regarding to sociodemographic information of participants, ACMDQ and REBA scores is briefly described below:

3.3.1 Sociodemographic information of participants

Average and standard deviation of sculptors age was calculated, for both women and men. Marital status and education were also considered.

3.3.2 ACMDQ score data analysis

For the ceramic kneading activity, it was calculated the frequency of discomfort in the body segments, also the severity and the extent to which discomfort interfered with work. The prevalence of MD in a week was calculated for the total of self-reported data from sculptors.

3.3.3 REBA Score analysis

The grand REBA score was obtained with score A and score B for indicating the risk level of the posture an suggest action level for the improvement. Frequency and percentage of the participants with the REBA scores were calculated for each body segment.

3.3.4 REBA and ADMDQ scores correlation

The dependence of REBA and CMDQ scores was calculated thought the Pearson correlation coefficient.

4. RESULTS

4.1 Sociodemographic information of participants

This study included 83 sculptors, from which eight participants (9.2%) were excluded due to participation withdrawal (N = 5) or medical treatment (N = 3), resulting in a study sample of 75 participants, 23 women and 52 men (women age 38.35 ± 2.75 years, men 42.25 ± 3.87 years).

4.2 ACMDQ data analysis

It was found that 83% of the workers experienced discomfort a least 1-2 times in a week, and 15% reported discomfort in several times in a day. The severity of discomfort was 65% for moderate to very uncomfortable (68%). Intervention with work was 58% in slightly mode and to substantial interference was 34%. Prevalence was calculated from the ACMDQ score for each body segment (Table 2):

Table 2 Musculoskeletal symptoms prevalence

Body segment	Never	1-2 Times last week	3-4 Times last week	Once every day	Several times every day
Neck	1.316	3.947	14.474	36.842	43.421
Shoulder R	1.316	7.895	10.526	53.947	26.316
Shoulder L	0.000	9.211	13.158	59.211	18.421
Upper Back R	0.000	2.632	38.158	39.474	19.737
Upper Back L	0.000	7.895	30.263	42.105	19.737
Upper arm R	0.000	27.632	32.895	34.211	5.263
Upper arm L	2.632	21.053	34.211	32.895	9.211
Lower back R	3.463	27.701	45.014	43.283	12.119

Lower back L	0.000	18.421	48.684	22.368	10.526
Forearm R	6.579	42.105	25.000	22.368	3.947
Forearm L	7.895	44.737	25.000	17.105	5.263
Wrist R	7.895	46.053	25.000	21.053	0.000
Wrist L	3.947	53.947	25.000	14.474	2.632
Hip/Buttocks R	22.368	40.789	19.737	17.105	0.000
Hip/Buttocks L	22.368	31.579	27.632	18.421	0.000
Thigh R	10.526	53.947	27.632	7.895	0.000
Thigh L	5.263	44.737	42.105	7.895	0.000
Knee R	3.947	46.053	38.158	6.579	5.263
knee L	3.947	46.053	38.158	6.579	5.263
Lower leg R	3.947	42.105	28.947	19.737	5.263
Lower leg L	5.263	39.474	38.158	17.105	0.000

According to Table 2, there is a high prevalence of MS in various body segments. Results reveals that 43.421% of MS has been found in several times a day. It was observed that 53.947% of MS in right shoulder occurs once every day and a 59.211% in left shoulder. Upper right back (39.474%) and upper left back (42.105%) occurred once every day.

4.3 REBA Score analysis

REBA results were arranged according to body segments: the back score of 87% of participants was between 2 and 3, which tell us participants were required to lean forward during kneading activity. The neck score was between 1 and 2, indicating the neck of participant was in a tilting position between 15 and 30 grades while performing their task. The upper arm score for the 89% of participants was between 2 and 3. The leg score for all participants was 1, which means were in a seat position. The lower arm score was 2, meaning that participants were sightly abducted.

Figure 1 presents a box plot graph for REBA scores, maximum value was 15, minimum value was 4, 3rd quartile is 11.75 and first quartile is 8. REBA scores revealed that level actions were between 3 and 4 which show that high scores are related to the kneading task of sculptors. The kneading task demands awkward postures. Musculoskeletal symptoms are highly prevalent among neck, shoulder, and back segments.

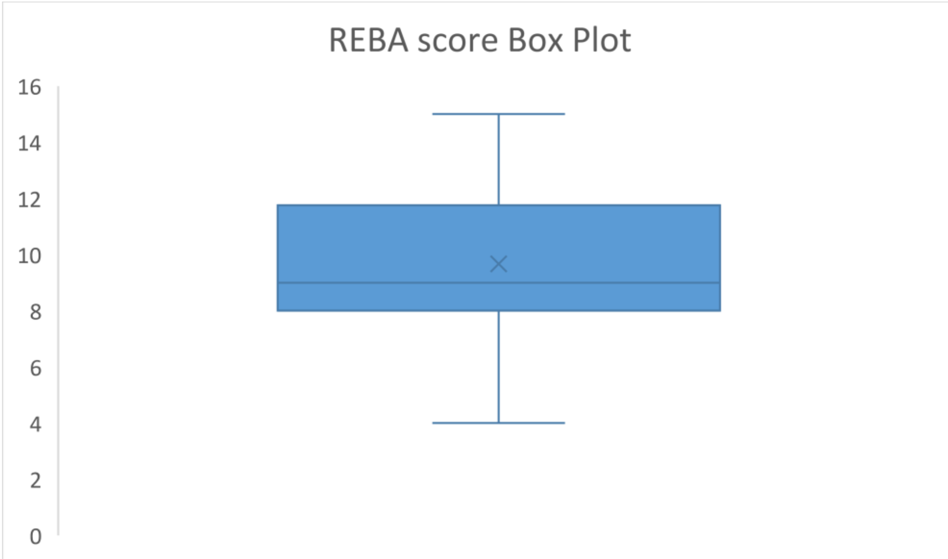

Figure 1: REBA Score Box Plot

4.4 REBA and ADMDQ scores correlation

According to results showed in table 3, it was found that there is a low Pearson Coefficient in the process to correlate CMQD and REBA indexes. There was performed the correlation test for each body segment assessed. They were also tested the hypothesis regarding to the linearity of linear regression model, but results showed that none of test were passed. Highest values of R squared were found for neck, shoulder, and upper arm, but they were not significative in terms of the test. Similar studies (Takala et al., 2020), revealed that validity of data insights, cannot be reached due that results reveals that a poor relationship was found between MS and related REBA scores.

The Pearson correlation coefficient indicates the strength of a linear relationship between two variables, but its value generally does not completely characterize their relationship.

Table 3 Pearson Coefficient: CMQD and REBA indexes

Body segment	R squared
Neck	0.0384
Shoulder R	0.0144
Shoulder L	0.0293
Upper Back R	0.0027
Upper Back L	0.0168
Upper arm R	0.0224

Upper arm L	0.0151
Lower back R	0.0106
Lower back L	0.0053
Forearm R	0.0041
Forearm L	0.0027
Wrist R	0.0008
Wrist L	0.0058
Hip/Buttocks R	0.0481
Hip/Buttocks L	0.0301
Thigh R	0.0002
Thigh L	0.0333
Knee R	0.0076
knee L	0.0095
Lower leg R	0.0004
Lower leg L	0.0481

5. DISCUSSION/CONCLUSIONS

The present study assessed the risk factors and the prevalence of MS among sculptors. The prevalence of MS was found high, and the most affected body segments were the lower back, neck, and shoulders. Findings indicate that all body segments of workers are affected during their task. It is evident the need for training, which certainly would be effective in reducing some of risk factors and severity of MS.

Rathore et al. (2020) found that variables related to working postures collected through the REBA method and musculoskeletal symptoms for the different body segments were significantly correlated through regression models, however in this study, results showed that there is a poor correlation between self-reported MS and REBA scores. Other authors (Kee and Karwowkski, 2007), (Sanchez-Lite et al., 2013) investigated the relationship between the prevalence of MS using questionnaires and assessment results.

The validity of an ergonomic risk assessment could be appraised assessing how well its risk is associated with the MS (Takala et al., 2020), however in this study such validity can not be reached due that results that reveals that a poor relationship was found between MS and related REBA scores. In other studies (Rathore et al., (2020), Yazdanirad et al. (2018)) that used subjective MS symptom data obtained from Cornel Musculoskeletal Discomfort Questionnaire, found that objective and subjective MS do not necessarily correlate. Coury and Padula (2002) points out that REBA do not assess the work-related musculoskeletal load which is a main factor in the development of MS, this asseveration supports our findings, where a low correlation was found between MS and REBA scores.

According to Serranheira et al. (2008) the risk factor associated to MS are related to individual, activity and psychosocial aspects such gender, age, anthropometric characteristics, and lifestyle. This factor contributes to the occurrence of MS. Other authors (Corbeil et al, 2013) demonstrated that, when performing tasks that involve manual lifting and handling of loads, overweight individuals are prone to affect the structures of the back, that could lead to the risk of musculoskeletal injury. In this study they were not took in account the induvial and psychosocial aspects that potentially affect the development of MS. There is an opportunity for new research approaches that could include those factors to the purpose of getting a more robust information regarding MS and their associated musculoskeletal disorders.

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BIOMECHANICAL ANALYSIS OF LIFTING TASK AMONG CONSTRUCTION WORKERS

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Resumen: La seguridad de los trabajadores de la construcción ha sido una preocupación entre las empresas de construcción de todo el mundo (Zhang y Chen, 2015). Los síntomas trastornos musculoesqueléticos (TME) son una enfermedad ocupacional de alta prevalencia que afecta a los trabajadores manuales, como los de la construcción (Stattin y Jävholm, 2005). Schneider (2001) informa que un 37% de todas las lesiones son TME. Los trabajadores de la construcción están expuestos a factores de riesgo físicos elevados, como posturas incómodas y levantamiento de pesas que están relacionados con los TME en esas actividades (Jaffar et al., 2011).

Según Grzywi (2016) en la industria de la construcción, los factores de riesgo más importantes de los TME están relacionados con las actividades de elevación y las posturas incómodas, debido a que esto requiere mantener una alta fuerza muscular durante períodos prolongados de tiempo. Cuando las tareas de levantamiento de cargas se prolongan y son frecuentes; se pueden observar varios efectos, como fatiga muscular y malestar, esto aumenta el riesgo de desarrollar TME (Straker, 2003). En este estudio se ha realizado un análisis biomecánico de la postura de levantamiento de cargas de una cubeta de hormigón, en la tarea de construcción de techos de viviendas. Se evaluaron cinco trabajadores de la construcción quienes refieren un buen estado de salud empleando un modelo biomecánico estático para calcular el momento de fuerza generado en el centro de rotación ubicado en la espalda baja. Dos esfuerzos mecánicos se compararon, uno el generado para la actividad de levantamiento en condiciones reales y el otro con el momento de fuerza generado durante una postura de elevación ideal para determinar si hay una diferencia en los momentos de fuerza. Se empleó la técnica de intervalos de confianza para comparar medias con varianzas diferentes con un nivel de confianza de 95%. Una diferencia podría ser una señal del riesgo de desarrollar un TME en la tarea de elevación. Los resultados revelaron que hay una diferencia entre los momentos de fuerza generados en las tareas de elevación ideales y reales. Los factores de riesgo observados en esta tarea de construcción pueden contribuir a comprender los TME para mejorar la salud y la productividad de los trabajadores. Aunque las conclusiones apoyan la eficacia de la aplicación de posibles intervenciones para reducir los riesgos de las TME, se observaron algunas limitaciones y, por lo tanto, es necesaria una investigación futura. Algunas de las recomendaciones para futuras investigaciones son considerar una muestra más grande de participantes para generar una evaluación y comparación más robusta entre las diferentes posturas de elevación y cómo éstas impactan en el riesgo de desarrollar TME. Además, se recomienda incluir a los trabajadores de la construcción que han acumulado una experiencia considerable de levantamiento repetitivo para ser evaluados (frente a los participantes novatos utilizados en este estudio). Otra cuestión importante es el efecto de factores de riesgo externos como la temperatura y la humedad durante las tareas de elevación repetitivas realizadas por los trabajadores de la construcción. Además de estas consideraciones, es importante decir que este estudio no ser generalizado a otras actividades de construcción, por lo que en futuras investigaciones pueden considerarse otros tipos de actividades de construcción.

Palabras clave: levantamiento, cargas, construcción, trabajadores, evaluación.

Relevancia para la ergonomía: Este estudio muestra el potencial de la intervención ergonómica en las actividades de construcción y diseño de estaciones de trabajo con el fin de mejorar las prácticas en el levantamiento de cargas y con ello reducir los riesgos de desarrollo de molestias musculoesqueléticas.

Abstract: The safety of construction workers has been a concern among construction companies all over the world (Zhang and Chen, 2015). Musculoskeletal symptoms disorders (MSDs) are a high prevalent occupational health that affects manual workers, such as the construction (Stattin and Jävholm, 2005). Schneider (2001) reports a 37% of all injuries are MSDs. Construction workers are exposed to elevated physical risk factors such awkward postures and lifting weights that are related to MSDs in those activities (Jaffar et al., 2011).

Accordingto Grzywi (2016) in construction industry, the most important MSDs risk factors are related to lifting activities and awkward postures, due that such requires maintaining high muscle force for extended periods of time. When lifting tasks are prolonged over the time, and are frequent; several effects can be seen, such muscular fatigue and discomfort, this increases the risk of developing MSDs

(Straker, 2003). In this study it has been done a biomechanical analysis of the lifting posture of concrete bucket load for the house roofing construction activity. Five healthy construction workers were assessed during the lifting activity using a static biomechanical model to calculate the force moment generated in rotation center located in the low back. The calculated force moment in the real lifting activity was compared against the force moment during an ideal lifting posture to determine if there is a difference in force strength moments. A difference could be a signal of the risk of developing a MSDs in the lifting task. Results revealed that there is a difference between the force moments generated in the ideal and real lifting tasks. The observed risk factors in this construction task can contribute to understanding MSDs to enhance worker health and productivity. Although the conclusions support the effectiveness of implementing potential interventions to reduce MSDSs risks, some limitations were observed, and hence future research is required. Some of the recommendations for future research are to consider a larger sample of participants to generate a more robust evaluation and comparison between the different lifting postures and how these impact on the risk of developing MSDs. Furthermore, experienced construction workers who have accrued considerable experience of repetitive lifting should be evaluated in any future study conducted (vis-à-vis the novice participants used in this study). Another important issue is to be considered is the effect of external risk factors such temperature and humidity during repetitive lifting tasks performed by construction workers. Besides these considerations, it is important to say that this study may not be generalized to other construction activities future research should consider different types of construction activities.

Keywords. Lifting, construction, workers

Relevance to Ergonomics: This study shows us the potential scope for the ergonomics intervention in construction activities and workstation design to improve the way of performing the lifting task, which could lead to improve working conditions and reduce risks of MSDs.

1. INTRODUCTION

The safety of construction workers has been a concern among construction companies all over the world (Zhang and Chen, 2015). A significant improvement has been done regarding construction safety (Seo et al., 2015). Much research has been focused on studies to improve construction worker's safety (Zaira and Hadikusumo, 2015). MSDs are a high prevalent occupational health that affects manual workers, such as the construction (Stattin and Jävholm, 2005). In the United States, MSDs have a prevalence of 32% of all injury and illness that lead to the absence from work (BLS, 2020). Schneider (2001) reports a 37% of all injuries are MSDs. Construction workers are exposed to elevated physical risk factors such awkward postures and lifting weights that are related to MSDs in those activities (Jaffar et al., 2011).

The Occupational Safety and Health Administration (OSHA), from USA, monitors workplace safety, and there is a similar organism in México. The attention to this matter from different sources has reduced the injury rate in the construction sector. However, the construction tasks are considered a high-risk area where musculoskeletal disorders (MSDs) are present (Want et al., 2016). Construction Industry has many activities such masonry work, concrete work, tile work and dry wall installation, where MSDsare present (Yan et al., 2017). All these activities have high physical demands, due that workers are exposed to force exertion, repetitive movements such as bending, twisting, vibration, and heavy lifting (Boschman et al., 2015). Accordingto Grzywi (2016) in construction industry, the most important MSDs risk factors are related to lifting activities and awkward postures, due that such requires maintaining high muscle force for extended periods of time. When lifting tasks are prolonged over the time, and are frequent; several effects can be seen, suchas muscular fatigue and discomfort, this increases the risk of developing MSDs (Straker, 2003).

In this study it has been done a biomechanical analysis of the lifting posture of concrete bucket load for the house roofing construction activity. Five healthy construction workers were assessed during the lifting activity using a static biomechanical model to calculate the force moment generated in rotation center located in the low back. The calculated strength force moment in the real lifting activity was compared against the force moment during an ideal lifting posture to identifythose lifting activities where moments exceed the moment value on an ideal lifting task. Confidence interval for comparing means with different standard deviation was used to determine differences between force moment means in both real and ideal lifting construction tasks. Five different weights were considered to perform de analysis and comparison of force moment means.

2. OBJETIVES

The following research objective was outlined:

To calculate the force strength moments generated during the lifting activity of construction workers in both ideal and real lifting conditions, considering five different weights.

To compare the force strength moment exerted between the ideal and the real lifting tasks in construction workers.

3. METHODOLOGY

3.1 Study design and participants

A cross-sectional study was performed during three-week period in the city of Hermosillo, Sonora among construction workers from one construction site. The size of the participant in this study was (N=5). Participants were excluded if they were currently undergoing medical treatment. Data were collected during thethree periods each day. Approval of the study was obtained from the Ethics Committee from Construction company. Participants received information of thestudy goals and after this, workers who agreed to participate, signed a consent term. Participants were free to withdraw from the study at any time and were provided with their individual study results.

3.2 Procedure

Biomechanical models are representations that allow us to understand conditions such as body postures and the efforts present in them. The comparison of the behavior of the model in the comfort state, with the actual behavior of the system under study, provides information to determine the interactions between the different elements that make up the system.

Postural biomechanical models are aimed to understand real situations, such as determining maximum loads in different positions, the appropriate size of tools, the configurations of workstations with less stress, for the purposes of this research, the postural biomechanical model is used to calculate the force strength moments in the lifting task of construction workers for five different weights. Not only the internal loads due to the body weight, are the only variables involved in the design of a model, the external loads and the postures that are acquired in the different tasks at industrial level, make it impossible to design laboratory experiments to simulate tasks and thus obtain information to design workstations, yet we cannot take a human to positions and limit loads, and that is why biomechanical models are used, which also allow interpolations and extrapolations to estimate the maximum capacity of a musculoskeletal system for both postures and loads, and thus establish specific design guides for workstations, especially in activities for which the biomechanical model is the only means of predicting potentially hazardous loads; for example, when lifting a load, which in a certain posture does not represent a danger to the lower back, however, with any variation of posture, combined with the internal loads and body weight, can represent a serious danger and damage to the musculoskeletal system.

For example, when lifting a load, which in a certain posture does not represent a danger to the lower back, however, with any variation of posture, combined with the internal loads and body weight, can represent a danger and damage to the musculoskeletal system.

A static biomechanical model (Fig 1) was defined to analyze the force moments for bothtwo conditions: the lifting weight task in the real situation and the same lifting weight under the ideal lifting posture. Participants were required to lift five different weights three times a day, and they were asked to lift the same weights under an ideal posture, that was carefully supervised. They were calculated force moments for both situations according to biomechanical model. The variables of this model, are the center of mass CM1 for the head, the center of mass CM2 for the arm, the center of mass CM3 for the forearm, the center of mass CM4 for the wrist, the center of mass CM5 for the trunk, the center of mass CM 6 for the segment of the thigh; head mass m1, forearm mass m2, arm mass m3, hand mass m4, trunk mass m5, thigh mass m6, length of head segment L1, length of arm segment L2, length of forearm segment L3, the length of the wrist segment, L4, length of the trunk segment L5, the length of the thigh segment L6, in addition to the external forces present in the task to be analyzed; moreover, the angles of inclination of the segments are considered: Θ1, head segment rotation angle, Θ2 arm rotation angle, Θ3 forearm rotation angle, Θ4 wrist rotation angle, Θ5 torso-waist inclination angle, Θ6 thigh inclination angle; angles all, measured from the segment and to the vertical opposite to the clock hands.

The force moments were calculated according to biomechanical model against rotation center CR4, as showed in figure 1.

Rotation angles were measured with a calibrated goniometer, the repeatability and reproducibility of instrument was tested with an expanded R&R study with balanced data. The variability of the interaction between the user and the part was verified using the ANOVA method. Error due to measurement instrument was 7% which is considered acceptable.

For the purposes of this investigation, considers the body as a system of segments and rotation points, subject to internal loads due to the weight of each of the segments, as well as to external loads considered for analysis. Force moments were calculated according to Newton Laws. Because the segments are not parallel, the angles to the axis of the abscissa, it is necessary to consider the moments of force that are generated, thus the conditions of equilibrium of moments are:

$$\sum M_j = 0$$

$$M_j = M_{j-1} + [\overline{jCM_L}\ (Cos\ \theta)W_L] + [\overline{JJ-1}\ ]Cos\theta_j\ R_j$$

Mj Load moments in each rotation center
jCM$_L$ Distance from rotation center to body segment mass center
θj posture angles in each rotation center
W$_L$ body segment weights
J j-1 body segment length
R j-1 Reaction forces in adjacent rotation

In general, the body posture does not influence the external reaction forces, but it does influence the moments of force that are generated. Because muscles respond to moment of strength, it is possible with simple static models, to get valuable information about the muscle groups that are activated. When there is an erect position with your arms in front of your body, there is a moment of low intensity in the region of your lower back and waist. When there is a flexion of the trunk and the arms are extended, very large moments of force are generated, especially in the extremities, and therefore the moment of reaction in the waist and lower back increases noticeably.

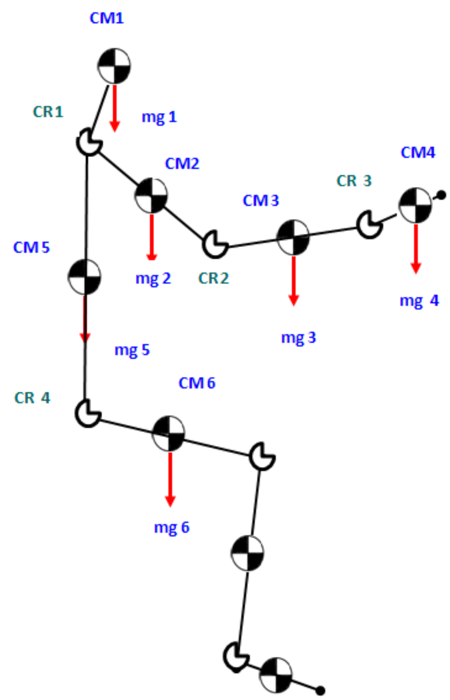

Figure 1 Static biomechanical model

3.3 Data analysis

Force moment data was first statistically processed to obtain means and standard deviations for the five weights lifted. A confidence interval for comparing two means of force moments with a confidence level of 95% for each lifted weight.

3.3.1 Sociodemographic information of participants

Average and standard deviation of workers age, height and weight were calculated.
3.3.3 **Force Moments means comparison**

To know if there is a statistically difference between the means of force moments in every lifted weight, it was calculated a confidence interval with a confidence level of 95%. Confidence intervals were calculated for the five weights lifted.

4. RESULTS

4.1 Sociodemographic information of participants

This study included 9 construction workers, from which four participants (37.5%) were excluded due to participation withdrawal (N = 3) or medical treatment (N = 1), resulting in a study sample of 5 participants (age 23.45 ± 1.30 years, height 1.68 ± 7.25, weight 65 ± 5.902 kg).

4.2 Force moment data

The lifting tasks assessed during the study was the material handling that involved the lifting of a concrete bucket during the roofing preparation. The forcemoments generated for the two lifting tasks were calculated, table 1 shows the results for the five weights lifted by workers.

Table 1 Force moments Means and Standard deviations by weight lifted

		15 kg		20 kg		25 kg		30 kg		40 kg	
		Real lifting	Ideal Lifting	Real lifting	Ideal Lifting	Real lifting	Ideal Lifting	Real lifting	Ideal Lifting	Real lifting	Ideal Lifting
Force moments (N/m2)	Mean	342.52	282.12	346.88	290.33	350.92	292.1	359.19	292.94	358.37	287.8
	Standard deviation	40.449	29.374	52.299	35.427	48.128	35.889	55.232	36.262	55.757	39.361

4.3 Force moment comparison

According to data from table 1, it was applied a confidence interval to compare means of force moments between the two conditions: the real lifting and the ideal supervised lifting, from two independent samples with a confidence level of 95%, and results of above procedure are shown in table 2.

According to results from table 2, with 95% confidence level, the difference in mean of force moment for every lifted weight, shows that there is a difference in all cases, which tell us that force moments generated in an ideal lifting posture generates a low force moment that could be associated with a low risk of MSDs.

Table 2 Confidence Intervals for a difference between two means

Weight (kg)	Confidence interval $(1-\alpha) = 95\%$
15	[58.660, 62.138]
20	[54.606, 58.500]
25	[56.893, 60.707]
30	[64.310, 68.290]
40	[68.571, 72.629]

5. DISCUSSION/CONCLUSIONS

This study sought to quantify the force moments generated in two instances: during the lifting of concrete bucket (different weights) in the real situation and the same lifting under an ideal lifting technique. The findings have strong implications to justify improvements regarding the training of construction workers.

According to results we could recommend the need to reduce the weight of load being lifted. Also, we could say that lifting must be done abovethe knee height. Davis et al (2010) found 50% a reduction in the lifting weight, decreases the loads to the lumbar back muscles by 22.5%. The team lifting could be a good practice to reduce force moments during lifting and reduce therisk of MSDs.

Due that they were found statistically significant differences in force moments during the real and ideal lifting tasks, it is evident the need of ergonomic intervention. Some prevention actions could be considered. Theseactions are related to changes in the worker’s job schedule based in their individual’s physical capacity. This study shows us the potential scope for the ergonomics intervention in lifting construction activities to improve the training plans regarding the lifting technique.

The results of this study revealed that increased lifting weights significantly increased force strength moments. Furthermore, the results found a significant difference between means of ideal and real lifting postures. These findings indicate that workers frequently involved in risk factors such as lifting weights, lifting durations, and lifting postures during repetitive lifting tasks may increase their risk of developing MSDs. The results of this study provide strong empirical implications that justify the need to reduce the risk of MSDS in construction. It was observed that the workers not only need to reduce the weight of load being lifted but also avoid lifting below their knee height. It could be recommendable the team lifting or the use of mechanical lifting equipment to reduce the risk of MSDs. Karsch et al. (2001) recommends the use of adjustable lift tables to improve body posture. Proper lifting techniques and education of risk factors could improve awareness of MSDs.

The observed risk factors in this construction task can contribute to understanding MSDs to enhance worker health and productivity. Although the conclusions support the effectiveness of implementing potential interventions to reduce MSDSs risks, some limitations were observed, and hence future research is required. Some of the recommendations for future research are to consider a larger sample of participants to generate a more robust evaluation and comparison between the different lifting postures and how these impact on the risk of developing MSDs. Furthermore, experienced construction workers who have accrued considerable experience of repetitive lifting should be evaluated in any future study conducted (vis-à-vis the novice participants used in this study). Another important issue is to be considered is the effect of external risk factors such temperature and humidity during repetitive lifting tasks performed by construction workers. Besides these considerations, it is important to say that this study may not be generalized to other construction activities future research should consider different types of construction activities.

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CONTRADICTIONS IN THE UNIVERSITY TEACHING DURING THE PANDEMIC

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Resumen Este artículo tiene por finalidad definir las tensiones y contradicciones existentes en el proceso de enseñanza universitaria. Esto es importante estudiar dicho proceso involucrando tratando de involucrar el mayor número de variables que se involucran en este. Para ello, se utiliza la Teoría de la Actividad permitiendo, además, estudiar dicho proceso en el ambiente natural donde se lleva a cabo este. Esto permite tomar una fotografía, que denota inmovilidad del sistema que contiene dicho proceso, y analizar cada elemento por separado y la relación entre ellos. El contexto escogido fue un instituto perteneciente al sistema educativo gubernamental. Para estudiarlo se escogió un profesor impartiendo clases durante dos semestres del 2020 y el primer semestre del 2021. Dos métodos fueron utilizados para recabar datos y su análisis fue realizado mediante el empleo de la Teoría de la Actividad proveyendo un marco adecuado para tal fin. Como resultado fueron encontradas cuatro tipos de tensiones y contradicciones en similar número de niveles. Cada una de ellas proveyó lo necesario para poder innovar el proceso de la enseñanza universitaria. La principal innovación fue provista por los estudiantes y los profesores en la búsqueda del logro del objetivo educacional. Esto pudo observarse en la adecuación de espacios privados en espacios preparados para llevar a cabo el proceso de enseñanza universitaria.

Palabras clave: Contradicciones, Tensiones, Pandemia, Enseñanza Universitaria, Factores Ergonómicos y Psicosociales, Teoría de la Actividad

Relevancia para la ergonomía: El descubrimiento de contradicciones y tensiones dentro del proceso de enseñanza universitaria permitirá desarrollar estrategias para disminuirlas mediante la innovación de sus actividades. Esto permitirá tener mejores condiciones para estudiantes y docentes dentro de este proceso. Así, este tipo de estudio aportará antecedentes para futura investigación en universidades localizadas en otras ciudades o regiones.

Abstract: The purpose of this article is to define the tensions and contradictions that exist in the university teaching process. This is important to study said process involving trying to involve the greatest number of variables that are involved in it. For this, the Activity Theory is used, allowing, in addition, to study this process in the natural environment where it is carried out. This makes it possible to take a photograph, which denotes immobility of the system that contains mentioned process, and to analyze each element separately and the relationship between them. The chosen context was an institute belonging to the government educational system. To study it, a teacher was chosen teaching classes during two semesters of 2020 and the first semester of 2021. Two methods were used to collect data and their analysis was carried out through the use of the Activity Theory, providing an adequate framework for this purpose. As a result, four types of tensions and contradictions were found at a similar number of levels. Each of them provided what was necessary to be able to innovate the university teaching process. The main innovation was provided by students and teachers in pursuit of the educational goal. This could be observed in the adaptation of private spaces in spaces prepared to carry out the university teaching process.

Keywords. Contradictions, Tensions, Pandemic, University Teaching, Ergonomic and Psychological Factors, Activity Theory.

Relevance to Ergonomics: The discovery of contradictions and tensions within the university teaching process will allow the development of strategies to reduce them through the innovation of its activities. This will allow better conditions for students and teachers within this process. Thus, this type of study will provide information for future research in universities located in other cities or regions.

1. INTRODUCTION

The learning process involves various elements connected to each other in order to achieve the objective of modifying the behavior of individuals in direct consequence of their experiences (Wilder, 2019). This can be seen from the point of view of Engineering as it involves external and internal elements affecting said process. The internal elements involve individuals being the main reason for this. Along these lines, it is important to study in detail the cognitive processes, which can affect the learning process. Here, detailed studies of these cognitive processes can help with the discovery of better strategies to produce changes in behaviors. In the same way, in the current literature there are multiple examples of models that present various elements that can be considered to achieve the desired changes in behavior. Hence, the strong relationships between these elements can help on producing the expected individual alterations (Kolb, 1984). In turn, this can infer how multiple combinations can be made between the elements, increasing the complexity in achieving the objectives, which are implicitly indicated in the various models developed for this. Specifically, it is about evaluating the effectiveness of the various combinations shown in these models.

On the other hand, external elements are related to those that can affect this process and are contained in the environment in which the learning process takes place. Some of these are the ones that mediate the process in a given context. In this line, various elements such as technology (Park, 2009), presentations on specialized software (Thomas and McKay, 2010), problem solving (Yew et al., 2016), among others, are considered. Consequently, several investigations have been developed to measure the impact of external elements at the individual level. In the same way and at the same time, they have also made it possible to measure the effectiveness of combinations of internal and external elements within the learning process.

In addition, various forms of research emerged when considering the internal and external elements in this process. Most of these studies were carried out in different contexts measuring their effectiveness. A recurring context used to investigate the learning process has been the university. In this context, various elements and combinations have been studied (Artigue, 1999). For example, some of the elements are processes for learning (Bennett et al., 2017), strategies to increase effectiveness (Biggs, 1999), recognition of student paradigms (Yang and Tsai, 2008), social networks (Madge et al., 2009), among others. As a result of these investigations, it has been discovered that most are carried out in controlled environments, so there is an area of opportunity in scientific knowledge related to research in natural contexts where there is no control over the possible results. In addition, the consideration of the internal and external elements that affect the learning process can be a great opportunity to discover other elements that affect that process, emerging other areas of research in the area.

This article focuses on covering the topics mentioned to fill this gap. The discovery of these elements is carried out through the search and location of tensions and contradictions at various levels within said process and which, in turn, allow innovation within the teaching process at the university. This is from the point of view of Ergonomics as an area of improving the conditions of those involved in the process. Specifically, the research was carried out within the temporal context that represents the pandemic that has hit worldwide and where the university teaching process has been directly affected for 18 months. This is considering the time this article is being written.

2. OBJECTIVES

To define the tensions and contradictions to which Industrial Engineering students are exposed during university education through the use of the Activity Theory to reduce their impact during the pandemic.

3. METHODOLOGY

3.1 Activity Theory

This theory helped to discover the knowledge within the environment even when individuals are unaware of its existence. In addition, it provided the theoretical, methodological and practical foundations to study the university teaching process in the aforementioned context. Here the consciousness of the process, activity (or behavior) is a product of itself and works by studying it holistically (Kaptelinin, 2005). Also, this process results from its continuous realization, human interactions and experiences with other individual beings within the surrounding environment directly influencing the mentioned process. In addition, the process is aimed at achieving objects or objectives to generate results (Leontév, 1978). On the other hand, the theory considers that individuals have a social nature and are directly influenced by their culture, language and behavior of other individuals located in the surrounding organizations. These organizations can be the family, communities, groups, among others.

The previous assumptions help to understand the motivations in this process. These motivations can be cognitive (generated inside the human being) and social (generated outside). In the same way, these motivations determine the goals to be achieved, being affected by the existing conditions of the surrounding environment. In turn, goals are made up of actions aimed at achieving goals. Hence, actions are carried out by operations performed automatically or routinely under stable conditions within the environment. Otherwise, if the conditions are unstable, the trades become stocks to the point where the conditions become stable again and the stocks are once again converted to trades. This is a cycle of the human process or activity that is repeated in direct relation with the conditions of the surrounding environment. The foregoing shows that capturing its essence is a challenge that was carried out in routine operations within the contexts of interest.

Likewise, the theory generated the foundations to find and use each element of the process under study. These are: what subject (s) carry out the activities or the process, what are their object (s) or objective (s), what tools (mental and / or physical) they use to mediate the activity or the process, which community is involved, what rules and norms of interaction they follow, how they divide the work and what is the expected result. In the same way, this theory helped to make sense and understand the information collected, this is why activities must be understood through what people do and why they do it. Additionally, its understanding was holistic based on its dynamism and complexity closely related to its environment, providing conditions to interpret and study activities in its natural environment. This was through the support of methodological strategies for the collective case study, increasing its knowledge with analytical and non-statistical generalizations.

Furthermore, the theory suggests that all activities are governed by the following principles: all human activity is collective, mediated by artifacts or tools, and goal-oriented; there are multiple opinions; it has a history resulting from transformations carried out over time; tensions and contradictions are the origin of these changes thus developing indicated activity; and this can have various expansion transformations resulting in changes and innovations as a consequence of the accumulation of tensions and contradictions (Engestrom, 1999). The latter can be located in each element of the activity (primaries); related to each other (secondary); related between the motives/objects of a central element of a system and the motives/objects of a more culturally advanced element (tertiary); and related between the core activity and other nearby (quaternary) activities (Engestrom 2001).

3.2 The Case Study

In Mexico, there are different types of universities and each one of them seeks to achieve different objectives, which are requested by its central bodies. These universities are mainly classified as public and private. Private universities are run by a board of trustees, and these universities are primarily focused on generating profits for their board members. On the other hand, various government agencies administer public universities. These defined the objectives to be achieved by indicated universities. Usually, the main objective is to develop the competencies required to secure work in undergraduate students. This is the case of the institute participating in the study, that is a public university that depends on by a government agency. This institute is a campus of a decentralized organization of the federal government that groups 254 institutes, four equipment development centers and two research centers. These institutes and centers are located in the main cities of Mexico. In addition, it is important to point out that the government body regulates the degree programs as well as the contents of the various subjects that make up these academic programs, focusing mainly on the training of engineers. Hence, it is relevant to note that the participating institute is located in a city located in the northwest of Mexico. This population's main characteristic is the convergence of the different cultures existing in Mexico, providing it with unique characteristics compared to other cities located in Mexico.

On the other hand, the institute, as a crucial representative of the government organization, must provide the place and environment necessary to achieve the goal, with a close link between students and teachers. In the same way, in turn, the teacher is a mediator between the institute and the students. The foregoing allows the teacher to generate their own ways to achieve the objectives indicated within the study programs that make up the academic programs. This includes the different norms that regulate the learning process in the institute and its objective is the satisfaction of the institute and the students, tacitly including the satisfaction of the teacher. To verify the fulfillment of the various tasks within the teaching process and the achievement of its objectives, the teacher must plan and implement the particular objectives set out in each of the syllabi of the study program. For this, the professor presents in the initial stage of the semester the planning for the achievement of the particular objectives and is verified three times throughout the semester in order to confirm the achievement of mentioned objectives. It is relevant to point out that the program presents the need to have prior knowledge, which is required by students so that they can take these subjects within the study program. This is for the student to relate indicated previous knowledge and its application in the competencies to be developed within the subjects to be studied.

Therefore, this research was carried out during the period from January 2020 to July 2021, involving Industrial Engineering students at the Tecnológico Nacional de México, Campus Instituto Tecnológico de Tijuana. This was inviting students who are enrolled in the institute from the first to the twelfth semester in the face-to-face and semi-face-to-face study modalities. The face-to-face modality refers to students fully dedicated to their studies or 100% students. On the other hand, semi-face-to-face students are those students who take face-to-face classes in order to obtain advice on those topics that are complex to learn and to reinforce them, they require direct advice from teachers. This type of modality was created to satisfy the demand of those people who want to study engineering combining commented studies with their work.

3.3 Methods to Collect Data

The methods used to gather information served to examine the unique and routine events that happen in the university teaching process; to contemplate the individuals and the physical and intellectual tools used; to inspect the sub-processes, activities, actions and operations carried out; and to explore the subsystems, systems and supra-system in which the subjects participating in mentioned process are immersed. Two methods were used to collect data during field work. On the one hand, various documentation related to the university teaching process and that provided by the institute were reviewed. The data included were the contents of the subjects, organizational manuals, information generated during the semester by each teacher who teaches the subject under study, rules and regulations, among other documents used in the routine operation of the institute. 35 documents were obtained from the institute. Similarly, a professor provided all the materials used in the teaching process during the semesters January-June 2020, August-December 2020 and January-June 2021. This professor taught the subjects Operations Research I and Operations Research II averaging 34 students in each of the four groups assigned each semester, serving 120 to 160 students per semester. The documents obtained contain the information generated during the semester: copy of the exams; a task that aims to make a summary of a scientific article related to Operations Research; a final project report and requested questionnaires related to the learning process. Approximately 950 documents that included exams, assignments (summaries) and blueprints were collected for further analysis.

On the other hand, a questionnaire was conducted which included open-ended questions and consisted of a battery of 14 items. These questions focused on discovering each of the elements of the human activity system represented by the university teaching process. For this, a bibliographic review was carried out regarding the main factors involved in the university teaching process. The second task was to change said questionnaire to electronic format to be disseminated among the students. Here the tools provided by Google® were used. 399 responses were collected during the three semesters. It is important to note that only students taking the subjects indicated above were considered.

It is necessary to emphasize that the research was carried out in accordance with ethics and good customs in the handling of the generated data and information.

For this, everything was encrypted, thus ensuring its confidentiality during its collection and analysis process. In addition, this research takes into consideration of the TecNM Code of Conduct to ensure the proper use of the information obtained and its analysis.

3.4 Analysis Methods

The Activity Theory, as an analytical tool, allowed to understand the relationships between individuals, the object of the process or activity and the mediation of components at the individual and group or collective level. This was within the learning process in order to discover that each individual can be considered separately and in turn, forming part of the whole. In other words, within the process, each individual is linked to it but exhibiting shared goals for the achievement of the object of the activity. Its deconstruction generates some advantages in order to obtain important knowledge about how motivations move, which are directed to the achievement of goals within the learning process where social and cultural residues are integrated in the context under study. This is made possible by the activity sequences that are framed using the Activity Theory. Figure 1 presents the general form of the activity system.

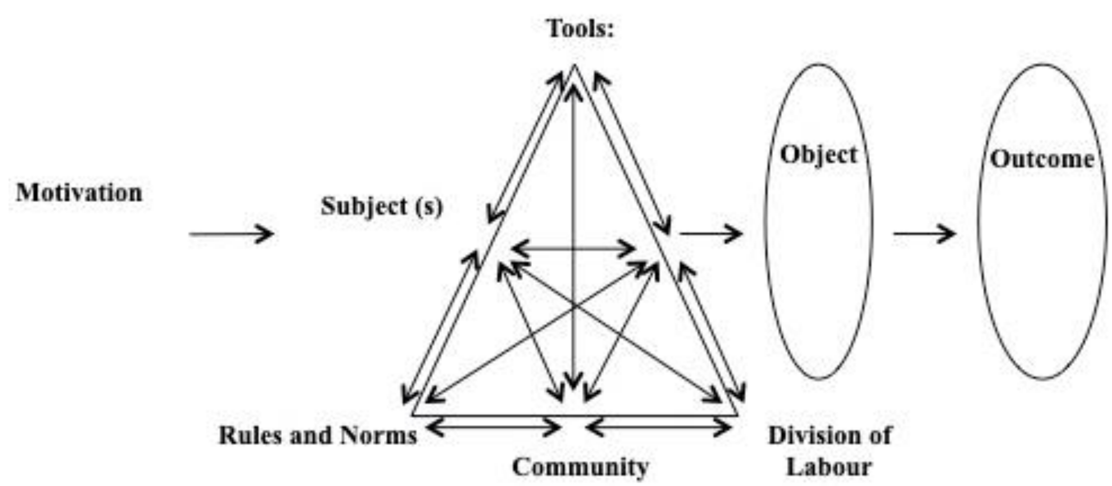

Figure 1. The structure of a human activity system (adapted from Engestrom, 2001)

However, the activity, as a unit of analysis, offered advantages and disadvantages to study what is happening in the university teaching process. These were found in the way in which the activity should be analyzed. To achieve this, three generations of the Theory of Activity were developed. The first focuses on the idea of mediation by artifacts or abstract and material tools. The second is based on the concept of collective mediation by rules and norms, community and division of labor. The Figure above shows both the first and second generation in the shape of a triangle. The first generation includes the motivation, subject (s), tools, object and result. The second generation incorporates the rest of the elements shown in the figure. The third generation presents the opportunity to study those related to the dialogues and diversity between different perspectives, traditions or systems (Engestrom, 2001).

Therefore, an interpretive approach was chosen as a feasible approach to obtain a deep understanding of the diversity of perspectives on the university teaching process as a natural context under study. To do this, multiple methods were used to capture the little-known of the context (Denzin and Lincoln, 2000), mentioned above. The case study was considered a viable approach as the research includes and is centered in a natural context. Also, this type of approach provided advantages over other approaches to investigate the nature of the university teaching process at the mentioned institute.

Hence, the human activity system allowed decomposing the university teaching process into its elements, described in section 3.1. This allows knowing its object(ive), its actions in the achievement of goals and the routine operations carried out in direct relation to its surrounding context. This is a characteristic of these systems for being unstable and the Activity Theory helped to obtain knowledge of these through understanding the human system and its dynamic nature. In the same way, this theory allowed to know in depth and its scope within the context under study. Thus, in its analysis its elements were sought and once these were discovered, the tensions and contradictions existing within the system and in relation to other systems around the university teaching process were found. These were at the primary level (each element of the system); secondary level (between the elements of the system); tertiary level (between the objectives of this system and a culturally advanced system) and, finally, the quaternary level (are those between close systems).

All the data obtained were transcribed verbatim and analyzed applying an open, axial and selective coding approach. These data were examined to saturate the categories referring to the elements of the activity system of each individual who participates in the university teaching process. Three activity systems were created and linked into one, displaying the shared objectives. Special emphasis is placed on finding the aforementioned contradictions and tensions. In addition, the discovered elements were used to discover links in light of the contextual characteristics that give meaning to the relationships between their elements and the activity systems. The motivations and uses of the tools are two elements that opened the discussion referring to directly or indirectly affecting the university teaching process.

Along these lines, the encounter of contradictions and tensions revealed the clash of the elements, but also, this revealed the gaps to innovate the teaching process. Also, the review of information that was generated during the semesters of the study had the objective of knowing those contradictions and tensions within said process. This could be observed in the exams, assignments and projects carried out. This also included discovering the main physical and intellectual tools used in the process; the rules and regulations that regulate routine work and interpersonal relationships; the division of labor through what is indicated in each of the personal jobs. In the same way, this helped to identify the various activities, actions and operations required in routine work in university teaching.

Finally, each student who participated in this research was contextually analyzed and the importance of their activities within the system was understood. The same was done for each document and questionnaire reviewed. Also, it was performed by each element of the human activity system. This provided additional information to propose improvements in the university teaching process.

4. RESULTS

According to the analysis of the information collected, three systems of human activity were developed. Each of them is related to the participants involved in the university teaching process. To make a rich picture of how individuals converge in the process, systems come together representing shared objectives or goals. Figure 2 presents the three human activity systems and shows the shared objects.

Below, the tensions and contradictions at the four levels are noted in the previous section. These were ordered based on the level of commitment in achieving the objectives within university teaching.

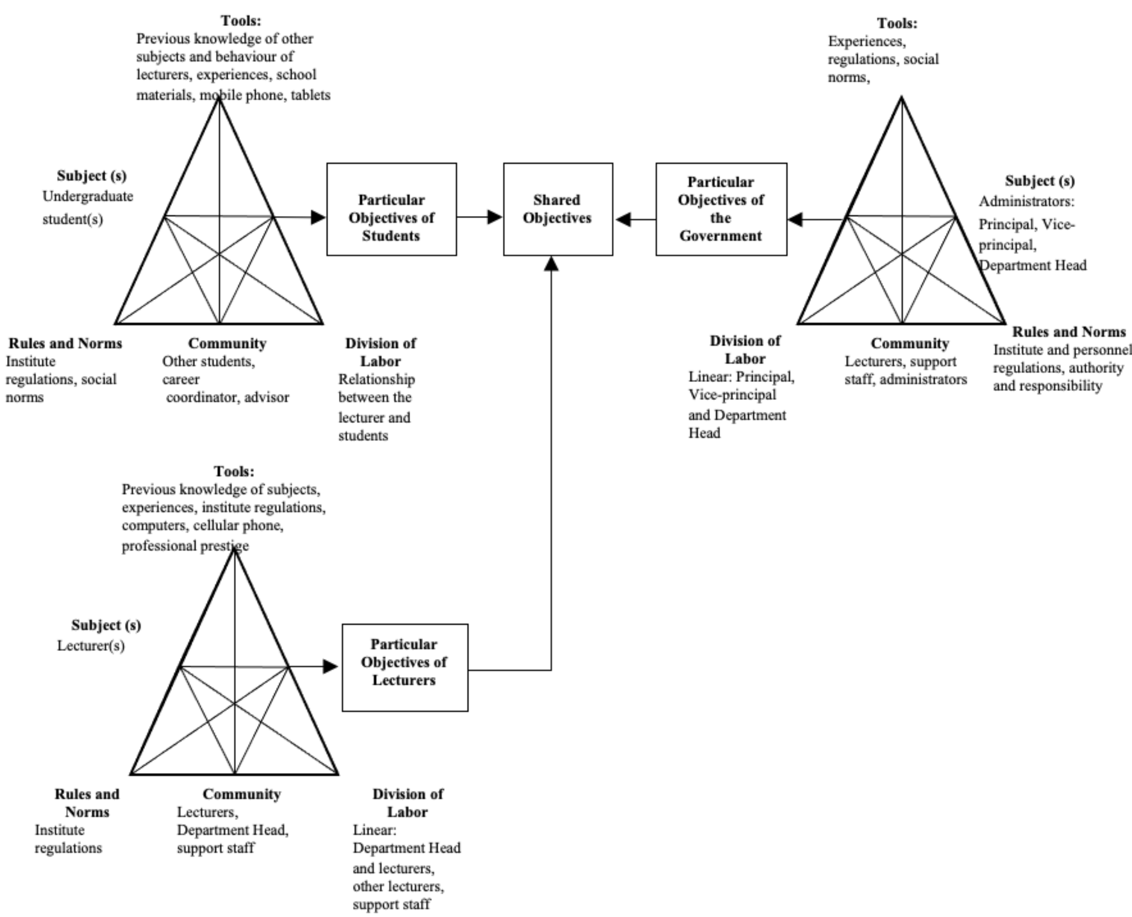

Figure 2. The structure of shared objectives between students, administrators and lecturers (adapted from Hernández-Escobedo *et al*, 2020)

4.1 Tensions and Contradictions at Primary Level

In relation to the regulations of the central organization, the administrators of the institute have the authority and responsibility to achieve the goals set by the central organization. Specifically, one of those goals is related to the university teaching process in terms of facilitating that process. It includes the provision of infrastructure and equipment. Also, it incorporates certain regulations in order to control student behavior. These administrators are also responsible for finding new ways to carry out activities focused on providing various elements to facilitate that process. However, during the pandemic, the provision of certain physical tools was not achieved by leaving teachers to use their own tools. This resulted in the partial achievement of objectives, affecting mentioned process.

In reference to the regulations, the objectives of the teachers were clearly stated. One of them was being a mediator between administrators and students. This could be observed as the agents in converting the objectives set out in the programs into practical actions to carry out the university teaching process. For this, certain regulations related to the relations between students and teachers were used, facilitating the university teaching process. This relationship was observed in how teachers evaluated the teaching process considering the students' backgrounds and how the objectives to be achieved. It also included the use of material and abstract tools indicated in the program. However, these were modified according to the new needs and challenges that working virtually implied. Here, the lack of the physical tools required within the university teaching process was the cause of partially achieving its objectives.

Regarding institutional regulations, students were the most important human activity system within the university teaching process. The entire system was aligned to consider their needs in reference to the context including its elements. Hence it was stated that organizational goals should bring knowledge, experiences and competencies to students in order to prepare for work in the near future. To do this, students become familiar with these regulations to facilitate the process. Also, they noted the types of abstract tools and materials that they can use in the process. However, the lack of adequate physical tools to participate in this process was a variable that directly affected the achievement of the objective. This showed that, despite making efforts to achieve the objectives, these were limited by the lack of these physical tools.

4.2 Tensions and Contradictions at Secondary Level

Administrators had evolved the ways in which they modify the characteristics of the elements of their human activity system. For example, they generally changed the rules and regulations from their perspective to increase the number of students per classroom, in the case of face-to-face classes. This action generated tensions and contradictions in relation to the rules set out in the institutional regulations that clearly marked the maximum number of students per classroom. This was in order to increase the number of students in each classroom. Sometimes, the surplus of students per classroom is close to 30%. It is important to note that the number of students per classroom is limited based on construction regulations and Civil Protection laws, that are existing regulations related to the use of facilities. However, this excess capacity was not considered during the pandemic since the tools used have greater capacities without affecting performance. In other words, the groups could be increased, thus reducing the costs involved by increasing the number of students served by teachers at a lower cost.

However, the teachers proposed the interpretation of the objectives according to their personal and professional goals. This included various forms of weighting of objectives in the form of evaluation indexes. In addition, this meant that each teacher considered various criteria such as attendance, exams, solving exercises, application projects, understanding of current literature, among others. Once the criteria were chosen, the teachers weighted and assigned percentages to them to serve a greater number of students. The basis for this percentage allocation was 100% through a formula that presents these criteria. Some tensions arose with students and administrators because they may consider that it was not established in the objectives of the program. However, the professors used academic or academic freedom as the main argument to reinforce the evaluation criteria. It was important to point out that this argument was part of the institutional regulations that allowed its application in the aforementioned context. This, in turn, put into perspective the increase in the size of the groups to be served, thus generating a new way of achieving the objectives considering the challenges that mentioned increment implied.

In the same way, students used the regulations of the institute for their advantage. It included the weighting of those sections related to the benefits in operational terms of the process. For example, it was common for students to take advantage of the opportunity offered to them to choose the teacher who teaches the subject of study, directly impacting the size of the groups. This caused imbalances in the number of students per classroom, since, on occasions, the authorities increased the number of them. These imbalances were not only manifested in the number of students per classroom, but also in the imbalance of workloads per teacher. For this, it was normal for the regulations were modified to allow such increases, as mentioned above. Students can produce unusual situations that posed additional risks in terms of civil protection problems in face-to-face classes. However, in virtual classes, this caused an increase in teachers' workloads, reducing attention to various problems that arose during university teaching and that impacted in the achievement of objectives.

4.3 Tensions and Contradictions at Tertiary Level

Managers used various abstract and material or physical tools to achieve goals. It included the use of regulations that were not disseminated among teachers and students. Sometimes these actions caused various tensions with both students and teachers. Referring to the students, they had expressed their frustration with how the new regulations stopped certain actions included in the university teaching process. For example, the inhibition of the use of material tools such as computers and cell phones within the university teaching process carried out in person. This could be observed through the decrease in the bandwidth used on the Internet and that inhibited the mentioned use of those devices. The argument presented to carry out this decision included a regulation related to the use of funds provided by the central organization and that indicated a clear limitation of costs related to Internet services. On the other hand, the teachers exposed some tensions in the use of computers as material tools within the teaching process. This was because the computers used in the institution do not have the technical capacity to support the current software used in the course, or the computers did not have that software. This inhibited the use of material tools within this process by using software that required equipment with greater technical characteristics or information processing capabilities. This was increased during the pandemic, since most of the students presented connectivity problems as a result of not having internet connections that could support the bandwidth needed to attend virtual classes.

On the other hand, the use of material and abstract tools within the teaching process was a source of tensions and contradictions between the various individuals involved in the process. It was because some of the tools did not meet the minimum technical specifications to use them in this process. For example, the use of computers and specialized software was pointed out in the programs as necessary tools to solve examples during classes. However, these tools sometimes did not run the software. Faced with these situations, some teachers chose to use free software on students' mobile phones and computers; however, the decrease in Internet bandwidth limited these uses, as mentioned above.

In the same way, another issue, which was related to the use of abstract materials and tools within the university teaching process, was the knowledge on the part of students that the institute did not have computers with information processing capabilities according to what required to solve problems in class. On certain occasions, the computers could not run the necessary software to solve the exercises in class, so they decided to use their personal computers. However, the administrators imposed some restrictions on the connection to the institutional network, denying them connectivity in face-to-face classes. This inhibited the use of the mentioned software. Furthermore, the students were unable to connect their cell phones to the Internet because the bandwidth was insufficient to serve the number of users at the same time. Consequently, this directly affected the face-to-face class process. This was increased as a consequence of transferring these needs to the places of residence of the students and their families. By using their phones to attend virtual classes, students increased their costs for internet connectivity.

4.4 Tensions and Contradictions at Quaternary Level

This type of tension and contradiction was a consequence of the previous analysis of the aforementioned. For example, the convenient interpretation of the various existing regulations within the university teaching process. Each of the human systems showed this interpretation and at the end, it was shared among them. Here, the innovation of each of these systems was clear in achieving the objectives initially set.

In the same way, it was the interpretation of safety regulations in relation to the maximum number of students per class. The number was modified based on administrative needs in face-to-face classes and was reaffirmed in virtual classes. However, attention must be paid to what may happen once face-to-face classes were returned after the end of the pandemic will be declared.

In the same way, it was the interpretation of safety regulations in relation to the maximum number of students per class. The number was modified based on administrative needs in face-to-face classes and was reaffirmed in virtual classes. However, attention must be paid to what may happen once face-to-face classes are returned after the end of the pandemic will be declared.

5. CONCLUSIONS

The results revealed an interesting rewriting and understanding of rules and regulations used to achieve objectives within the university teaching process. In the same way, the unusual use of some abstract and material tools was crucial in their achievement. Hence, what was related to norms and rules, each individual used these in terms that could facilitate the achievement of his objectives. However, this caused tensions and contradictions that produced, in turn, various actions exhibiting innovation in them in practical and philosophical terms. This could be observed in the way in which these norms and rules were rewritten, directly affecting the aforementioned process. For example, in the case of administrators, the rewriting of these norms and rules determined the weight of putting the university teaching process above Civil Protection legislation and the increased workload on teachers.

In addition, the use of abstract tools and materials clearly indicated how it was a crucial factor that affected the university teaching process. This was observed in the different ways in which they are seen and considered within this process. That was, if the foregoing was observed from an economic perspective, the use was limited to the minimum expression in carrying out various actions in order to minimize its impact on the process. Here, the students and teachers made changes in the activities focused on how the objectives of the process should be the achieved. It was discovering the innovation in these activities and in direct consideration of the use of these tools.

However, it is important to point out that the innovation could be observed as a way to achieve the objectives stated by an organism clearly far from the university teaching process, such as the central organ that is far from the teaching practice. For example, reducing the funds used to pay for Internet services was a restriction that needs to be studied in detail. This is to put in perspective the achievement of objectives and thus discovering the benefits on being achieved as a result of increasing the funds to raise the bandwidth used on the Internet within the campus. This should offer options for those students who wish to use their computers in class once they return to face-to-face classes. This action can change some parameters in how the university teaching process would be carried out in the institute and where the change of certain norms and rules can also be considered in order to improve mentioned process. In addition, the study in detail the convenience of establishing the size of the groups in consensus with those involved (administrators, teachers and students) and the existing resources without losing sight of the regulations applicable to the case.

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GENDER PERSPECTIVE IN THE UNIVERSITY TEACHING, A FORGOTTEN PSYCHOLOGICAL FACTOR

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Resumen El presente artículo investiga las relaciones existentes entre los factores de riesgo psicosocial de los estudiantes de Ingeniería Industrial dentro de los entornos educacional y laboral, así como sus efectos en el género. Para ello, fue necesario definir claramente cuáles son los desequilibrios existentes entre las relaciones del entorno y los seres humanos, así como sus diferencias, de tal manera que pueda ser percibida la inequidad y discriminación dentro de los factores de riesgo psicosocial. Por tal motivo, se definió una metodología que permitió evaluar y explicar dichos impactos desde diversas perspectivas. Aquí se consideraron estudiantes y egresados de ingeniería sin importar su género y edad permitiendo expandir el conocimiento en dichos temas de interés. Siete categorías fueron descubiertas mostrando las áreas donde se visualizaron los factores psicosociales desde la perspectiva de género. Estos factores, a su vez, permiten generar propuestas de mejora en los entornos en estudio y laborales. De la misma forma, se espera que estas propuestas puestas en práctica generen mejores condiciones estudiantiles y laborales, en la medida que las organizaciones decidan adoptar las propuestas para la atenuación de estos factores psicosociales en reconocimiento del género.

Palabras clave: Perspectiva de Género, Enseñanza Universitaria, Factores Psicosociales, Teoría de la Actividad.

Relevancia para la ergonomía: El descubrimiento de aquellos factores que impactan en los profesionales de Ingeniería Industrial dentro de las fases de su formación y del ambiente laboral es relevante. Esto puede ayudar a desarrollar propuestas de cambio en ambos contextos, evaluar los efectos de dichos factores,

reducir su impacto y formar profesionales de la ingeniería conscientes de dichos factores y formas de mitigación para una sociedad igualitaria, la cuál esto redundaría en mejores condiciones laborales.

Abstract (Spanish/English, this order): This article investigates the relationships between the psychosocial risk factors of Industrial Engineering students within educational and work environments, as well as their effects on gender. To do this, it was necessary to clearly define the existing imbalances between the relationships between the environment and human beings, as well as their differences, in such a way that inequity and discrimination within psychosocial risk factors can be perceived. For this reason, a methodology was defined that made it possible to evaluate and explain these impacts from different perspectives. Here, engineering students and graduates were considered regardless of their gender and age, allowing the expansion of knowledge in commented topics of interest. Seven categories were discovered showing the areas where psychosocial factors were viewed from a gender perspective. These factors, in turn, allowed the generation of proposals for improvement in educational and work environments. In the same way, it is expected that these proposals put into practice will generate better educational and working conditions, to the extent that the organizations decide to adopt the proposals for the attenuation of these psychosocial factors in recognition of gender.

Keywords. Gender perspective, University Teaching, Psychological Factors, Activity Theory.

Relevance to Ergonomics: The discovery of those factors that impact Industrial Engineering professionals within the phases of their training and the work environment is relevant. This can help to develop proposals for change in both contexts, evaluate the effects of these factors, reduce their impact and train engineering professionals aware of these factors and forms of mitigation for an egalitarian society, which would result in better working conditions.

1. INTRODUCTION

At present, various issues are of national and regional interest due to the various problems that they represent to society. In particular, it can be noted that health (Uribe Prado, 2014), gender inequality (Martínez, 2015), and discrimination (Horbath and Gracia, 2014) are three issues that have had a great impact on daily life. It is a combination in the environment in which individuals are generally immersed. Furthermore, in a specific way, lately and due to various changes in legislation related to the work environment, the aforementioned issues have begun to receive attention since they have shown that are problematic situations that must be addressed for the benefit of individuals (Vera and Trujillo, 2018). This is because there is evidence that, to achieve the development of the country, it is necessary to mitigate or reduce their impact (Girardo and Mochi, 2012).

For this reason, these problems can be addressed from different perspectives; however, one perspective that has shown its benefits in this type of problem is Ergonomics. This is a discipline supported by scientific basis that tries to understand those close and latent relationships of the individual with various elements of the environment or system, in such a way that various theories, principles, data, and methods are allowed to be applied in the design of commented system, seeking to improve the conditions for the well-being of human beings and their performance (IEA, 2016). That is, the objective of Ergonomics is, specifically and relative to the work environment, to preserve the conditions of health, comfort, and safety in workers (IEA, 2016). This can be observed in a healthy, comfortable, and safe environment to achieve, which, in turn, allows to improve the performance of individuals (Amaro, 2016). However, the safety, comfort, and health of workers can be affected by various factors. These can be originated in the same context or environment, such as lighting (Omidiandost et al, 2015), noise (Lee et al, 2016), or temperature (Califano et al, 2017), among others. In addition, forced, and uncomfortable postures, adopted by workers when carrying out various activities, are other factors to be considered. There are also factors included within the same environment that are sometimes not fully visible but they are directly related to work, such as psychosocial factors. These factors include those interactions between work, the environment, and the conditions of the organization, on the one hand; the capabilities of human beings, their needs, their culture, and their personal situation outside of work, on the other hand; which, through perceptions and experiences, can influence health, performance and job satisfaction (OIT, 1986).

Likewise, these interactions can generally come to generate balance among themselves, in such a way that individuals and working conditions create situations and conditions of trust. This, consequently, in turn, allows obtaining benefits in terms of motivation, ability at work, and health (Gallardo and Quintanar, 2008). Otherwise, if there are imbalances between these interactions, the consequences may be different (Quiñones et al., 2012). This can cause physiological, psychosomatic (headaches, muscle pain, sleep disorders) and psychic (lack of attention, among others) (OIT, 1986; Gallardo and Quintanar, 2008). Likewise, it can be observed in dysfunctions within the organization through various actions such as absenteeism, interpersonal relationships, job demotivation, accidents, among others (OIT, 1986).

However, the lack of full consideration of the differences in relation to gender, their needs, their culture and their situation outside of work, has generated imbalances that can be observed in terms of the dysfunctions mentioned above (Quiñones et al., 2012). In other words, in previous decades, it has been carefully observed that these considerations have been put on one side or have been completely ignored (Thornley et al., 2014). The laws related to gender inequality and employment discrimination (Solís, 2015), and psychosocial risk factors (Luna-Chávez et al., 2019) are two clear ways to correct such lack of consideration. Furthermore, in particular terms and with the aim of deepening this lack of consideration, it is necessary to investigate and understand these differences in the context or environment in which future engineering professionals are trained, who once completed their training, are inserted in the work environment; that is, it is necessary to visualize mentioned lack of consideration in education (Unda et al., 2016), and in the work environment of engineers in order to suggest improvement in both contexts.

The foregoing is within the context represented by students of Industrial Engineering, which is taught at the Tecnológico Nacional de México/Instituto Tecnológico de Tijuana (TecNM/ITT from here to onwards), and companies that have inter-institutional relations with this institute. This relationship was considered directly or indirectly. The direct relationship is one that exists between the institute and the service or manufacturing companies through agreements or work agreements between them in such a way that both parties benefit from their work in achieving their individual objectives, and what in certain point, converge supporting each other. On the other hand, indirect relationships are those that occur between the institute and service or manufacturing companies through the obtaining of benefits from one or both parties in achieving their objectives, but they do not use agreements or work agreements where they are establishing these convergence points.

Regarding students, these were considered all those who are enrolled in the institute from the first to the twelfth semester in both face-to-face and semi-face-to-face modalities. The latter being an important reference since this modality was created to satisfy the demand of those people who wish to study engineering by combining said studies with their work.

Therefore, the novelty of this project is to consider those psychosocial risk factors, in full consideration of the differences in relation to gender, their needs, their culture, and their situation outside of their work, to which engineering professionals are exposed within the university teaching process and the work environment.

2. OBJECTIVES

As a general objective is to define the effects of psychosocial risk factors on gender in Industrial Engineering students through the use of the Activity Theory to propose its reduction from the normative perspectives.

Also, the realization of this project was limited to: a) To discover the main psychosocial risk factors that affect students and professionals of Industrial Engineering to make proposals to change the conditions of the context in which they are developed. b) To measure the effects of the main psychosocial risk factors and their impact in consideration of gender in order to propose improvements in the conditions of the context reducing their effects.

3. BACKGROUND

In Mexico, there are various studies on psychosocial factors in various contexts related to the previously discussed (Aldrete et al., 2008; Salcedo et al., 2010; Villamar Sánchez et al., 2019; González Corzo, 2012; Silva-Gutiérrez and Cruz-Guzmán, 2017; Bakker et al., 2014). Among the contexts are education at various levels and its main actors, teachers and students. Generally, these studies measure some of the imbalances caused by psychosocial factors. One of these imbalances is the Burnout Syndrome, which causes human beings to show chronic stress that can be manifested in a lack of interest, responsibility, and motivation towards job performance (Villamar et al., 2019). Likewise, this type of stress can cause various diseases, including diabetes, hypertension, psychological disorders and heart attacks.

Another of the imbalances that has been studied is Mobbing (harassment). This is related to the psychological harassment suffered by certain individuals, generally at lower organizational levels by individuals at higher organizational levels, and that, systematically, the latter exhibit negative social behaviors over the former (González-Corzo, 2012). This social behavior can cause illness.

However, it has been found that such studies have not put into perspective the need to consider differences in relation to gender, their needs, their culture and their situation outside of their work. In particular, the study would focus on engineering professionals in the training phases and within the work context.

Psychosocial factors, specifically at work, are present where there are workers and their consequences can be at the individual level, observable in health, and well-being, and/or at the organizational level, observable through work performance, and absenteeism, among others. The International Labour Organization defined such factors as the “interactions between work, its environment, job satisfaction, and the conditions of its organization, on the one hand, and on the other, the worker's capabilities, his needs, his culture, and their personal situation outside of work, all of which, through perceptions, and experiences, can influence health, performance, and job satisfaction” (OIT, 1986, p. 3).

On the other hand, it has been clearly distinguished that the presence of psychosocial factors depends on the direct relationship with their context and the work that individuals perform. Certain factors can, in turn, be the cause of various imbalances, such as those mentioned above. This suggests, in itself, that the psychosocial factors present must be characterized in consideration of the environment, its demands, and the individuals who are immersed in mentioned environment.

Likewise, gender differences, their needs, culture, and situation outside of work must be considered, because they generally focus on what is related to the consideration of the gender perspective. This perspective refers to the full recognition of the existing differences by gender, needs, culture, and the situation outside of work (Niño Contreras and Sánchez Pérez, 2020; Pérez et al., 2019). This has been treated internationally as a problem and specifically in all those environments where there is gender inequality and discrimination (Pineda, 2017).

For this reason, to give certainty to the above, in Mexico there are specifically two norms related to psychosocial risk factors and labor equality and non-discrimination. The first is the recognition of existing problems within organizations and this is directly addressed in the NOM-035-STPS-2018 standard (Patlán-Pérez, 2020). Specifically, to give extreme importance, it refers to Psychosocial Risk Factors. On the other hand, the NMX-R-025-SCFI-2015 standard refers to labor equality and non-discrimination, by directly dealing with such differences (Romero, 2018). In terms of discrimination, the second, once implemented in the work centers and recognizing its objective, is included within the first one. That is, the norm relative to psychosocial risk factors, which is mandatory, fully recognizes the advantages of the second, which is optional to apply, excluding certain regulations within it because they are included in the second (Patlán- Pérez, 2020). That is, if an organization decides to implement the second standard, which is optional, and at the time of implementing the first, certain sections of it are not evaluated, since the second includes them.

4. METHODOLOGY

4.1 Activity Theory

This theory helped discover knowledge within the environment even when individuals are unaware of its existence. In addition, it provided the theoretical, methodological and practical foundations to study psychosocial risk factors within the university teaching process. Here, the consciousness of the process, activity (or behavior) is a product of itself and works by studying it holistically (Kaptelinin, 2005). Also, this process results from its continuous realization, human interactions, and experiences with other individual beings within the surrounding environment directly influencing mentioned process. In addition, the process is aimed at achieving objects or objectives to generate results (Leontév, 1978). On the other hand, the theory considers that individuals have a social nature and are directly influenced by their culture, language, and behavior of other individuals located in the surrounding organizations. Commented organizations can be the family, communities, groups, among others.

The previous assumptions helped to understand the motivations in this process. These motivations can be cognitive (generated inside the human being) and social (generated outside). In the same way, these motivations determine the goals to be achieved, being affected by the existing conditions of the surrounding environment. In turn, goals are made up of actions aimed at achieving goals. Hence, actions are carried out by operations performed automatically or routinely under stable conditions within the environment. Otherwise, if the conditions are unstable, the trades become stocks to the point where the conditions become stable again and the stocks are once again converted to trades. This is a cycle of the human process or activity that is repeated in direct relation to the conditions of the surrounding environment. The foregoing shows that capturing its essence is a challenge that was carried out in routine operations within the contexts of interest, particularly the discovery of psychosocial factors.

Likewise, the theory generated the basis to find and use each element of the process under study. These are: what subject(s) carry out the activities or the process, what are their object(s) or objective(s), what tools (mental and/or physical) they use to mediate the activity or the process, which community is involved, what rules and norms of interaction they follow, how they divide the work, and what is the expected result. In the same way, this theory helped to make sense, and understand the information collected, this is why activities must be understood through what people do, and why they do it. Additionally, its understanding was holistic based on its dynamism, and complexity closely related to its environment, providing conditions to interpret and study activities in its natural environment. This was through the support of methodological strategies for the collective case study, increasing its knowledge with analytical, and non-statistical generalizations.

Furthermore, the theory suggests that all activities are governed by the following principles: all human activity is collective, mediated by artifacts or tools, and goal-oriented; there are multiple opinions; it has a history resulting from transformations carried out over time; tensions and contradictions are the origin of these changes thus developing mentioned process or activity; and this can have various expansion transformations resulting in changes and innovations as a consequence of the accumulation of tensions and contradictions (Engestrom, 1999). The latter can be located in each element of the activity (primaries); related to each other (secondary); related between the motives/objects of a central element of a system, and the motives/objects of a more culturally advanced element (tertiary); and related between the core activity and other nearby (quaternary) activities (Engestrom 2001).

4.2 The Case Study

In Mexico, there are different types of universities and each one of them seeks to achieve different objectives, which are requested by its central bodies. These universities are mainly classified as public and private. Private universities are run by a board of trustees, and these universities are primarily focused on generating profits for their board members. On the other hand, various government agencies administer public universities. These define the objectives to be achieved by commented universities. Usually, the main objective is to develop the competencies required to secure work in undergraduate students' students. This is the case of the institute participating in the study, it is a public university that depends on a government agency. This institute is a campus of a decentralized organization of the federal government that groups 254 institutes, four equipment development centers and two research centers. These institutes and centers are located in the main cities of the nation. In addition, it is important to point out that the government body regulates the degree programs as well as the contents of the various subjects that make up these academic programs, focusing mainly on the training of engineers. Hence, it is relevant to note that the participating institute is located in a city located in the northwest of Mexico. This population's main characteristic is the convergence of the different cultures existing in the region, providing it with unique characteristics compared to other cities located in the nation.

On the other hand, the institute, as a crucial representative of the government organization, must provide the place and environment necessary to achieve the goal, with a close link between students and teachers. In the same way, in turn, the teacher is a mediator between the institute and the students. The foregoing allows the teacher to generate their own ways to achieve the objectives indicated within the study programs that make up the academic programs. This includes the different norms that regulate the learning process in the institute and its objective is the satisfaction of the institute and the students, tacitly including the satisfaction of the teacher. To verify the fulfillment of the various tasks within the teaching process and the achievement of its objectives, the teacher must plan and implement the particular objectives set out in each of the syllabi of the study program. For this, the professor presents in the initial stage of the semester the planning for the achievement of the particular objectives and is verified three times throughout the semester in order to confirm the achievement of declared objectives. It is relevant to point out that the program presents the need to have prior knowledge, which is required by students so that they can take these subjects within the study program. This is for the student to relate of previous knowledge and its application in the competencies to be developed within the subjects to be studied.

Therefore, this research was carried out during the period from January 2020 to July 2021, involving Industrial Engineering students from the TecNM/ITT. This was inviting students who are enrolled in the institute from the first to the twelfth semester in the face-to-face and semi-face-to-face study modalities. The face-to-face modality refers to students fully dedicated to their studies. On the other hand, semi-face-to-face students are those students who take face-to-face classes in order to obtain advice on those topics that are complex to learn and to reinforce them, they require direct advice from teachers. This type of modality was created to satisfy the demand of those people who want to study engineering combining the studies with their work. In particular, at this stage of the research, all students were considered who, despite being considered as students who are completely dedicated to their university studies, some of them work. These students generally work in companies where they recognize their partial studies in Engineering and are treated as Engineering practitioners. This provides an additional status to that of student and relevant information from both contexts considered in this research: academic and work. This allowed to enrich the investigation.

4.3 Methods to Collect Data

The methods used to gather information served to examine the unique and routine events that happen in the university teaching process; contemplate the individuals, and the physical and intellectual tools used; inspect the sub-processes, activities, actions, and operations carried out; and explore the subsystems, systems, and supra-system in which the subjects participating in mentioned process are immersed. Two methods were used to collect data during field work. On the one hand, various documentation related to the university teaching process, and that provided by the institute were reviewed. The data included were the contents of the subjects, organizational manuals, information generated during the semester by each teacher who teaches the subject under study, rules, and regulations, among other documents used in the routine operation of the institute. 35 documents were obtained from the institute. Similarly, a professor provided all the materials used in the teaching process during the semesters January-June 2020, August-December 2020 and January-June 2021. Said professor taught the subjects Operations Research I and Operations Research II averaging 34 students in each of the four groups assigned each semester, serving 120 to 160 students per semester. The documents obtained contain the information generated during the semester: copy of the exams; a task that aims to make a summary of a scientific article related to

Operations Research; a final project report and requested questionnaires related to the learning process. Approximately 950 documents that included exams, assignments (summaries), and blueprints were compiled for further analysis.

On the other hand, a questionnaire was conducted which included open-response questions and consisted of a battery of 14 items. These questions focused on discovering each of the elements of the human activity system represented by the university teaching process. For this, a bibliographic review was carried out regarding the main factors involved in the university teaching process. The second task was to change commented questionnaire to electronic format to be disseminated among the students. Here, the tools provided by Google® were used. 399 responses were collected during the three semesters. It is important to note that only students taking the subjects indicated above were considered.

In the same way, a second questionnaire was developed using as a basis the Norm NOM-035-STPS-2018 relative to psychosocial factors (Patlán-Pérez, 2020) and the questionnaire developed by Niño Contreras & Sández Pérez (2020). This questionnaire was put online in one of the tools provided by Google®. This questionnaire consists of a battery of 107 items identifying gender inequity and psychosocial factors. Additionally, three pilot tests were carried out to refine details for a better understanding of commented questionnaire. It is relevant to note that at the time of writing this article, only 15 students had participated, nine female and six males. The results are considered initial with the objective of obtaining the participation of a large percentage of students in both modalities.

Also, it is necessary to emphasize that the research was carried out in adherence to ethics and good customs in the handling of the data, and information generated. For this, everything was encrypted, thus ensuring its confidentiality during its collection, and analysis process. In addition, this research takes into consideration the TecNM/ITT Code of Conduct to ensure the proper use of the information obtained and its analysis.

4.4 Analysis Methods

The Activity Theory as an analytical tool allowed us to understand the relationships between individuals, the object of the process or activity and the mediation of components at the individual and group or collective level. This was within the learning process in order to discover that each individual can be considered separately and in turn, forming part of the whole. In other words, within the process, each individual is linked to it but exhibiting shared goals for the achievement of the object of the activity. Its deconstruction generates some advantages in order to obtain important knowledge about how motivations move, which are directed to the achievement of goals within the learning process where social and cultural residues are integrated in the context under study. This is made possible by the activity sequences that are framed using the Activity Theory. Figure 1 presents the general form of the activity system.

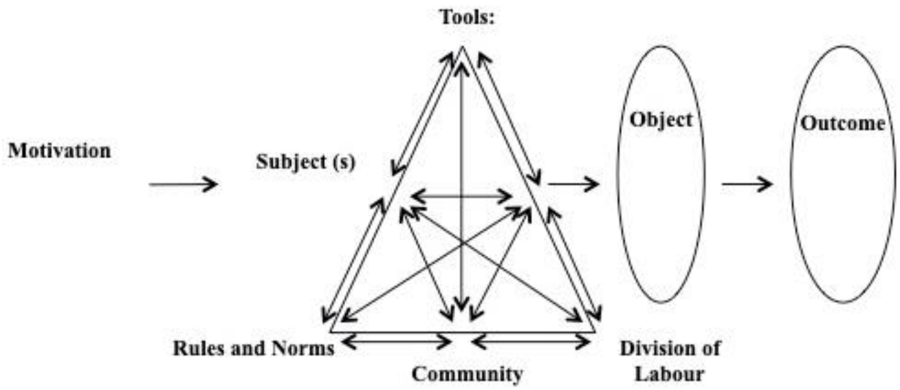

Figure 1. The structure of a human activity system (adapted from Engestrom, 2001)

However, the activity as a unit of analysis offers advantages and disadvantages to study what is happening in the teaching process. These are found in the way in which the activity should be analyzed. To achieve this, three generations of the Activity Theory were developed. The first focuses on the idea of mediation by artifacts or abstract and material tools. The second is based on the concept of collective mediation by rules and norms, community and division of labor. The figure above shows both the first and second generation in the shape of a triangle. The first generation includes the motivation, subject (s), tools, object and result. The second generation incorporates the rest of the elements shown in the figure. The third generation presents the opportunity to study those related to the dialogues and diversity between different perspectives, traditions or systems (Engestrom, 2001).

Therefore, an interpretive approach is chosen as a feasible approach to obtain a deep understanding of the diversity of perspectives on the university teaching process as a natural context under study. To do this, multiple methods were used to capture the little-known of the context (Denzin and Lincoln, 2000), mentioned above. The case study is considered a viable approach as the research includes and is centered in a natural context. Also, this type of approach provides advantages over other approaches to investigate the nature of the university teaching process at the mentioned institute.

Hence, the human activity system allows decomposing the university teaching process into its elements, described in section 3.1. This allows knowing its object(ivo), its actions in the achievement of goals and the routine operations carried out in direct relation to its surrounding context. This is a characteristic of these systems for being unstable and the Activity Theory helped to obtain knowledge of these through understanding the human system and its dynamic nature. In the same way, this theory allowed to know in depth and its scope within the context under study. Thus, in its analysis its elements were sought and once these were discovered, the tensions and contradictions existing within the system and in relation to other systems around the university teaching process were found. These were at the primary level (each element of the system); secondary (between the elements of the system); tertiary (between the objectives of this system and a culturally advanced system) and, finally, the quaternary (are those between close systems).

All the data obtained were transcribed verbatim and analyzed applying an open, axial and selective coding approach. These data were examined to saturate the categories referring to the elements of the activity system of each individual who participates in the university teaching process. Three activity systems were created and linked into one, displaying the shared objectives. Special emphasis is placed on finding the aforementioned contradictions and tensions. In addition, the discovered elements were used to discover links in light of the contextual characteristics that give meaning to the relationships between their elements and the activity systems. The motivations and uses of the tools are two elements that opened the discussion referring to directly or indirectly affecting the university teaching process.

Along these lines, the encounter of contradictions and tensions revealed the clash of the elements, but also, this revealed the gaps to innovate the teaching process. Also, the review of information that was generated during the semesters of the study had the objective of knowing those contradictions and tensions within said process. This could be observed in the exams, assignments and projects carried out. This also included discovering the main physical and intellectual tools used in the process; the rules and regulations that regulate routine work and interpersonal relationships; the division of labor through what is indicated in each of the personal jobs. In the same way, this helped to identify the various activities, actions and operations required in routine work in university teaching.

Finally, each student who participated in this research was contextually analyzed and the importance of their activities within the system was understood. The same was done for each document and questionnaire reviewed. Also, it was performed by each element of the human activity system. This provided additional information to propose improvements in the university teaching process. Here, the analysis focused on psychosocial factors from a gender perspective. Therefore, the results to be presented below are partial results of an ongoing investigation, where it is expected that they will partially change and additional categories will emerge. In the same way, it is expected that the results provide additional information that enrich the ways to mitigate these psychosocial factors for the benefit of the students who graduated from the institute.

5. RESULTS

The results obtained show various problematic situations in which students are immersed inside and outside of school. Within the school, those related to social interactions with fellow students, teachers teaching the various subjects, and other support personnel in university teaching can be pointed out. Within their work environment, they are interactions with their co-workers, including staff with higher responsibilities and authorities and other students having similar responsibilities. Therefore, below are the categories where problems have been located that were classified as psychosocial risk factors affecting their performance in both contexts.

5.1 Academic Situations

This section refers to all those uncomfortable situations that have involved students, regardless of gender. These can be from compliments, comments and undesirable messages. Although it is generally assumed that these only involve female students, it was found that male students have also been involved. In addition, female students indicate that they have been immersed in this type of situation within the workplace. These kinds of situations have also involved male students. In the same way, the female students point out that this type of situation has involved, for the most part, male students and, to a lesser degree, male teachers within the academic environment. Despite being an uncomfortable situation with male teachers, female students point out that there is no comparison in degree of frequency with what they live in the work context. On the other hand, male students indicate that there is an understanding of what female students are within the work and academic environment. Uncomfortable situations can be understood as ignorance of a human being and lack of professionalism that harms work and academic contexts. Likewise, this is clearly indicated in the case of male teachers.

5.2 Discriminatory Expressions

This section refers to all denigrating expressions that are used within work and academic environments, regardless of gender. The female students mention that, within the academic context, unfortunately it is a practice that generally occurs among female students and to a lesser extent, among male students. That is, female students use these expressions to refer to other female students. Otherwise, male students use them to a lesser degree referring to female students. On the other hand, the female students point out that in the labor context there is a greater degree of denigrating expressions of the professional-men referring to the female professional. In the case of teachers, female students and male students do not indicate the use of these expressions by them and they within the academic context.

5.3 Dual Presence Activities

This section refers to interference in the work relationship with the family and specifically with that influence that one has with family responsibilities. This was generally pointed out by female students who had the additional responsibility of being a mother. In these cases, the students indicated that there were additional personal and professional challenges carrying out the roles of student, worker and mother at the same time. Although they acknowledged receiving support from their families and partners during the times in these roles, they sometimes had to temporarily leave these roles to attend to their responsibilities as a mother. This put in evidence the academic difficulties that these roles represented and this was evident in the absences to work, to classes and sometimes, leaving mainly the student role. In addition, certain students left their studies for periods ranging from one semester to four to meet this responsibility. Additionally, several students showed that they had failed the subjects as a result of not being able to attend to their academic responsibilities due to attending to their responsibilities in the role of mothers. Also, certain students indicated that they consequently fell behind in their studies.

5.4 Gender Discrimination

This section refers to the exclusion in certain responsibilities with close reference to gender. This can be seen in perceiving gender equality; however, the facts show otherwise. For example, female students noted that it was common practice to believe that areas of career opportunity were those related to quality. This is because women develop competencies that are appreciated in the work environment. This was confirmed by the male students and they also pointed out that it was commented on by certain male teachers and some female teachers in the classes, in addition to certain female students. In the same way, certain female students confirmed that, in their experience, most of the work had been offered a job in quality areas. Therefore, job responsibilities in certain areas of companies such as manufacturing, engineering, maintenance, etc., are generally awarded to male students, putting female students in second place.

5.5 Social Background

This section refers to the working conditions of recruitment in the work environment and the existing conditions in the academic environment. The female students and the male students indicated that there are similar conditions in the academic environment and there are no differences of any nature. On the other hand, male students indicated that, to the best of their understanding, the working conditions of recruitment differ from those of female students. Mainly, this can be verified with the wages received. Although this is not conclusive since it is a sensitive issue in professional terms, the female students pointed out that there is a difference in the area of salaries. Another difference in working conditions is relative to additional benefits such as health insurance. Male students suggest that they offer better benefits than female students. The foregoing has not been corroborated by the female students.

5.6 Workloads

This section refers to workloads in work and academic environments. The female students indicated that there are differences in workloads in the workplace in relation to male students. They suggest that the main reasons are the responsibilities that male students have and this can be seen in the salaries received. Although this is not conclusive, male students perceive that the workload is closely related to the salary received. However, the female students indicate that these differences have an advantage in academic terms, this allows them to focus on performing the required activities in the academic context. The above can be perceived as a way to minimize the working conditions of the contract.

5.7 Work Schedules

This section refers to working hours in the work context and hours in the academic context. The students-women and students-men did not perceive differences in the schedules within the academic context. On the other hand, male students did perceive differences in their working hours in reference to female-student working hours. They suggest that their working hours are longer than those of their colleagues and this is a consequence of the salary differences that are perceived by them. That is, the working day is longer because her salary is higher compared to that of her colleagues. On the other hand, certain female students suggest that this is not always the case. They suggest that a cause may be the lack of certain skills to manage responsibilities; although, they pointed out that another cause may be the workloads to which male students are exposed.

6. CONCLUSIONS

The results show that Industrial Engineering students are immersed in various problematic situations that can be classified as psychosocial risk factors. These situations are directly related to gender and particularly, in the context in which they are immersed. On the one hand, the academic context has presented certain situations that indicate a difference between female students and male students. These differences are discovered in the degree of propensity to be immersed; but even so, students regardless of gender are prone to awkward situations. On the other hand, female students are more likely to be immersed in uncomfortable situations within the work context. This shows that this psychosocial risk factor affects students of both genders. Also, another psychosocial risk factor that can involve both genders is discriminatory expressions. This factor occurs in different degrees in direct relationship between genders.

In the same way, other factors that present degrees of affectation are the activities of double presence and discrimination by gender. These psychosocial risk factors are directly related to gender and are more prevalent in the workplace. Here, it can be pointed out as a consequence of the responsibilities involved in being a mother. In addition, it was pointed out as a cause of late completion of Engineering studies, particularly female students in the role of mothers. On the other hand, female students point out that their job opportunities are sometimes limited to certain job areas, such as only quality. This suggests the loss of job opportunities and professional development in areas other than the one mentioned.

Likewise, these differences between female-students and male-students can be consistently observed in the salary received, workloads and working hours. In the first case, the salaries of the female students are lower compared to the salaries of the male students. This is partially overlooked by female students due to the weighting represented by the workloads and working hours in which male students are immersed within the work context. This allowed female students to focus on completing their undergraduate studies in the best possible way.

Therefore, it can be seen that some of the psychosocial risk factors can occur both in the academic context, and in the work context. The difference between them is the degree of presence. In other words, Industrial Engineering students are prone to being immersed in psychosocial risk factors within the academic context, and within the labor context. However, the psychosocial risk factors that occur in the workplace are notorious and can limit the professional and personal development of students close to graduation.

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ERGONOMIC ANALYSIS IN THE GREENHOUSE TOMATO PRODUCTION PROCESS FOR THE DETECTION OF MUSCULOSKELETAL LESIONS

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Resumen El cultivo del tomate convirtió a Sinaloa en la economía agroexportadora altamente competitiva que hoy conocemos; alrededor de este se fueron creando empresas con efectos de arrastre, relacionando un conjunto de industrias para conformar un sistema organizado de productores, instituciones financieras y empresas transportadoras; también se desarrollaron aprendizajes sobre técnicas de cultivo, comercialización e incursión en los mercados. (Hustick Meléndez, 2014).

El Tomate es una de las hortalizas que se cultiva en mayor extensión en el mundo. En el caso de la producción bajo invernadero, se cultivan principalmente genotipos de tomate de crecimiento indeterminado, de diferentes tamaños de fruto: pequeños (‘cherry’ y uva), medianos (‘cocktail’), y grandes (gordos, para racimo y ‘saladette’) (Castellanos, 2009). El rendimiento de tomate responde a diversas variables, como el tipo de tomate, el peso del fruto, el ciclo de cultivo, el genotipo, las condiciones ambientales, la presencia de plagas y enfermedades, la densidad de siembra, y las podas (Monge-Pérez, 2019).

El progresivo incremento de la producción de tomate en los últimos años se sustenta en la agricultura bajo condiciones de invernadero, donde se permite obtener los mayores rendimientos por hectárea (SIAP, 2018). En las cosechas del vegetal, los agricultores mexicanos obtienen rendimientos importantes, los cuales superan la media internacional. El estado de Sinaloa es el mayor productor de tomate, con 1,088,252 toneladas en 2018 (SIAP, 2019).

Las tareas que se realizan en el campo dan lugar a frecuentes problemas musculo esqueléticos, la mayoría de los trabajos, como invernaderos exigen un considerable esfuerzo físico que sumado a la naturaleza repetitiva de muchas tareas, supone un riesgo considerable de lesiones por movimientos repetitivos. Además las condiciones ambientales asociadas a las tareas en invernadero, puede agravar las consecuencias de las lesiones. (Portal para la promoción de ergonomia en el sector agrario , 2015) El objetivo de este trabajo es realizar un análisis ergonómicos en el proceso de producción de tomate en invernadero para la detección de lesiones musculoesqueléticas, se tomará durante 2 semanas muestras representativas para realizar el análisis de datos e identificar las lesiones musculoesqueléticas a las que están expuestos los trabajadores.

Palabras clave: Invernaderos, siembra, jornaleros, ergonomía

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

Abstract: Tomato cultivation turned Sinaloa into the highly competitive agro-export economy that we know today; A round it, companies with drag effects werw created, linking a set of industries to form an organized system of producers, financial institutions and transport companies: Learning about cultivation, maketing and market foray techniques were also developed. (Hustinck, Melendez, 2014).

Tomato is one of the vegetables that is grown to the greatest extent in the world. In the case of greenhouse production, mainly undetermined growth tomato genotypes are grown, of different fruit sizes: small ('cherry' and grape), medium ('cocktail'), and large (fat, for bunch and ' saladette ') (Castellanos, 2009). Tomato yield responds to various variables, such as the type of tomato, fruit weight, crop cycle, genotype, environmental conditions, presence of pests and diseases, planting density, and pruning (Monge- Pérez, 2019).

The progressive increase in tomato production in recent years is based on agriculture under greenhouse conditions, where it is possible to obtain the highest yields per hectare (SIAP, 2018). In the crops of the vegetable, Mexican farmers obtain important yields, which exceed the international average. The state of Sinaloa is the largest tomato producer, with 1,088,252 tons in 2018 (SIAP, 2019).

The tasks that are carried out in the field give rise to frequent musculoskeletal problems, most of the jobs, such as greenhouses; require considerable physical effort that, added to the repetitive nature of many tasks, poses a considerable risk of repetitive motion injuries. In addition, the environmental conditions associated with greenhouse tasks can aggravate the consequences of injuries. (Portal for the promotion of ergonomics in the agricultural sector, 2015) The objective of this work is to carry out an ergonomic analysis in the greenhouse tomato production process for the detection of musculoskeletal injuries, representative samples will be taken for 2 weeks to perform the data analysis and identify musculoskeletal injuries to which workers are exposed.

Keywords: greenhouses, ergonomic, sowing, Laborers

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

1. INTRODUCTION

Protected agriculture is one that is carried out under conditions in which the farmer can control some environmental factors. Thus, it minimizes the impact that climate changes cause to crops. The most used structures in protected agriculture are greenhouses, shade mesh, high and low tunnels. (MEXICO, 2016).

In Mexico there are 40 thousand 862 hectares planted with protected agriculture, 22.2 percent (more than nine thousand hectares) are in Sinaloa, ranking as the leading entity at the national level in this production system. The area sown with protected agriculture represents 0.7 percent of the total area sown in Sinaloa; however, the value of production represents 11.1 percent. In the northern entity seven municipalities concentrate protected agriculture: Culiacán, Navolato, Elota, Guasave, Mocorito, Mazatlán and Escuinapa; of these, Culiacán and Navolato have 90 percent of planted area (8 thousand 157 hectares), of production 852 thousand 514 tons) and value of production (4 thousand 719 million pesos). (SADER, 2019) (4 mil 719 millones de pesos). (SADER, 2019).

The progressive increase in tomato production in recent years is based on agriculture under greenhouse conditions, where it is possible to obtain the highest yields per hectare (SIAP, 2018). In the crops of the vegetable, Mexican farmers obtain important yields, which exceed the international average. The state of Sinaloa is the largest tomato producer, with 1,088,252 tons in 2018 (SIAP, 2019).

The tasks that are carried out in the field give rise to frequent musculoskeletal problems, most of the jobs, such as greenhouses, require considerable physical effort that, added to the repetitive nature of many tasks, poses a considerable risk of repetitive motion injuries. In addition, the environmental conditions associated with greenhouse tasks can aggravate the consequences of injuries. (Portal for the promotion of ergonomics in the agricultural sector, 2015) The objective of this work is to carry out an ergonomic analysis in the greenhouse tomato production process for the detection of musculoskeletal injuries, representative samples will be taken for 2 weeks to perform the data analysis and identify musculoskeletal injuries to which workers are exposed.

2. OBJETIVES

2.1 General objective

Perform an ergonomic analysis in the greenhouse tomato production process for the detection of musculoskeletal injuries.

2.2 Specific objectives

- Carry out a diagnosis of greenhouse tomato production activities to detect risk factors.

- Apply evaluations for the identification of cumulative musculoskeletal injuries and trauma disorders through the Corlett and Bishop Body Discomfort map method (Corlett, 1976), and the Rula Method**.**

3. METHODOLOGY

1. Carry out a diagnosis of the greenhouse tomato production area through tours, identifying the characteristics of the workers, work stations to detect risk factors.
2. Apply ergonomic evaluation methods, RULA Method and Corlett and Bishop to detect musculoskeletal injuries in workers.
3. Proposal for improvements in the work system or recommendations.

4. RESULTS

The Tecnológico Nacional de México campus Guasave has a greenhouse 20 meters long and 10 meters wide for vegetable production processes. The variety of Tomato that is handled in the greenhouse is Hybrid Indeterminate Tomato called El CIF F1 with uniform fruits in size and shape, thick wall, deep red color with long shelf life and high yield.

The greenhouse tomato production process is managed on a stem with a cycle of 150 days, approximately 5 months. The maturation stage begins 100 days after transplanting and is harvested twice a week. With 2 lines per row and each row is separated every 120 cm.

There are 3 workers working in the greenhouse, all men with an age range of 20 to 48 years, with a daily shift of 8 hours. The environmental conditions to which they are exposed during the activities inside the greenhouse are: temperature between 38 to 42 degrees Celsius and a humidity of 70% for 8 hours.

Figure 1. Greenhouse Tomato production process.

During the analysis of the stages, the risk factors that were detected are 3 inappropriate postures, in the cutting activity and measurements of the stems and furrows. As well as it is seen that the activities carried out do not comply with the allowed ranges, of the operator, and raising the arms for more than 9 seconds in each cut with a frequency of 4 cuts per minute.

The RULA ergonomic evaluation method was applied to the 3 inappropriate postures that were detected in the cutting activity.

Figure 2. Inappropriate posture cut number 1

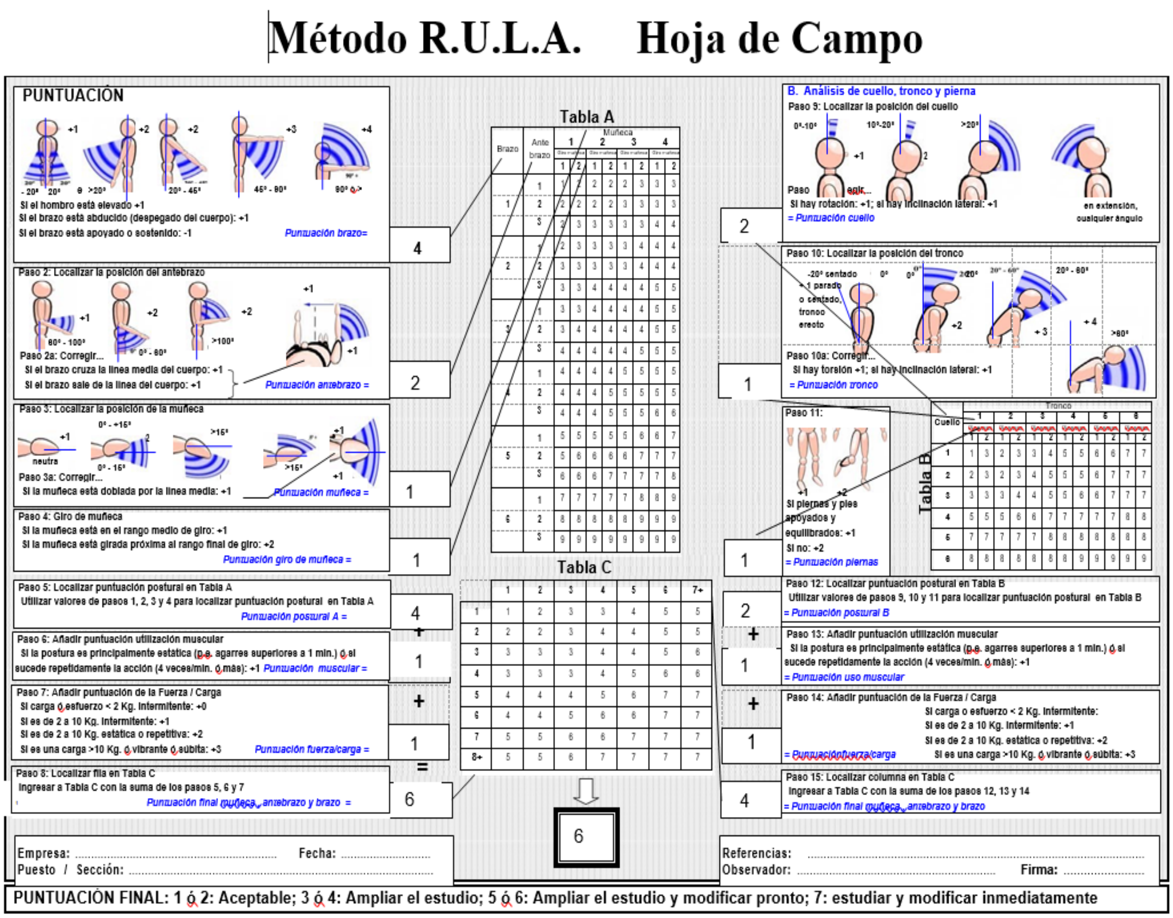


Figure 3. Application of Rula method to inappropriate posture cut number 1.

In the inappropriate position cutting activity 1, the RULA method yielded the result of 6, which indicates that the task needs to be redesigned, making the pertinent changes, because the worker's posture develops cumulative traumatic disorders.

Figure 4. Inappropriate posture cut number 2

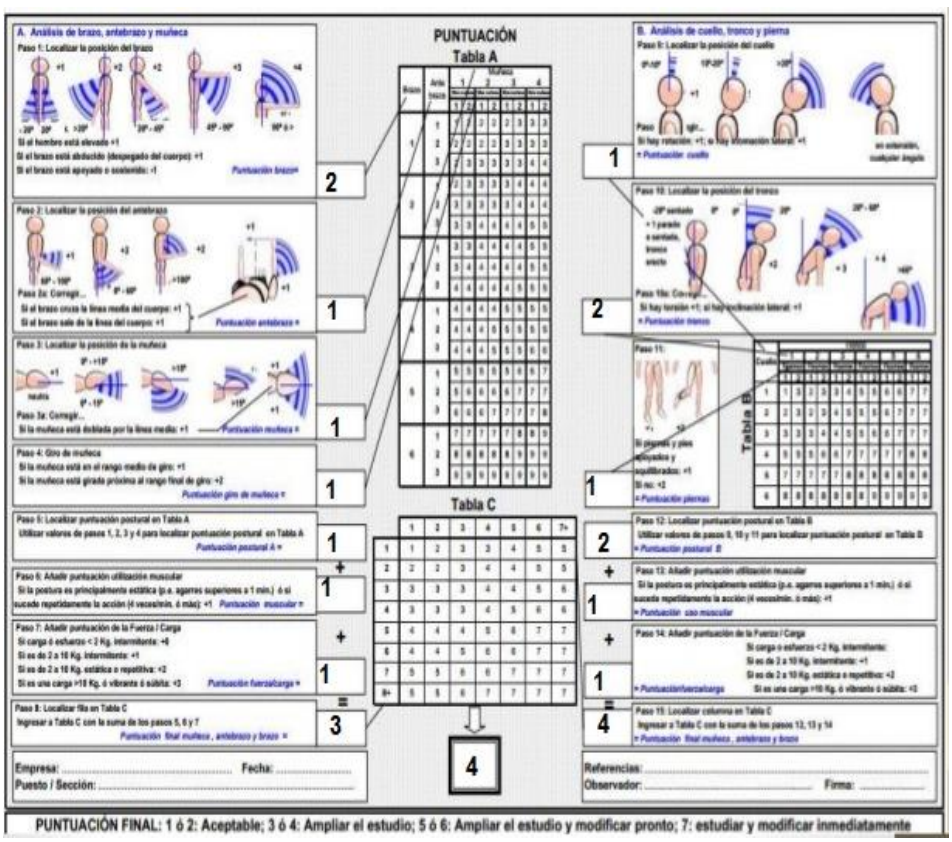


Figure 5. Application of the Rula method to the inadequate posture, cut number 2

In the activity of cut position 2, the RULA method yielded the result of 4, which indicates that the task needs to be redesigned, make changes soon, because with time it will develop cumulative traumatic disorders.

Figure 6. Inappropriate posture cut number 3

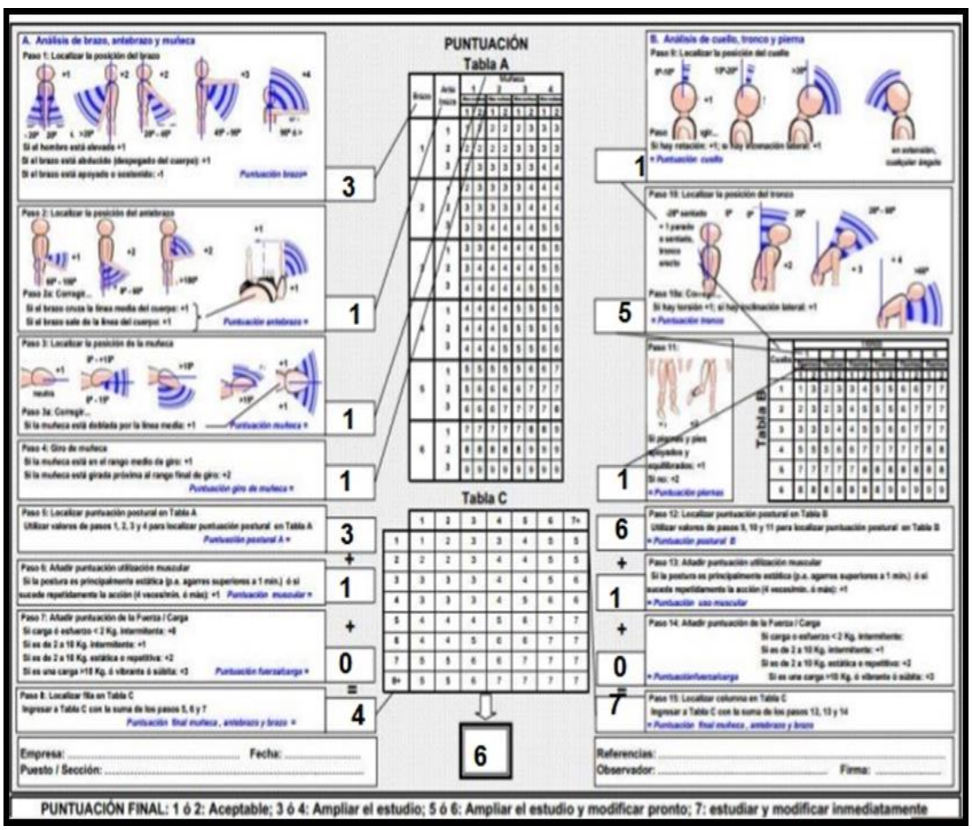


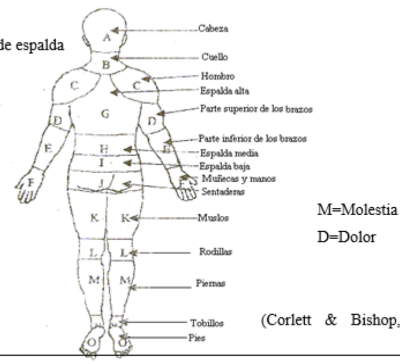
Figure 7. Application of the Rula method to the inadequate posture cut number 3

In the cutting activity in inadequate posture 3, the RULA method yielded the result of 6, which indicates that the task needs to be redesigned as soon as possible, make immediate pertinent changes, because the worker's posture develops Strong cumulative traumatic disorders.

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



(Corlett & Bishop, 1976)

Observaciones:

	ENTRADA							SALIDA						
A														
B	M	M	M	M	M	D	D	M	M	M	D	D	D	D
C	M	M	M	M	M	D	D	M	M	M	M	D	D	D
D	M	M	M	M	M	M	M	M	M	M	M	M	D	D
E														
F														
G	M	M	M	D	D	D	D	M	D	D	D	D	D	D
H	M	M	M	M	D	D	D	M	M	M	D	D	D	D
I	M	M	M	M	D	D	D	M	M	M	D	D	D	D
J														
K	M	M	M	M	M	D	D	M	M	M	M	D	D	D
L	M	M	M	M	M	M	M	M	M	M	M	M	D	D
M														
N														
O	M	M	M	M	M	D	D	M	M	M	M	D	D	D

Figure 8. Application of the Corlett and Bishop method

Through the application of the Corlett & Bishop method in the greenhouse worker, a high risk is registered. In the cutting activity, cumulative trauma disorders (DTA's), aches and pains in: neck, shoulders, forearms, thighs, knees, upper, middle and lower back are recorded. Presenting postural problems, during the work period**.**

5. DISCUSSION/CONCLUSIONS

Ergonomic analysis makes it possible to detect the risk factors to which workers are exposed when they carry out greenhouse operations. The environmental conditions, such as temperature and humidity, to which the workers are exposed, develop a low performance, presenting physical exhaustion, deconcentration, fatigue from 4 days of work. The inadequate postures that the worker presents when performing the task, develops cumulative trauma disorders in the following areas: Neck, shoulders, forearms, thighs, knees, feet as well as lower, middle and upper back. With the application of the RULA Method in these 3 inappropriate postures, level 6, 4, 6 is detected for each posture of analysis.

A proposal to counteract the effect of environmental conditions in a greenhouse is to intersperse the activities inside and outside the greenhouse, as well as the worker's exposure time inside the greenhouse. It consists of doing a rotation of activities, first inside the greenhouse and the next activity outside it, with work periods of two hours and rest of 10 minutes, in order for the worker to take recovery time, to perform tasks within a greenhouse at a temperature of 46 to 48 degrees Celsius. For the taking and selection of the product in high and low heights of the stem, a cutting device is recommended and not perform unnecessary postures in the activity.

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ERGONOMIC ANALYSIS AND IMPLEMENTATION OF A SEMIAUTOMATIC CATHETER SANDING SYSTEM

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Resumen: El propósito de este artículo es dar a conocer el impacto que un análisis ergonómico pude generar en las áreas de trabajo de una empresa manufacturera de productos médicos, la cual viene presentando en los últimos tres años varios problemas de fatiga, lesión y ausencia de personal en el área de producción de lijado de catéter. El contexto de este trabajo muestra los procedimientos necesarios que debieron realizarse durante la investigación para la identificación de factores de riesgo, que sirvieron de soporte para la aplicación o adaptación de las mejoras ergonómicas.

Se realizó una introspección en las líneas de producción para evaluar visualmente las estaciones de trabajo, observando los alcances, posturas, y si la operación es principalmente parado o sentado, para posterior darle seguimiento y realizar el análisis a fondo; adicional se tomó un video que mostro las posturas desarrolladas y la duración de la tarea, así como la frecuencia de los movimientos involucrados en la operación.

Se determinó como herramienta de apoyo RULA (Rapid Upper and Limb Assessment) un método ergonómico bastante digerible y de fácil manejo, además de ser muy confiable al momento de generar diagnósticos de riesgo; este arrojo en extremidades superiores, así como cuello y tronco, un riesgo que oscilaba entre lo moderado (amarillo) y alto (rojo), según correspondía la operación, lo cual dio la pauta a seguir, para que se tomaran las decisiones correctas sobre qué operaciones son más críticas y requerían erradicarse o cambiarse. Se aplicó una mejora correctiva que permitió erradicar el nivel de riesgo en su totalidad en las operaciones involucradas.

La implementación de un sistema semiautomático de lijado de catéter, fue el resultado posterior al análisis del caso, como respuesta inmediata para erradicar las desviaciones posturales, así como los síntomas expresados en el personal por la continua exposición.

Palabras Clave: análisis, RULA, sistema, semiautomatización, lijado.

Relevancia para la ergonomía: El presente proyecto tiene como principal impacto, una expresión diagnóstica objetiva de la exposición postural y los niveles de riesgo derivados de ello, que permitirán gracias a la intervención de este método de análisis propuesto, poder definir los mecanismos de ajuste necesarios para combatir el efecto y justificar la intervención de un sistema semiautomático que ayudara a erradicar la problemática.

Abstract: The purpose of this article is to publicize the impact that an ergonomic analysis could generate in the work areas of a medical products manufacturing company, which in the last three years has been presenting several problems of fatigue, injury and absence of personnel in the catheter sanding production area. The context of this work shows the necessary procedures that had to be carried out during the investigation to identify risk factors, which served as support for the application or adaptation of ergonomic improvements.

An introspection was carried out in the production lines to visually evaluate the workstations, observing the reaches, postures, and if the operation is mainly standing or sitting, to later follow up and carry out the in-depth analysis; In addition, a video was taken that showed the postures developed and the duration of the task, as well as the frequency of the movements involved in the operation.

RULA (Rapid Upper and Limb Assessment) support tool was determined as a fairly digestible and easy-to-use ergonomic method, as well as being very reliable when generating risk diagnoses; this courage in the upper extremities, as well as neck and trunk, a risk that ranged between moderate (yellow) and high (red), depending on the operation, which gave the guideline to follow, so that the correct decisions were made about what operations are more critical and required eradication or replacement. A corrective improvement was applied that made it possible to eradicate the risk level in its entirety in the operations involved.

The implementation of a semiautomatic catheter sanding system was the result after the analysis of the case, as an immediate response to eradicate postural deviations, as well as the symptoms expressed in the personnel by continuous exposure.

Key Words: ergonomic analysis, RULA, semiautomatic system, sanding.

Work area: Work evaluation, work design and analysis.

Relevance for ergonomics: The main impact of this project is an objective diagnostic expression of postural exposure and the risk levels derived from it, which will allow, thanks to the intervention of this proposed analysis method, to be able to define the necessary adjustment mechanisms to combat the effect and justify the intervention of a semi-automatic system to help eradicate the problem.

1. INTRODUCTION

This document will talk about the development of a project to implement a semi-automatic system of a sander, adapted to the production lines of a medical turning company in Tijuana BC, which has been dragging as a consequence, the constant complaints from of the personnel exposed to this activity and therefore the difficulty to use them in this operation of sanding of point. In the same way, the analysis of the design of the semi-automatic system is shown, as well as the ergonomic contribution in the Coronary line of the Guides family of said operation.

The problem has increased in the last year, resulting in disabilities due to health problems, and staff turnover, derived from the methodology used to carry out this task. The main reason is the repetitiveness during the process, which requires a series of postures outside of their normal state, as well as the duration and frequency with which they are performed. It is worth mentioning that the activity takes place during a daily shift from 6:30 a.m. m. at 4:30 p.m. m., with a total of 10 hrs, of which only two breaks are taken with an average time of 10 min each, taking place in the intervals of 9:15 to 9:45 and from 2:10 to 2:40 during the day.

The main complaints of the operators are:

Tiredness in the hand due to poor posture derived from holding the piece.

Tiredness in the shoulder due to the sanding process.

Discomfort in the elbow due to the process of clamping the piece.

The engineering area is at the disposal of designing, machining, assembling and installing a mechanism that reduces the ergonomic risk in this manual process.

2. OBJETIVES

General objective

Detect the different risk situations in the positions of the employees of the catheter sanding lines, in such a way that it contributes to the implementation of the necessary adjustments or redesign in the work area and thus reduces the risk of injuries and the index dropout in operators.**pecific objectives**

1. Carry out the inspection and monitoring for data collection in the catheter sanding area, using RULA (rapid) rapid evaluation of upper limbs as a support tool to determine the level of risk.
2. Implement a semiautomatic equipment for catheter sanding.

3. JUSTIFICATION

Using the RULA analysis method technique, all possible causes of risk of injury can be identified, in such a way that it allows making adjustments in the process, modifying and adapting under a semi-automated sanding system, which improves the quality of life of the operators, thus also allowing them to be certified in operation as indicated by the EHS (Enviroment, health and safety).

4. PROJECT LIMITATIONS

In this project, only the catheter sanding operation will be evaluated in the Guides line of the coronary area in a medical company.

Workers do not feel comfortable approaching the company doctor, so there is no complete record of injury cases in the Guides line sanding area.

5. PROCESS DESCRIPTION:

The operator takes 10 catheters and aligns them as seen in the following image:

Figure 1. Operator holding catheter.
Own source

He inspects them with a special magnifying glass and if he sees one in poor condition, he discards it and inspects it again, as can be seen in the following image:

Figure 2. Operator inspecting catheter.
Own source

Then the sanding begins with a special movement (1 minute approx.):

Figure 3. Operator performing catheter sanding.
Own source

After sanding, an inspection is carried out with a special magnifying glass:

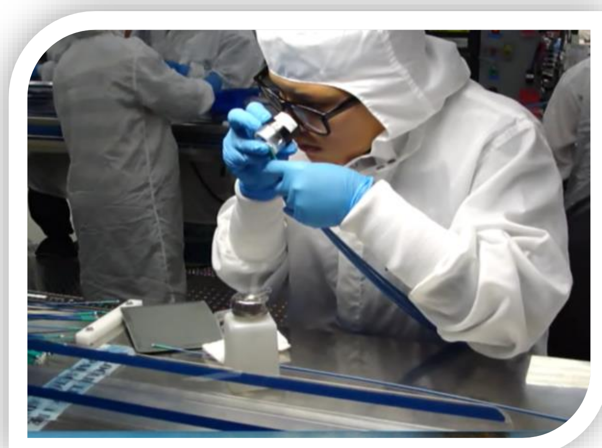

Figure 4. Operator performing second inspection.
Own source

Clean the catheters with a brush one by one as you can see in the picture below:

Figure 5. Operator cleaning catheter with alcohol.
Own source

Dry the catheters in this way:

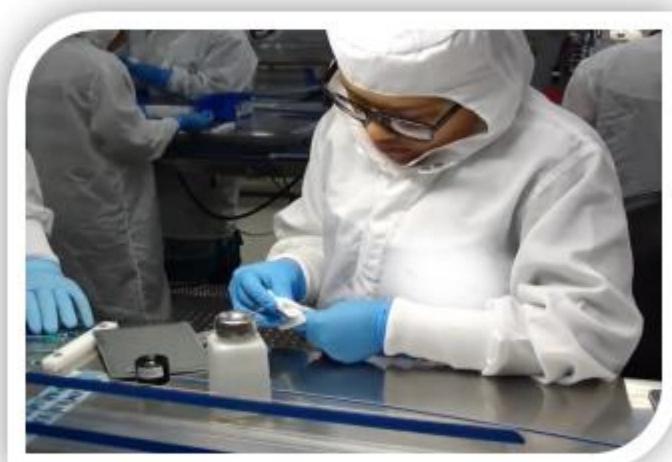

Figure 6. Operator drying catheter.
Own source

He lines them up and snaps them into place and ends their loop like this:

Figure 7. Operator finishes his operation by placing catheter in place.
Own source

6. THEORETICAL FOUNDATION

6.1 Ergonomic evaluation methods

Ergonomic evaluation methods allow the identification and assessment of risk factors in jobs, and later, based on the results obtained, propose redesign options that reduce the risk and place it at acceptable levels of exposure for the worker.

The risk exposure of a worker in a workplace depends on the extent of the risk to which he is exposed, the frequency of the risk and its duration. This information can be obtained through ergonomic evaluation methods, whose application is simple, compared to other more complex techniques or that require more specific knowledge or measuring instruments not always within the reach of ergonomists, such as oxygen consumption measurement, of heart rate, of the force supported by the L5 / S1 intervertebral disc (lumbosacral junction), of metabolic consumption, the use of electromyographs (EMG), etc.

6.2 Occupational diseases related to this activity

Tendon disorders

Tendons connect muscles to bones. When the muscles in the forearm (the movers) contract, the tendons (the cables) pull on the bones (the levers) in the hand, creating movement. This mechanics of movement is also applicable to other areas of the body.

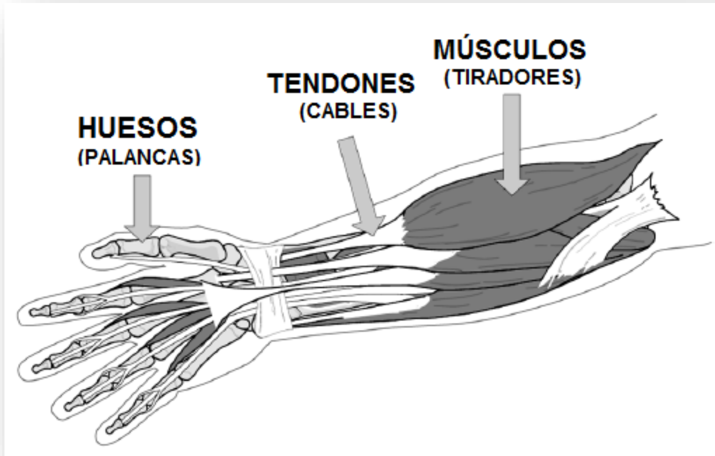

Image 8. Hand and arm lever system.

Tendon disorders usually occur at or near the joints, where the tendons rub against the ligaments and bones. Being exposed to non-neutral postures and powerful or highly repetitive forces can cause tendons or their linings to become inflamed or irritated. The affected area of the body can become inflamed as a result of such contact. The most common symptoms are mild pain over the tendon, discomfort when performing certain movements, and pain on contact.

Tendinitis

All the force of the muscles is transmitted through the tendon cables. If the cables are continually strained, they can become irritated, painful, and inflamed, leading to tendonitis. Tendonitis is a common condition of the wrists, elbows, and shoulders.

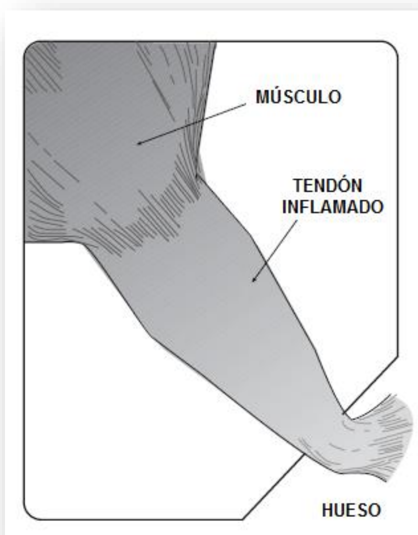

Image 9. Tendinitis- Inflamed tendon

Tenosynovitis

Tenosynovitis is often the result of extremely repetitive movements that cause inflammation of the tendons as well as the walls of the tendon sheath. An accumulation of tissues occurs on the walls of the tendon sheath causing lumps in the tendon sheath.

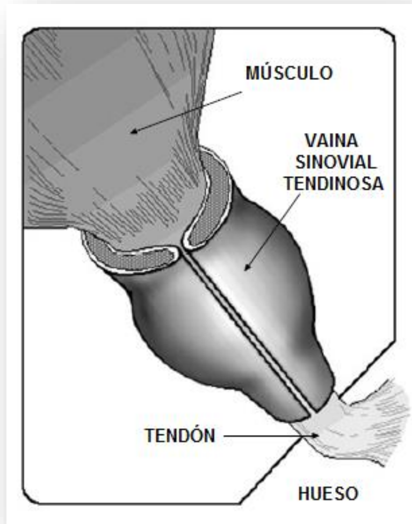

Image 10. Tenosynovitis- Swollen tendinous synovial sheath

De Quervain's disease

It is a common form of stenotic tenosynovitis (a combination of tendinitis and tenosynovitis) in which the tendon and tendon sheath become inflamed at the base of the thumb. It is the result of excessively bending the hand while exerting a strong grip. This condition is named after the French doctor who described it.

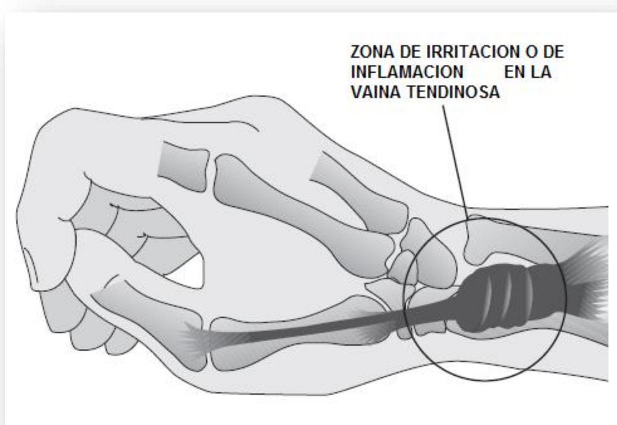

Image 11. De Quervain's disease

Cubital tunnel syndrome

Many people rest their shoulders on the surfaces available in their respective jobs, sometimes to support the weight of the head and sometimes to relieve pressure on the back. The ulnar nerve that runs near the elbow can be compressed when the elbow is exposed to hard surfaces, such as bare tables. This can lead to cubital tunnel syndrome.

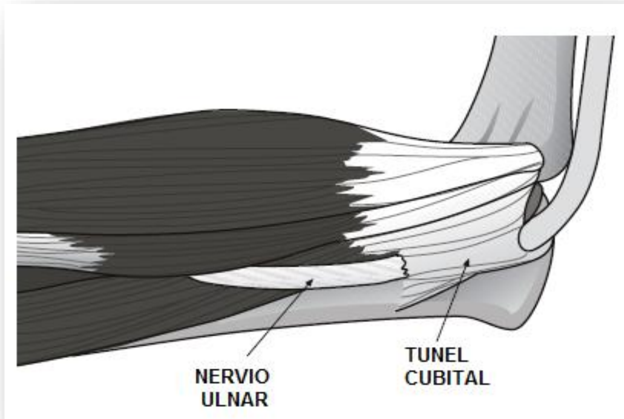

Image 12. The Cubital Tunnel

Thoracic outlet syndrome

Thoracic outlet syndrome is the general term used to describe compression of the nerves and blood vessels between the neck and shoulders. It can occur as a result of activities such as carrying heavy things on the shoulder and repeatedly reaching for objects above shoulder level.

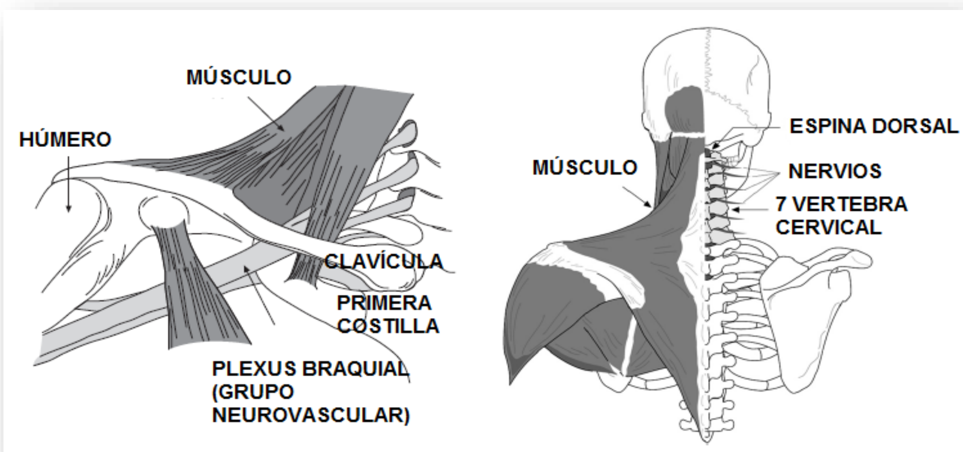

Image 13. Shoulder girdle and neck anatomy

Back disorders

Back disorders are also classified as work-related musculoskeletal problems. The most commonly affected regions are connected with tendons and ligaments, muscles, and nerves. To understand this type of injury, we should have knowledge of the anatomy and mechanisms of the back.

7. METHODOLOGY

7.1 The RULA method

Rapid Upper Limb Assessment

There are various methods that allow the evaluation of the risk associated with postural load, differing by the scope of application, the evaluation of individual postures or by sets of postures, the conditions for their application or by the parts of the body evaluated or considered for evaluation. One of the observational methods for posture evaluation most widely used in practice is the RULA method.

The RULA method was developed in 1993 by McAtamney and Corlett, from the University of Nottingham (Institute for Occupational Ergonomics), with the aim of evaluating the exposure of workers to risk factors that cause a high postural load and that can cause disorders in the upper limbs of the body. For the risk evaluation, the method is considered the position adopted, the duration and frequency of this and the forces exerted when it is maintained.

The RULA method evaluates individual positions and not sets or sequences of positions, therefore, it is necessary to select those positions that will be evaluated from among those adopted by the worker in the position. Those that, a priori, suppose a greater postural load, either because of their duration, or because of their frequency or because they present a greater deviation with respect to the neutral position, will be selected.

To do this, the first step consists of observing the of the tasks performed by the worker. Various work cycles will be observed and the postures to be evaluated will be determined. If the cycle is very long or there are no cycles, evaluations can be performed at regular intervals. In this case, the time spent by the worker in each position will also be considered.

The method should be applied to the right side and the left side of the body separately. The expert evaluator can choose a priori the side that appears to be subject to the greatest postural load, but in case of doubt it is preferable to analyze both sides.

The final value provided by the RULA method is proportional to the risk involved in performing the task, so that high values indicate a greater risk of the appearance of musculoskeletal injuries.

7.2 Development:

When a visit to the sanding area was made, it was easily observed that the working conditions are not adequate, mainly because the people in that position are short and the chair and table do not help their condition at all, making their condition even more difficult. performance creating an ergonomic and productivity conflict.

It was noted that they have acceptable lighting and that their work tools are within arm's reach.

There is an anti-fatigue mat that is detrimental to them because the operator's footprint is not uniform and when spending a few moments on the cover, their foot sinks in such a way that they twist their ankles a little, generating an uncomfortable and risky posture. for them.

When talking with the sanding operators about their working conditions, there was an emphasis on the wrist, elbow and shoulder pain due to the movement they make when sanding and by not having a work area that matches their height, they have chosen to perform the sanding. activity as they see fit without taking into consideration the future problems this could cause them.

7.3 Risk assessment through the method:

The application of the RULA method begins with observing the worker performing his operations and his postures during the operation in various work cycles.

Upper arm posture: The arm posture was observed to be in the range of 45 to 90 ° during the sanding operation.

Figure 14. Upper arm posture
Own source

The following image shows the first part of the evaluation of the upper arm postures, where it was determined that the movement was in the range of 40 ° to 60 ° and that the shoulders were kept elevated during the operation.

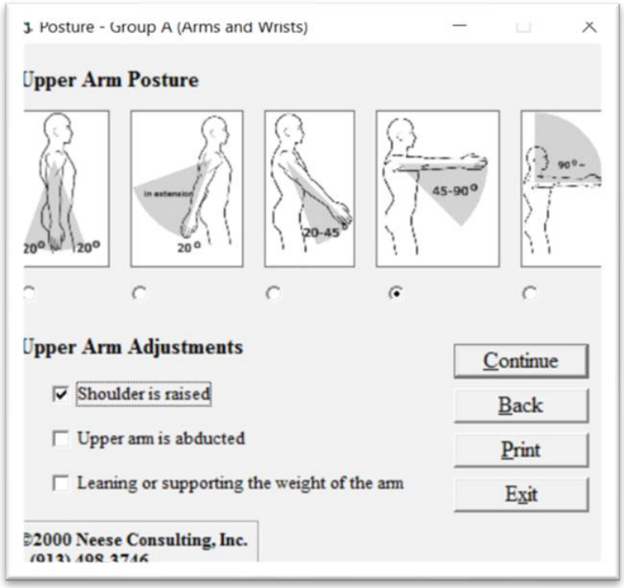

Figure 15. RULA evaluation application in upper arm
Own source

Lower arm posture: the arm movement is in the ranges of 0 to 60 ° and greater than 100 ° always working at a medium distance close to your body.

Figure 16. Lower arm posture
Own source

In the following image, the movement of the lower arm was evaluated, observing that the posture falls within the second option, which is greater than 100 ° and that the movements of the arms are close to the body.

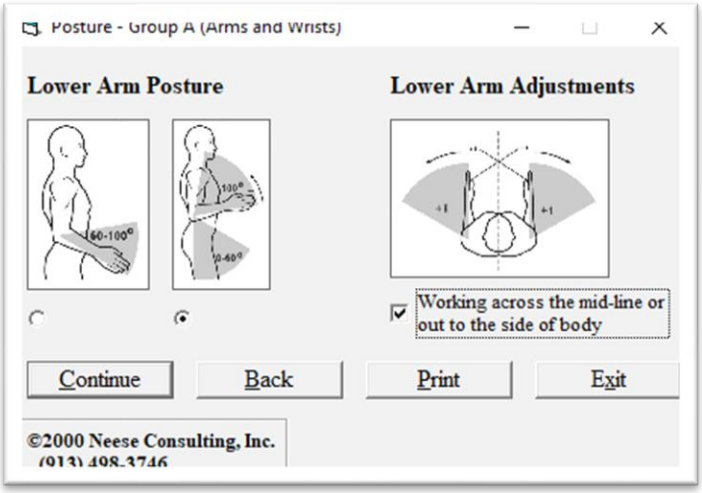

Figure 17. RULA evaluation application in the lower arm.
Own source

Wrist posture: A pronounced wrist posture is observed

Figure 18. Wrist posture during the operation.
Own source

In the following image, the movement of the wrist was evaluated, observing an up and down movement greater than 15 ° and no unusual movement was observed towards the sides of the wrist.

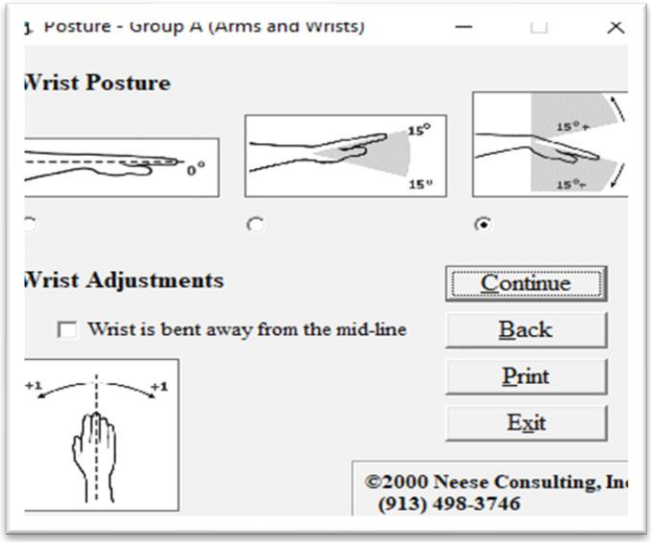

Figure 19. RULA evaluation application on wrist
Own source

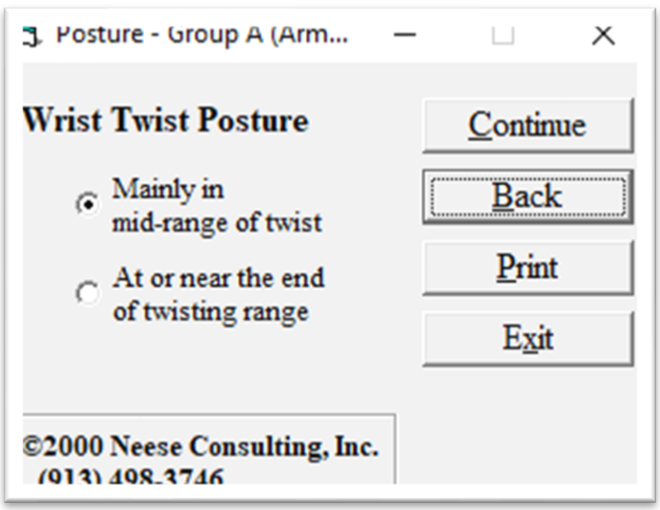

Figure 20. RULA evaluation application on wrist
Own source

Neck posture: The neck position was observed to tilt 20 ° or more forward for most of the operation.

Figure 21. Neck posture.
Own source

Regarding the X and Y axes, a detrimental forward tilt greater than 20 ° was observed and there was no twisting of the neck to the sides.

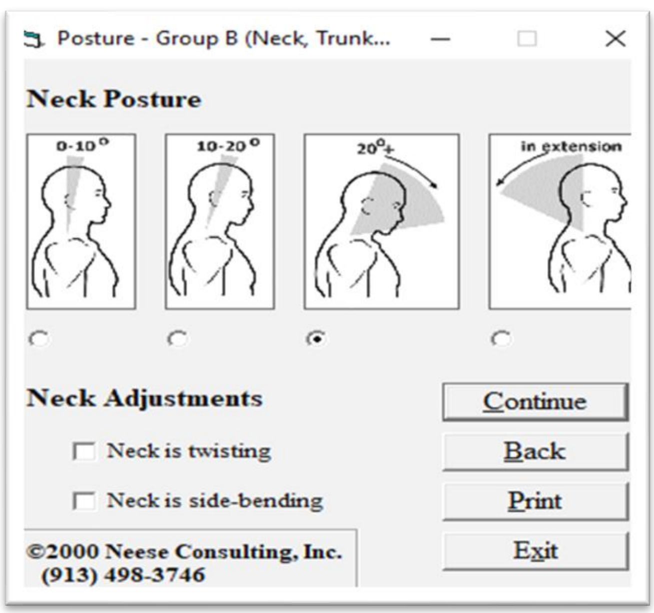

Figure 22. RULA evaluation application on neck
Own source

Trunk posture: The operator's trunk is tilted forward more than 20 ° throughout the sanding operation.

Figure 23. Trunk posture
Own source

A forward inclination of the trunk was observed, oscillating between 20 ° and 60 °. There is no torsion of the trunk.

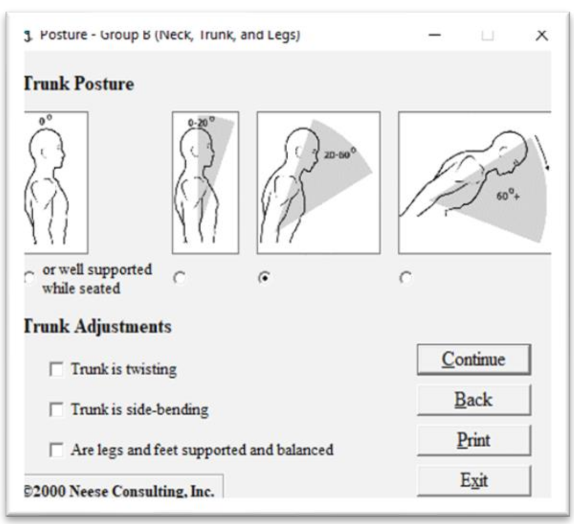

Figure 24. RULA evaluation application on the trunk
Own source

Next, it was weighted in group A (arms and wrists) as a repetitive activity greater than 4 times per minute and a force less than 2 kg was estimated. In group

B (neck, trunk and legs) it was pointed out that it is a moderate and not static and slightly repetitive posture and a force of less than 2 kg was estimated.

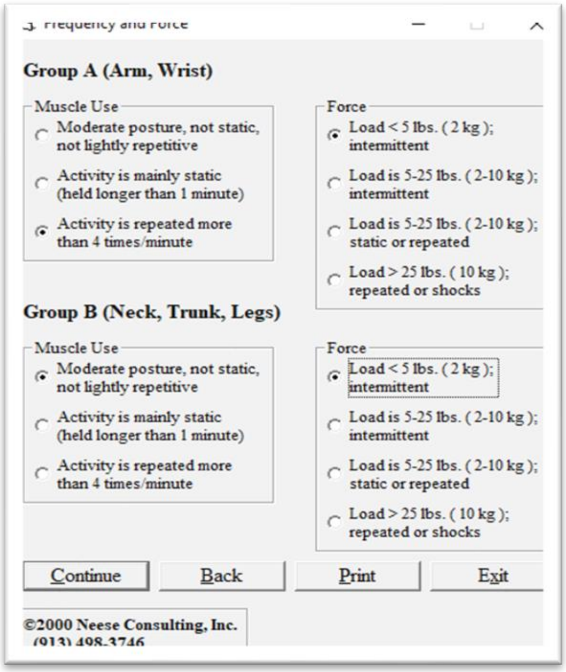

Figure 25. RULA evaluation of frequency and strength
Own source

Upon detecting a work area with risk factors, it was decided to evaluate the area and the operation through the RULA method, taking as a The result was an assessment of the great ergonomic risk faced by operators. By throwing a 7 as a final grade and based on the scale that the same software offers, we realize that the operation and the workstation have a high ergonomic risk.

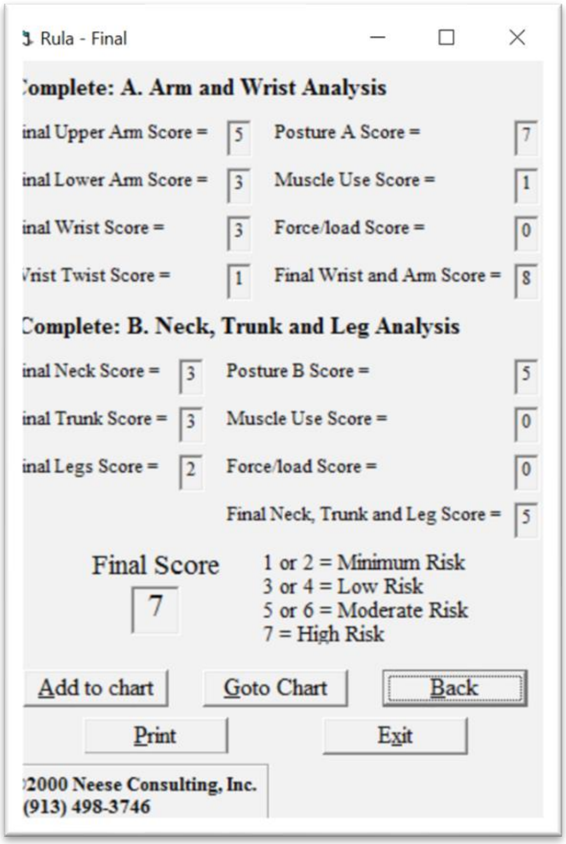

Figure 26. RULA evaluation results
Own source

8. ERGONOMIC CONTRIBUTION

A model based on automation principles was designed through the engineering department that had the necessary characteristics to help develop the sanding task in a semi-automatic way.

For the use of this sander, two manuals were created, a user manual and another maintenance manual for the equipment.

The objective of this manual is to publicize the characteristics and operation of tip sanding equipment and is aimed at the engineering areas involved, technical areas and personnel trained to use it.

8.1 Prototype usage feedback:

GUI-SEMI-automatic-TIP-Sanding prototype

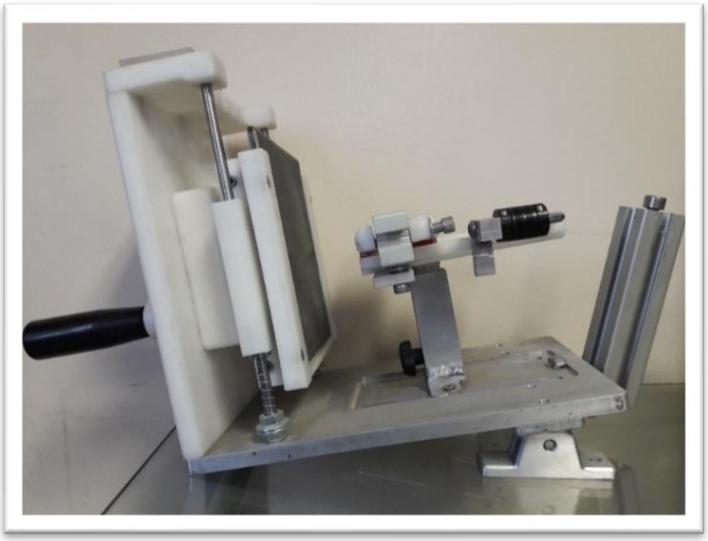

Figure 27. Side view sander prototype.
Own source

Figure 28. Front view sander prototype
Own source

GUI-SEMI-automatic-TIP-Sanding 80% complete

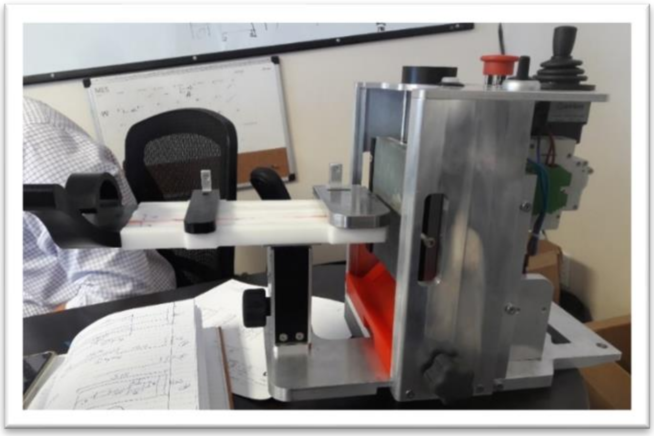

Figure 29. Side view sander
Own source

Figure 30. Top view sander
Own source

8.2 Description of GUI-SEMI-automatic-TIP-Sanding

Team functions:

1. Manual Mode: This mode allows the operator to move the tip sanding rotation from left to right and right to left as needed via the joystick selector.
2. Automatic mode: This mode automatically moves the sanding rotation of the tip from left to right during the programmed time and speed.

8.3 Operator control:

1. Joystick: The operator chooses the type of rotation (left or right) of the sander as needed in manual mode.
2. Main switch: On / Off the equipment.
3. Machine mode selector: Automatic or manual.
4. Timer: Sets the same time for left and right rotation of the tip sanding.
5. Speed: Sets the speed of the rotation. (Maximum 500 RPM).

8.4 Displays / Indicators

1. Red light: Indicates that the equipment is on

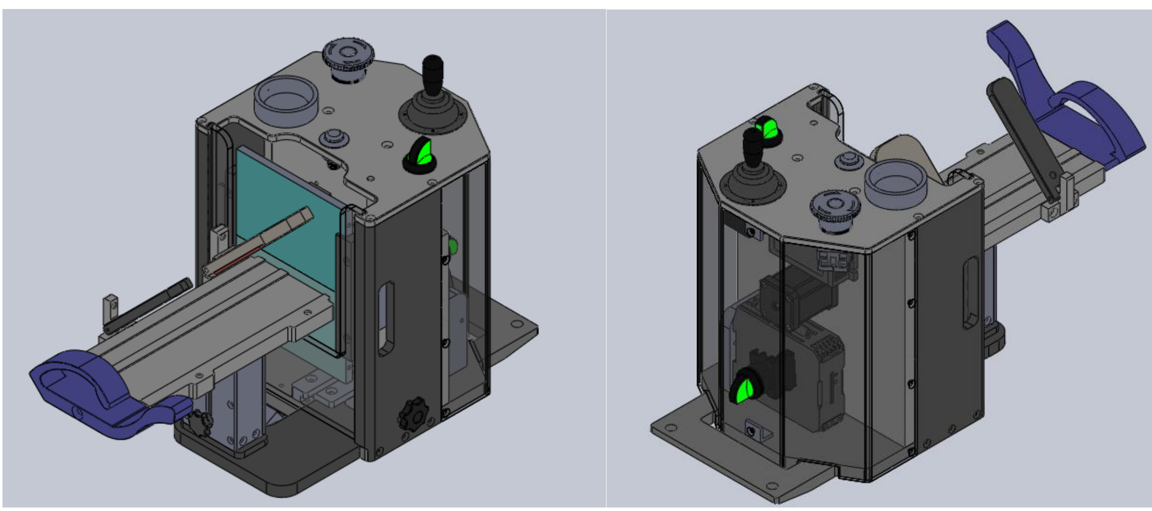

Image 31. Drawing of sander
Own source

8.5 Costs

Equipment Description	Quantity	Unit price	Total	App
Semi Automatic Tip Sanding	7	$9,025	$63,175	Automation

9. CONCLUSIONS

Based on the observation, it is easy to detect the existence of ergonomic problems in the sanding operation in the coronary line and through the evaluation of the RULA method, all the ergonomic risks to which the operators are exposed can be verified.

Although your work table is designed to facilitate the execution of your assigned operation, not all operators have the same physiology and these differences in height sometimes force them to take inappropriate and harmful postures, as they try to perform their work of in a faster way, they end up opting for postures that facilitate their movements to reach the work material.

From the result of this investigation and from what was observed, a series of recommendations were made aimed at protecting the physical integrity of the workers.

Regarding the factors that produce this problem, it was recognized that furniture is one of the main reasons that generate these risks since, although the dimensions are correct, its design can be improved for the user's comfort and thus achieve better performance.

However, the negligence and poor posture of the operators also directly cause the risks, for which over time they can present cumulative traumatic disorders that require monitoring to avoid them.

Recommendations

1. Promote awareness among staff, to adopt a correct posture to carry out their work activities, to reduce the annoyance by DTA’s.
2. Follow up on the evaluation of the support areas, warehouses and offices of the company to know the situation in which they carry out their activities and thus be able to make the necessary changes.
3. To achieve maximum use of the capacities and performance of the users, continuous training is required aimed at increasing the quality of life, safety and well-being.
4. The ideal is to design work spaces under an ergonomic environment, which allows the performance of operations in a comfortable way and health care, however, not knowing the subject and the conditions of the studied area do not allow it.
5. With regard to infrastructure, specifically facilities, it is important to review the workstations in all production areas and verify that the measures used in their design are adequate for the performance in carrying out the tasks activities.

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ERGONOMIC RISK FACTORS DURING VIRTUAL CLASSES

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Resumen: Debido a la emergencia sanitaria por COVID-19, México se declaró en pandemia y la educación se pasó al plano virtual, por lo que los alumnos y maestros tuvieron que adaptar los espacios con los que contaban en casa.

El objetivo del estudio es determinar el factor de riesgo ergonómico por medio del método ROSA, así como los síntomas presentados por los estudiantes universitarios en su área de estudio con ayuda del cuestionario nórdico. La investigación se limita a estudiantes universitarios que participan como voluntarios, de todos los semestres y carreras del Instituto Tecnológico de Sonora (ITSON), durante el periodo de clases virtuales de verano 2021.

En los resultados se encontró que los alumnos actualmente se encuentran afectados por las condiciones de su área de estudio estando más del 50% en un nivel de riesgo moderado o alto, el 97.26% de los estudiantes presentan por lo menos un síntoma y los segmentos del cuerpo más afectados son cuello, ojos y dorsal o lumbar. Por lo que se propone implementar una serie de mejoras en el área de estudio para evitar el desarrollo de TME y disminuir el nivel de riesgo ergonómico.

Palabras clave: Ergonomía, universitarios, clases online, factores de riesgo, TME.

Relevancia para la ergonomía: La presente investigación demuestra la importancia de aplicar la ergonomía en los espacios físicos donde los estudiantes reciben sus clases de manera virtual o a distancia a través del método de evaluación ROSA (Rapid Office Strain Assessment) para reducir el riesgo de padecer desórdenes músculo-esqueléticos relacionadas con extremidades superiores.

Abstract: Due to the health emergency due to COVID-19, Mexico declared itself a pandemic and education moved to the virtual plane, so students and teachers had to adapt the spaces they had at home.

The objective of the study is to determine the ergonomic risk factor by means of the ROSA method, as well as the symptoms presented by university students in their study area with the help of the Nordic questionnaire. The research is limited to university students who participate as volunteers, from all semesters and careers of the Technological Institute of Sonora (ITSON), during the virtual class period of summer 2021.In the results, it was found that the students are currently affected by the conditions of their study area, being more than 50% at a moderate or high level, 97.26% of the students present at least one symptom and the segments of the body more affected, are neck, eyes and dorsal or lumbar. Therefore, it is proposed to implement a series of improvements in the study area to avoid the development of TME and reduce the level of ergonomic risk.

Keywords: Ergonomics, university students, online classes, risk factors, MSD.

Relevance for ergonomics: This research shows the importance of applying ergonomics in physical spaces where students receive their classes virtually or remotely through the ROSA (Rapid Office Strain Assessment) assessment method to reduce the risk of suffering from musculoskeletal disorders related to superior limbs.

1. INTRODUCCTION

Due to the health emergency caused by COVID-19, on March 11, 2020, Mexico declared itself a pandemic and began to implement a series of recommendations and the “stay in home” plan to increase the protection of society. Therefore, a large part of the day-to-day activities were canceled or modified, education was no exception due to the fact that teachers and students had to adapt to the virtual modality from home, now taking as classrooms spaces with different ergonomic characteristics to those that were had in higher education schools, however, not all spaces have the appropriate characteristics, which directly affects the well-being of students.

2. OBJECTIVE

It seeks to determine the ergonomic risk factor, as well as the symptoms presented by university students in their area of study.

2.1 DELIMITATION

The research is limited to university students who participate as volunteers, from all semesters and careers of the Technological Institute of Sonora, during the virtual class period of summer 2021.

3. METHODOLOGY

In order to obtain reliable information, through an online survey, students were asked to answer two research instruments.

The first instrument, denominated ROSA method (Rapid Office Strain Assessment) evaluate the ergonomic conditions of the study area, assigning a score to each component of the space (chair, screen, keyboard, mouse and telephone), the ROSA score ranges from 1-10 points, where scores equal to or greater than 5 indicate that the risk is appreciable and action is required.

The second instrument used corresponds to the Nordic Kuorinka questionnaire, it is a standardized tool for the detection and analysis of musculoskeletal symptoms, applicable in the context of ergonomic studies in order to detect the existence of initial symptoms.

4. RESULTS

A first sample of 64 students was taken, of which 35.9% were women and 64.1% men in an age range of 18-29 years, with a mean of 21 years, who carried out a self-evaluation of the ROSA method.

To obtain an assessment of group A and B, the results obtained were summed by category and then averaged (Table 1).

Table 1. Scores by category

	GROUP A				GROUP B			
					B1		B2	
	Seat height	Seat depth	Arm rest	Back support	Monitor	Phone	Mouse	Keyboard
∑	158	138	156	133	164	100	165	153
$\bar{x}$	2,5	2,2	2,4	2,1	2,6	1,6	2,6	2,4
$\bar{x}$ Rounded	2	2	2	2	3	2	3	2

TABLE A		Seat height + Seat depth							
		2	3	4	5	6	7	8	9
Arm rest + Back support	2	2	2	3	4	5	6	7	8
	3	2	2	3	4	5	6	7	8
	4	3	3	3	4	5	6	7	8
	5	4	4	4	4	5	6	7	8
	6	5	5	5	5	6	7	8	9
	7	6	6	6	7	7	8	8	9
	8	7	7	7	8	8	9	9	9

TABLE B		Score or monitor							
		0	1	2	3	4	5	6	7
Score of pohone	0	1	1	1	2	3	4	5	6
	1	1	1	2	2	3	4	5	6
	2	1	2	2	3	3	4	6	7
	3	2	2	3	3	4	5	6	8
	4	3	3	4	4	5	6	7	8
	5	4	4	5	5	6	7	8	9
	6	5	5	6	7	8	8	9	9

TABLE C		Score of keyboard							
		0	1	2	3	4	5	6	7
Score of mouse	0	1	1	1	2	3	4	5	6
	1	1	1	2	3	4	5	6	7
	2	1	2	2	3	4	5	6	7
	3	2	3	3	3	5	6	7	8
	4	3	4	4	5	5	6	7	8
	5	4	5	5	6	6	7	8	9
	6	5	6	6	7	7	8	8	9
	7	6	7	7	8	8	9	9	9

Figure 1. Tables A, B and C ROSA Method

Table 2. Score of use time

DAILY USE TIME	%	POINTS
Less than 1 hour in total or less than 30 uninterrupted minutes	6.3%	-1
Between 1 and 4 hours in total or between 30 minutes and 1 hour uninterrupted	40.6%	0
More than 4 hours or more than 1 hour uninterrupted	53.1%	+1

Table 3. Risk factor and levels

SCORE	RISK	LEVEL
1	Unappreciable	0
2 - 3 - 4	Normal	1
5	Moderate	2
6 - 7 - 8	High	3
9 - 10	Very high	4

As can be seen in table 1 an average score of 2 was obtained in almost all categories, except screen and mouse where the average score was 3. To obtain the score for each group, the Tables of the method are used (Figure 1).

The score for Table A (chair) is 3, it increases or decreases according to the time of use (Table 1), in this case the score for the time of use was +1 because more than 50% of university students They are more than 4 hours or more than 1 hour uninterrupted in their study area, so the score for group A is 4. Group B (peripherals) is separated into two parts, obtaining a score of 3 points in B1 and 3 points in B2.

The highest score was the chair where 52% of the students have a chair with inadequate height, 42% presented insufficient space under the table, 48% chairs with non-adjustable height, 45% of the seats have a very short or very long length, 70% of the seats are not adjustable in size, only 48% have adequate armrests, in 56% of cases the armrests are not adjustable, 72% have a chair that provides good lumbar support, 22% work on very high tables and 58% of the backrests are not adjustable, the results indicate applying improvements in this group, followed by group B1 or B2.

In group B1, 42% of the screens are in a too low position, 48% have glare or reflections on their screen and 20% of the students use a cell phone to use the microphone during classes.

Group B2 (keyboard and mouse) indicates that in 44% of cases, the mouse is not aligned with the body, in 36% the mouse is very small, 33% have the mouse and keyboard at different heights, the 48% keep their wrists extended more than 15 ° when using the keyboard, 19% of the students present lateral deviation in the wrist with respect to the keyboard, in 19% the keyboard is too high and 47% of the cases the keyboard or platform are not adjustable.

Subsequently, the type of risk was determined (see table 3).

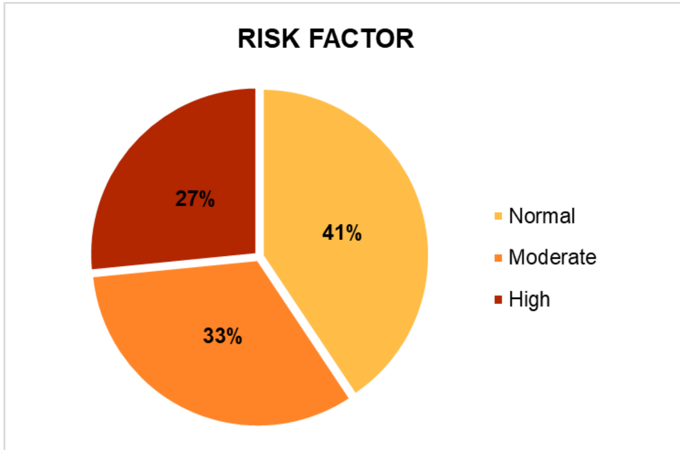

Figure 2. Ergonomic risk factor graph

The 41% of students are at a normal risk level so some elements can be improved, 33% are at moderate risk, which indicates that action is necessary, 27% at high risk so it is necessary to implement improvements as soon as possible, 0% students are at very high risk. The results found are similar to those of workers who make use of data display screens (PVD) during a pandemic (Hernández and Ramos, 2021). On the contrary, it was found that teachers are exposed to a greater ergonomic risk than university students (Vallejo, 2020).

Although most of it is at a normal level, it should be noted that no student is at a zero risk level, that is, negligible, so they all need to make changes in their area of study.

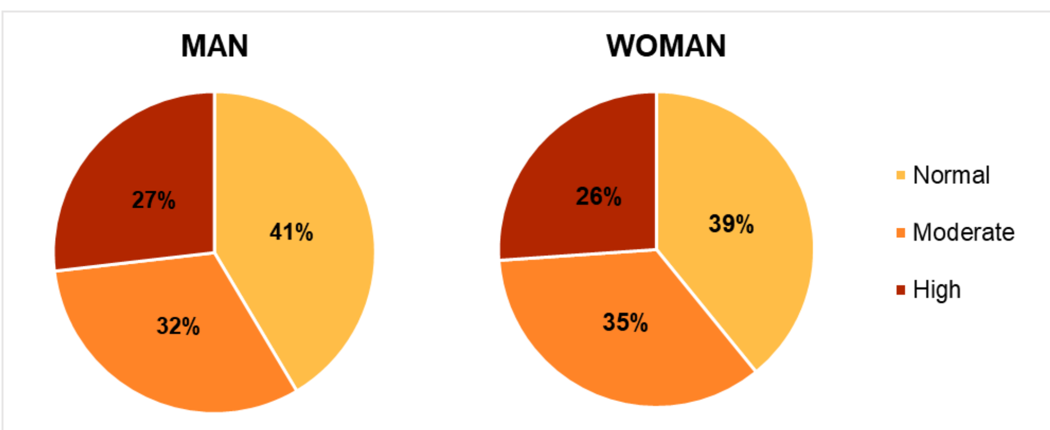

Figure 3. Risk factor divided by sex

Separating men and women, it was found that 41% of men are at normal risk, followed by moderate risk and finally high risk, which receives the lowest percentage. Something similar happens in the case of women, almost 40% are in a normal risk level, followed by 35% in moderate and the remaining in a high risk level. Therefore, men and women are similarly exposed to ergonomic risk.

In the second instrument73 students participated, 38.4% were women and 61.6% men, in an age range of 18-29 years with an average of 21 years, who answered a series of questions about the place where they take their classes and symptoms presented.

Figure 4. Photos of responders

The most common places to receive classes in virtual mode are the dining room, bedroom, living room and studio.

Table 4. Places where classes are taken divided by sex

	Dining room	Studio	Bedroom	Living room	Total
Man	20%	0%	73%	7%	100%
Woman	21%	4%	75%	0%	100%
Both	21%	1%	74%	4%	100%

It was found that 74% of students take their classes from their room, while 21% in the dining room, 4% in the living room and the remaining 1% in a study, a quarter of the students are in classrooms and dining rooms, being unsuitable places because their function is different and the furniture is not adjustable.

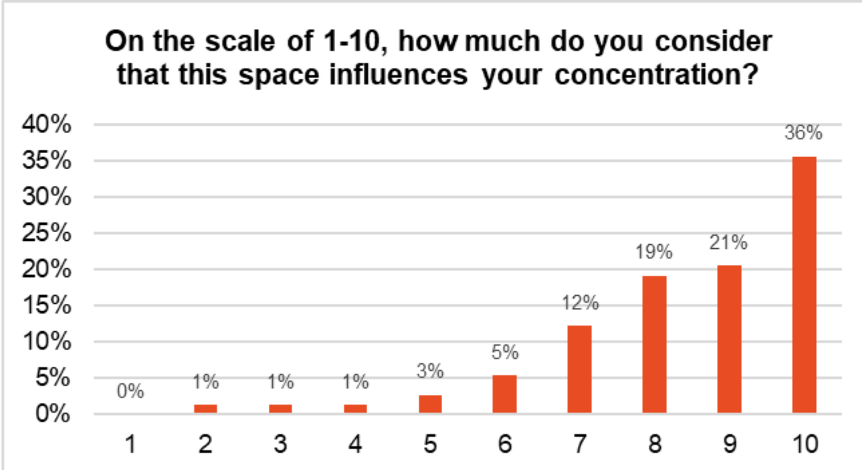

Figure 5. Concentration scale

The students were asked to rate on the scale of 1-10 how much they considered their study space influenced their concentration, 1 being very little and 10 quite a lot, more than 50% assigned a grade of 9 or 10, which means that space directly affects concentration.

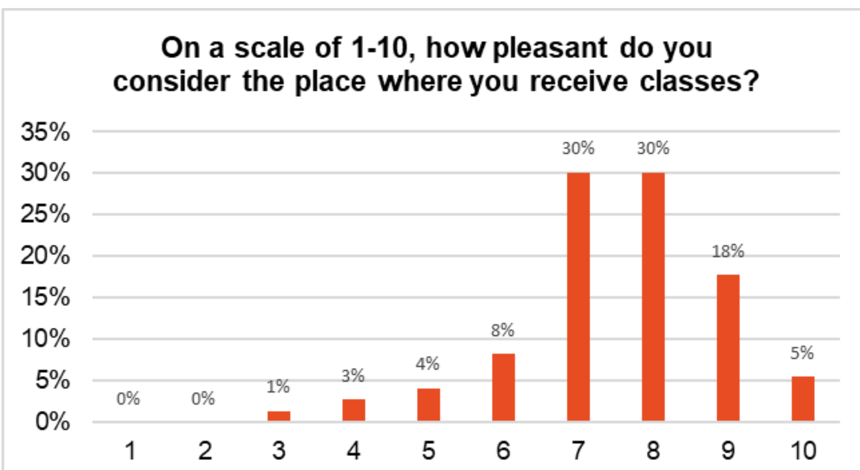

Figure 6. Pleasant scale

Subsequently, it was asked to rate from the scale to 1-10 how pleasant they considered their study space, with 10 being very pleasant and 1 not very pleasant, in the graph it can be seen that only 5% assigned a value of 10, this being the value maximum and indicating that the conditions are perfect, while 18% a value of 9, 60% being the majority with 7 or 8 which means that the place is considered good but not excellent and the remaining 17% assigned a value lower than 7, which means that this percentage of students find themselves in not very pleasant spaces.

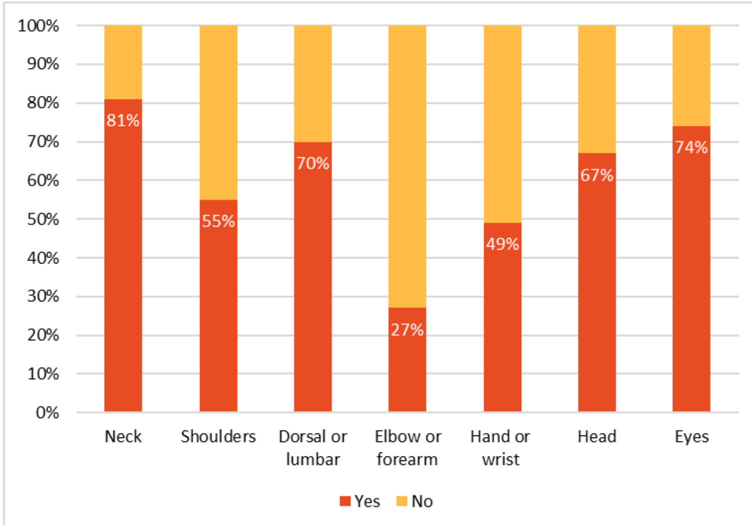

Figure 7. Discomfort presented by students

In the application of the Nordic questionnaire, the symptoms of the neck, shoulders, dorsal or lumbar, elbow and forearm, hand and wrist were considered, and the symptoms of head and eyes were added, since it has been determined that young users who use data display screens suffer from headaches, red eyes, irritation and tearing (Porcar, 2013).

Table 5. Duration of discomfort presented

	Neck	**Shoulders**	**Dorsal or lumbar**	**Elbow or forearm**	**Hand or wrist**	**Head**	**Eyes**
1-7 days	62%	58%	52%	67%	62%	48%	38%
8-30 days	15%	21%	25%	8%	18%	26%	27%
> 30 days, not in a row	16%	19%	21%	25%	18%	18%	27%
Always	7%	2%	2%	0%	3%	8%	9%

The graph shows the results of the cases of discomfort in the last 12 months, obtaining percentages between 27% and 81% being the neck, eyes and dorsal or lumbar the most affected parts, followed by the head, shoulders, hand or wrist and forearm or elbow. 97.26% of the respondents present at least one symptom, 50% of the students present 4 ailments or less in some segment of the body, and only 25% present more than 5.

Of the students who present symptoms, the highest percentage of pain is found in the category of 1-7 days in each of the segments, it should be noted that between 21% -36% present symptoms lasting> 30 days not followed or always, which is alarming since these conditions can turn into MSD.

Table 6. Discomfort presented in the last 7 days

	Neck	**Shoulders**	**Dorsal or lumbar**	**Elbow or forearm**	**Hand or wrist**	**Head**	**Eyes**
Yes	66%	56%	65%	50%	54%	76%	68%
No	34%	44%	35%	50%	46%	24%	32%

In the last week, 76% of the students have presented pain in the head, 68% in the eyes, 66% in the neck and 65% dorsal or lumbar, these being the most affected segments, while the least affected are elbow, hand or wrist and elbow or forearm having percentages lower than those mentioned above.

Of the 97.26% of those surveyed who present at least one symptom, 84.5% claim to have had discomfort in the last 7 days.

On a scale of 0-5 where 0 is mild discomfort and 5 is very strong, the university students were asked to assign a grade to their pain, where the head and eye segments received an average score of 3, being the highest scores followed by shoulders, dorsal or lumbar, neck, hand or wrist and elbow or forearm with 3 average points each of the sections.

Table 7. Medical treatments received in the last 12 months

	Neck	**Shoulders**	**Dorsal or lumbar**	**Elbow or forearm**	**Hand or wrist**	**Head**	**Eyes**
Yes	11%	12%	17%	4%	8%	44%	39%
No	89%	88%	83%	96%	92%	56%	61%

In the last 12 months of 97.26% of university students who have presented at least one symptom, more than half, 59% of students have received treatment for one or more symptoms presented, mostly the head and eye segments, followed by dorsal or lumbar, shoulders, neck, and with percentages less than 10% hand or wrist, and finally elbow or forearm.

The students attribute their neck, shoulder, dorsal or lumbar ailments in general to the bad postures adopted and the posture sitting for several hours, the discomfort in the hand and wrist to the use of peripherals and finally the symptoms of the head and eyes are attributes to prolonged exposure to screens and the brightness generated by it, in addition to fatigue, this coincides with what was said by Geraldo

(2014), postural risks in the office originate from maintaining the same posture or adopting bad postures.

5. RECOMMENDATIONS

It is very important to make improvements in the study areas to reduce the ergonomic risk factor, it is recommended that the chair be height and seat adjustable, that the chair has armrests at elbow height and preferably that they are also adjustable, the backrest must be reclined between 95 ° -110 ° and have lumbar support (Morán, 2021).

The screen should be positioned at eye level, at a distance of 45-75cm without lateral deviation, in the case of laptops, add a folding laptop base, it is important to use natural light to avoid glare on the screen. In the case of peripherals, it is advisable to have a mouse and keyboard at the same height, include a hand rest for the mouse and make it too small.

Pauses are important, “The prolonged sitting posture implies that the muscle groups that are supporting the weight of other structures must make static efforts, thereby limiting the oxygenation of these muscle groups and generating lactic acid. Both situations generate a state of physical fatigue greater than when the posture is dynamic. " (Valencia, 2015), it is important to take short breaks, get up and stretch at least every hour.

Even having a study area in optimal ergonomic conditions, posture is essential to avoid health problems, you must keep your back straight, knees bent at 90 ° with feet on the floor, shoulders relaxed, wrists should be aligned at the shoulders with respect to the mouse and keyboard.

In the case of laptops it is difficult to maintain a good posture since when typing it is necessary to approach the screen, causing the sword to bend, to avoid this you can use a wireless keyboard, in this way the screen will always be at a distance recommended and you will be able to maintain a good back posture.

Another fundamental point is to consider ergonomics when buying furniture or electronic equipment, generally most buyers focus their attention on dimensions and aesthetics, leaving aside functionality. Torres, et al. (2020) mention that the design of appropriate study stations, based on anthropometric measurements, allows to improve posture and reduce musculoskeletal disorders.

6. CONCLUSION

It was determined that more than 50% of university students do not have an ergonomic workspace, representing a direct health risk and there is no significant difference in the level of ergonomic risk between men and women.

The neck, eyes and dorsal or lumbar are the most affected parts in university students, 97.26% of those surveyed present at least one symptom in some segment of the body and 59% of them have received medical treatment for one or more ailments. Therefore, it is recommended to make improvements in the study areas to reduce the level of ergonomic risk and avoid the development of musculoskeletal disorders. In the presence of any persistent symptoms, it is necessary to seek medical attention and not let it pass.

Tele-education is here to stay, so it is important to consider that an ergonomically functional space will produce less impact on health, understanding that health is not something that can be bought and replaced.

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POSTURAL EVALUATION AND WORK AREA WITH ERGONOMIC METHODS; RULA AND ROSA IN A SOCIAL STATIONERY.

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Resumen: En los últimos años se ha observado un considerable incremento en la presentación de Transtornos muscuesqueleticos (TME), en terminos de porcentaje el 34% estos ocurren en la espalda, brazos y manos; por otra parte el 45% tiene afectaciones en huesos, músculos y ligamentos. El problema no es exclusivo de las grandes fábricas u organizaciones siendo indispensable prestar mayor atención a las Pequeñas y Mediana Empresas (PYMES) dado que representan un 72 % de los empleos de México. El presente estudio está enfocado en el proceso de producción de una papelería social de la localidad, donde, al hacer una evaluación previa, se identificó que las condiciones ergonomicas no son las adecuadas por el riesgo que representan. Ante esto se planteó el objetivo de identificar el nivel de riesgo y generar acciones que contribuyan a su disminución. Al aplicar los métodos RULA y ROSA se obtuvo puntuaciones de 5 y 9 respectivamente lo cual representa un nivel de riesgo elevado, ante esto se propuso la adecuación de la tarea así como algunas recomendaciones para que el operador realice sus actividades de manera segura. Como conclusión es importante señalar que las acciones a emprender estan enfocadas en aquellos aspectos que resultaron altos durante la evaluación lo que sin duda impactará en la disminución del nivel de riesgo detectado.

Palabras clave: Evaluación, posturas, RULA, ROSA

Relevancia para la ergonomía: Evaluar las condiciones de riesgo ergonómico en una pequeña empresa de la localidad.

Abstract: In recent years there has been a considerable increase in the presentation of musculoskeletal disorders (MSD), in terms of percentage 34% of these occur in the back, arms and hands; on the other hand, 45% have affectations in bones, muscles and ligaments. The problem is not exclusive to large factories or organizations, and it is essential to pay greater attention to Small and Medium Enterprises (SMEs) since they represent 72% of jobs in Mexico. The present study is focused on the production process of a social stationery store in the locality, where, upon making a prior evaluation, it was identified that the ergonomic conditions are not adequate due to the risk they represent. Given this, the objective of identifying the level of risk and generating actions that contribute to its reduction was raised. When applying the RULA and ROSA methods, scores of 5 and 9 were obtained respectively, which represents a high level of risk, in view of this, the adequacy of the task was proposed as well as some recommendations for the operator to carry out their activities safely. In conclusion, it is important to point out that the actions to be taken are focused on those aspects that were high during the evaluation, which will undoubtedly impact on the reduction of the level of risk detected.

Keywords: Evaluation, postures, RULA, ROSA
Relevance for ergonomics: Assess ergonomic risk conditions in a small local business.

1. INTRODUCTION

Musculoskeletal disorders (MSD) are diseases characterized by an abnormal condition of bones, muscles, tendons, nerves, joints or ligaments that results in an alteration of motor or sensory function. These pathologies arise when a certain structure is over-required and the necessary viscoelastic recovery period of the tissues in demand is exceeded. (López, J. and Cuevas, C. 2008).

Approximately 1.710 million people have musculoskeletal disorders worldwide. Among musculoskeletal disorders, low back pain is the most common, with a prevalence of 568 million people, making it the most common cause of disability in 160 countries. These disorders severely limit mobility and dexterity, leading to early retirements, lower levels of well-being, and a reduced capacity for social participation.

Musculoskeletal disorders are also the main factor contributing to the need for rehabilitation around the world. They are the largest contributor to the need for rehabilitation services among children and account for approximately two-thirds of rehabilitation needs in adults. According to a recent analysis of data on the global burden of disease, approximately 1.710 million people worldwide have this type of disorder.

The risk factors most commonly associated with the appearance of musculoskeletal disorders is excessive postural load. Continuously or repeatedly adopting improper postures at work creates fatigue and can lead to health problems in the long run. (Diego Mas, 2015).

At the national level, the Mexican Institute of Social Security (IMSS) released in 2015 the report of cases of osteoarticular morbidity classified as work risks, presenting an increase during the period 2011 to 2015; Among which, the carpal tunnel syndrome stands out, from 147 cases in 2011, to 540 in 2015, and shoulder injuries from 140 to 516 in the same period, that is, in both there was an increase of 300%.

On the other hand, load handling is responsible for 34% of MSDs, giving rise to muscular and ligamentous injuries to the back, arms and hands; while forced postures cause 45% of these disorders affecting bones, muscles and ligaments of the back. Balderas-López, M., Zamora-Macorra, M., & Martínez-Alcántara, S. (2019).

MSDs are frequently found in the jobs carried out in Small and Medium Enterprises (SMEs) since they are responsible for 72% of the jobs, hence the importance of carrying out studies in this type of company.

There are various methods that allow the evaluation of the risk associated with postural load, differing by the scope of application, the evaluation of individual postures or by sets of postures, the conditions for their application or by the parts of the body evaluated or considered for evaluation. . (Diego Mas, 2015). Among these methods are the so-called RULA and ROSA that are described below:

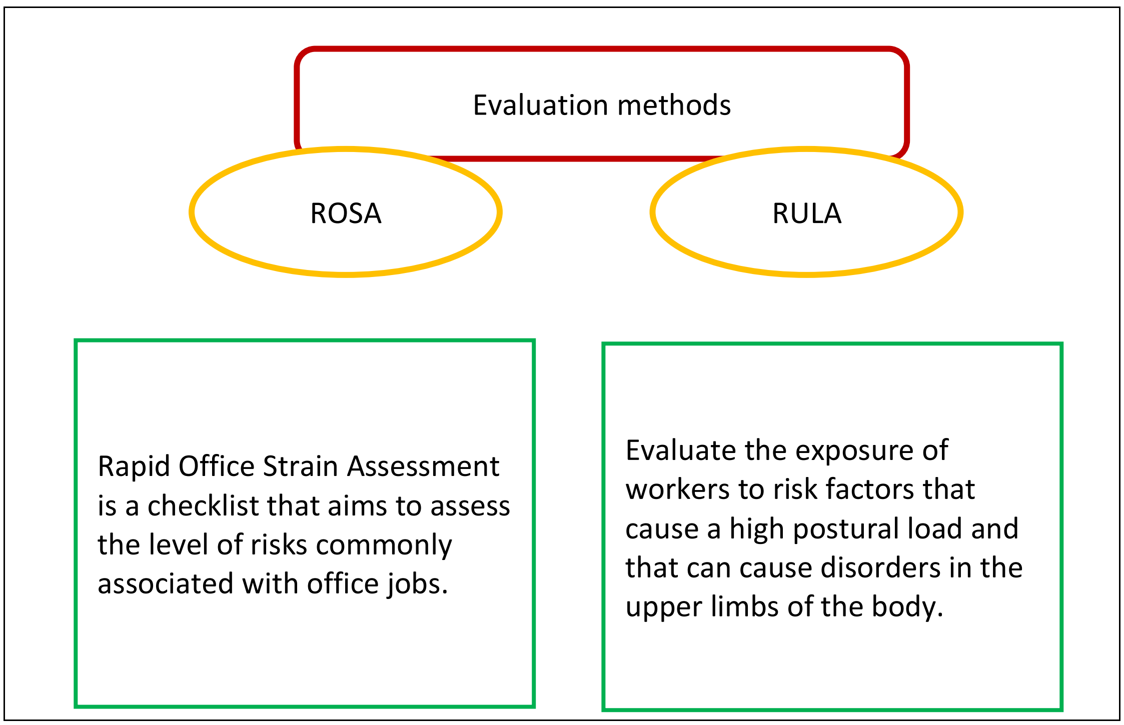


Figure 1. Outline of the main evaluation methods.

According to the project of PROY-NOM-036-STPS-2015, the use of various evaluation methods is promoted, such as those mentioned above, as proof of this in the now published NOM-036-STPS-2018 Ergonomic risk factors at Work-Identification, analysis, prevention and control. Part 1: Manual handling of loads the MAC method is suggested.

For the application of the methods it is sometimes necessary to carry out measurements, however, there may be situations in which it is not necessary and in others that the problem lies in some aspect that cannot be collected with these measurements (Alvarez, 2015) .

The company under study is a social stationery, located in the town where jobs requested by the client are used, such as: invitations, business cards, personalized envelopes and others. The main process is the realization of personalized gift envelopes, where the design is first made to the customer's specifications, then printed on the selected envelopes and finally they are packaged for delivery. According to an interview with employees at the end of the working day, they have manifested back, neck and arm ailments (see figure 2).

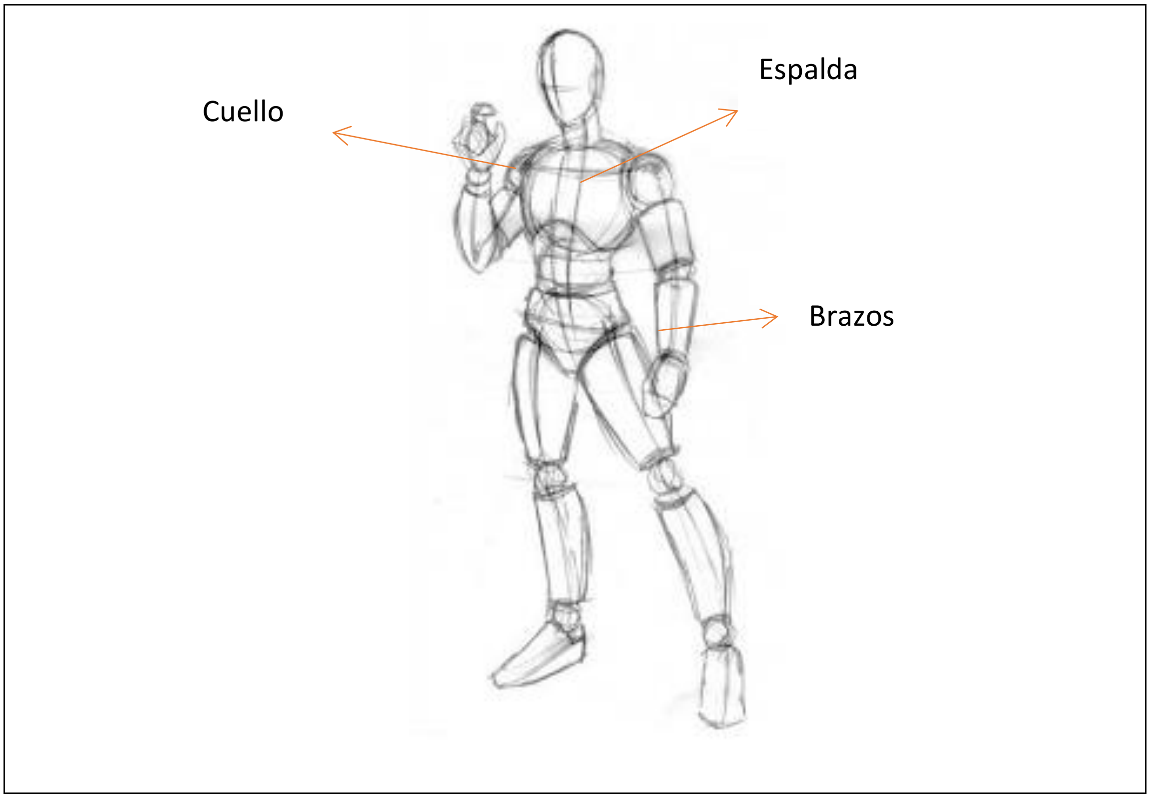


Figure 2. Sketch with the main affected parts of the TME.

One of the biggest problems that arise are the postures taken by the operator of said work site.

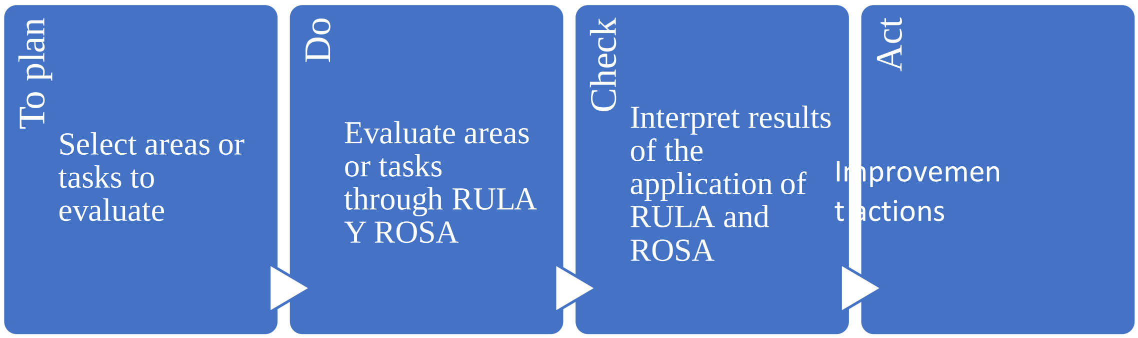
What is the level of ergonomic risk associated with the work activity performed by workers at the work site under study?

2. OBJECTIVE

Identify the level of ergonomic risk in the workplace of a company that buys and sells stationery items for the generation of actions that, if necessary, contribute to its reduction and adaptation to the job.

3. METHODOLOGY

For the study, the Plan, Do, Verify and Act (PHVA) method was available, complemented by the RULA and ROSA methods for identifying the level of risk in the workplace, said procedure consisted of the following:



1.Plan the areas to study: Here the areas and tasks to study were identified, this was done based on the interview with the business owner.

2.Evaluate work sites: The evaluation was carried out using the RULA and ROSA methods, for this, several images of the different positions adopted during the process were captured, those considered as risky were selected to finally proceed to their evaluation. this based on its route of analysis (López, et.al., 2020).

3.Analyze and interpret the results: the results obtained were analyzed according to the different scores obtained by applying the methods described above, that is, the extremities (in RULA) or, where appropriate, element of the work station (ROSA) were identified with values considered as high thus facilitating the approach.

4.Generate improvement proposals: In this part of the study various proposals were listed that will allow the improvement of the work method and impact on the work area.

4. RESULTS

A position taken by a worker who handles a guillotine for the manufacture of envelopes or cover letters is analyzed. The job consists of cutting paper with the help of both hands and repeatedly operating a guillotine. This task is carried out in the cutting area, where the worker usually cuts the paper to be able to make envelopes or resentation letters, the work she does is simple, but risky due to the positions that she herself performs.

Figure 3. Manufacture of envelopes or cover letters.

When applying the RULA method: the following was obtained:

Puntuación A= 4

Puntuación C= 5

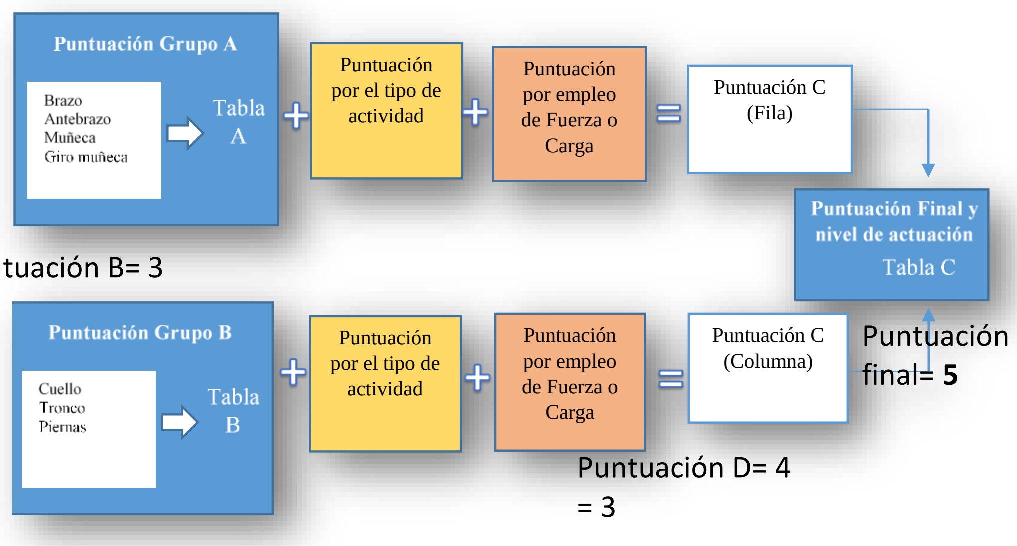


Figure 4. Results of the application of the RULA method.

The scores obtained in the method are the following:

Group A: analysis of the arm, forearm and wrist.

Scoring Arm 3, Forearm 2, Wrist 3, Wrist Twist 1, Muscle Activity 1, Load or Force 0.

Group B: analysis of the neck, trunk and legs.

Neck score 3, Trunk 2, Legs 1, Muscle activity 1, Load or strength 0.

Final score 5 with Risk level 3

To finish with the RULA method, the description of the final result is presented; the worker who is making envelopes or cover letters has a level 3 risk.

The score for the arms, wrist and neck stands out, of which a value of 3 was obtained, which is one of the highest that the method has. A final score of 5 denotes the need to make changes to the assignment.

When analyzing the same workstation through the ROSA method, the following was obtained:

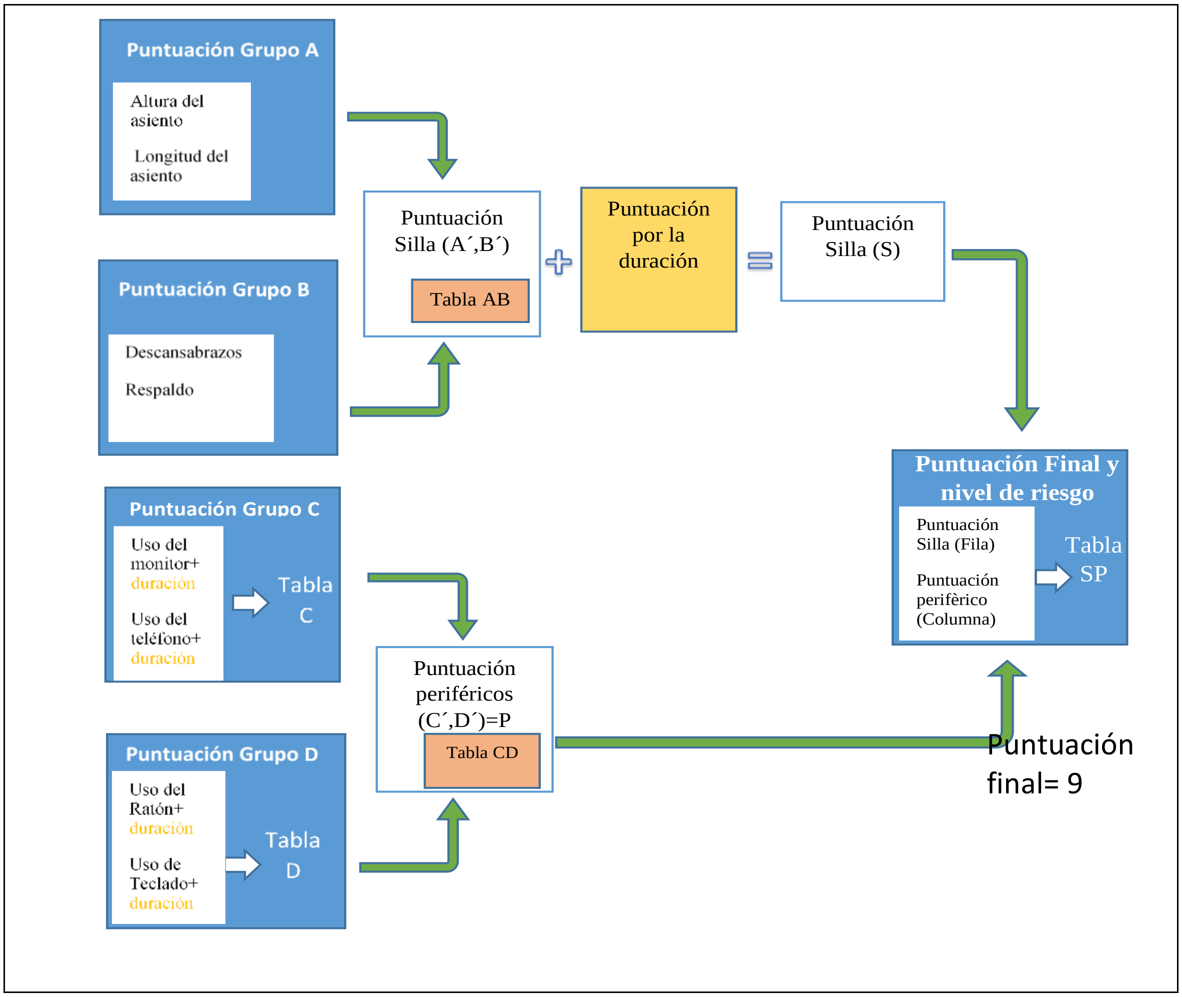


Figure 5. Results of the evaluation using the ROSA method.

The evaluation in the pink method was given as follows:

Seat height: 3 without foot contact; Seat depth: 3 Very short seat. More than 8 cm of space between the seat and the back of the knees and the depth of the seat is not adjustable; Armrests: 3 too low. The elbows do not rest on them and armrests not adjustable; Backrest: 3 No backrest or backrest not used to support the back and Non-adjustable backrest.This score obtained corresponds to a risk level of 4, which indicates that the ergonomic risk is maximum and that a change is necessary to lower the risk level as shown in the following image.

As a final result of the method, a score of 9 was obtained, with this having a risk level of 4 that indicates extreme risk, which is alarming because it refers to the fact that the way in which the work is being carried out is incorrect which it is causing the worker a burnout; which can become an injury in the future, for this it is necessary to implement new positions to carry out the assigned work and act urgently to reduce it.

As part of the improvement actions, there are:

RULA

- Improve the height of the work table to decrease the value of the neck and is between 10 and 20 degrees of inclination.
- Prevent the operator from twisting the wrists when performing the activity and having a very low angle of flexion.
- Adapt the work table with a support or recharger to avoid that the arms have a high flexion.

ROSA

- It is necessary to change the work chair for one that adapts to the ergonomic needs of the pink method, to mention some specifications are: adjustable backrest, armrests at the appropriate height, seat that can be adjusted in height, among others.
- Improve the height of the work table.

5. CONCLUSIONS

It is concluded that after carrying out both the rula and pink methods, the level of risk that these impact on the analyzed workstation is relatively high, because the work area is not given importance, so the operator is seen in the task of carrying out their operations in a forced and repetitive way. What is necessary is a radical adaptation of the entire work area so that the operator feels comfortable, can carry out their activities safely and can move away from the movements that are required.

Giving an answer to the question of the problem of the case under study, which is: What is the level of ergonomic risk associated with the work activity performed by workers at the work site under study? In the Rosa method, a risk level of 5 was obtained and in the Rula method a score of 9 was obtained, with a risk level of 4 being extreme.

If no action is taken, the operator will be forced to continue working in a forced manner, so there will be risks, which can even cause a musculoskeletal disorder.

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EVALUATION OF ERGONOMIC RISK FACTORS IN WORKERS OF A STATIONERY IN THE SOUTH OF SONORA.

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Resumen Los trastornos músculo esqueléticos (TME) se hacen presentes en los sitios de trabajo a raíz de la exposición a movimientos repetitivos, posturas incómodas o cargas pesadas. La evaluación ergonómica de los puestos de trabajo es de vital importancia ya que permite identificar factores de riesgo ergonómicos que pudieran ocasionar los TME y así atentar contra la salud del trabajador. El presente estudio tiene como finalidad establecer propuestas que permitan la disminución de riesgos ergonómicos asociados a la compra venta de artículos de papelería en un centro de trabajo. El procedimiento empleado tiene como base la metodología del ciclo PHVA empleada para la mejora continua de los sitios de trabajo, misma que es acompañada por el método OWAS para valorar de forma global todas las posturas adoptadas durante el desempeño de la tarea y el método ROSA el cual permite evaluar los riesgos ergonómicos en puestos de trabajo de oficina o su similar. Como resultados se obtuvo que 7 de las 10 posturas evaluadas a través de OWAS no presentan riesgo significativo, no obstante las posturas 2, 4 y 9 tienen niveles de riesgo de nivel 2 y 3 lo cual hace necesario generar propuestas de mejora o rediseñar la tarea. Así mismo al aplicar método ROSA en las posturas 2 y 9 se obtuvo niveles de riesgo de 10 y 7 respectivamente lo que significa ser absolutamente necesario llevar a cabo cambios en la tarea dado que es muy posible la aparición de TME. Seguido de esto se enlistan algunas propuestas de mejora basadas en el análisis antes descrito y se concluye que de llevar a cabo dichas recomendaciones se incrementará la productividad del trabajador y su satisfacción al momento de realizar las actividades.

Palabras clave: Ergonomía, riesgo ergonómico, factores, enfermedades de trabajo, TME.

Relevancia para la ergonomía: Identificar y disminuir los factores de riesgo presentados en los trabajadores de una papelería.

Abstract: Musculoskeletal disorders (MSDs) are present in the workplace from exposure to repetitive movements, awkward postures, or heavy loads. The ergonomic evaluation of jobs is of vital importance since it allows identifying ergonomic risk factors that could cause MSDs and thus threaten the health of the worker. The present study aims to establish proposals that allow the reduction of ergonomic risks associated with the purchase and sale of stationery items in a workplace. The procedure used is based on the methodology of the PDCA cycle used for the continuous improvement of the work sites, which is accompanied by the OWAS method to globally assess all the positions adopted during the performance of the task and the ROSA method the Which allows evaluating the ergonomic risks in office workstations or its similar. As results, it was obtained that 7 of the 10 positions evaluated through OWAS do not present significant risk, however positions 2, 4 and 9 have risk levels of level 2 and 3, which makes it necessary to generate proposals for improvement or redesign the task . Likewise, when applying the ROSA method in positions 2 and 9, risk levels of 10 and 7 were obtained respectively, which means that it is absolutely necessary to carry out changes in the task since the appearance of MSDs is very possible. Following this, some proposals for improvement based on the analysis described above are listed and it is concluded that carrying out these recommendations will increase the productivity of the worker and his satisfaction at the time of carrying out the activities.

Keywords. Ergonomics, ergonomic risk, factors, occupational diseases, MSDs

Relevance to Ergonomics: Identify and reduce the risk factors presented in stationery workers

1. INTRODUCTION

Ergonomics is a discipline that takes into account physical, cognitive, social, organizational and environmental factors, but with a "holistic" approach, in which each of these factors are not analyzed in isolation, but rather in their interaction with the others (INSST, 2019).

According to the Trade Union Institute for Work, Environment and Health, ergonomic risk factors are those work conditions that determine the physical and mental demands that the task imposes on the worker, and that increase the probability of injury. (ISTAS, 2015).

The World Health Organization (WHO) characterizes MSDs as “work-related” diseases of multi-causal origin. With this, it indicates that there are a series of occupational and non-occupational risk factors (physical burden, work organization, psychosocial, individual and sociocultural) that contribute to causing these diseases (CENEA, 2021). When the working conditions that require the adoption of forced postures, repeated movements, manual handling of loads, exposure to mechanical vibrations, etc. carry a high probability of producing MSDs.

If, in addition, to these risk situations that we call biomechanical factors, we add: exposure to psychosocial factors derived from an inadequate work organization, unfavorable environmental conditions (temperature, humidity, lighting, noise), poor characteristics in the work environment. work (workspace, order, cleanliness...), and the individual variables of each worker (body dimensions, sex, age, experience, training...), the overall ergonomic risk level of the workplace, will be significantly increased (ISTAS, 2015).

According to statistics from the Secretary of Labor and Social Security (STPS), occupational diseases in Sonora went from 43 in 2004 to 335 in 2013; On the other hand, work disabilities showed a change from 366 in 2004 to 1168 in 2013, which denotes a clear and unfavorable increase in both indicators.

The company under study is dedicated to the retail sale and distribution of school and office supplies, in the same way, it offers the service of copying, lining, stapling and laminating, among others. In an interview with the workers, they stated that they had health problems derived from work activity such as headaches, back pain, feeling tired, presenting stress, eyestrain and bad mood.

As part of a diagnosis made to the company, an instrument or checklist was applied which includes eight factors to evaluate in which a NO is marked if the checkpoint is being met, a YES if it is thought that the point is not being met. being met, but should and URGENT if the checkpoint is not being met and is considered a critical area. Figure 1 shows a summary of the information obtained.

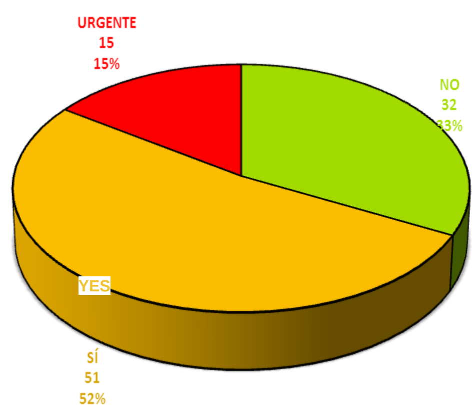


Figure 1. Overall results of the checklist
Source: self made.

Of the different factors evaluated with the checklist, it is established that the main focus of attention should be directed to the handling and handling of materials since 52% of the answers were Yes and 19% were Urgent, in the same way, in For manual tools, 54% of the answers fall on Yes and 33% on the Urgent box. Finally, we must also concentrate on the design of the job since 60% corresponds to Yes and 27% to Urgent.

Based on the above, the following research question is posed:

What will be the way to reduce the ergonomic risks associated with the work of workers in a company dedicated to buying and selling stationery?

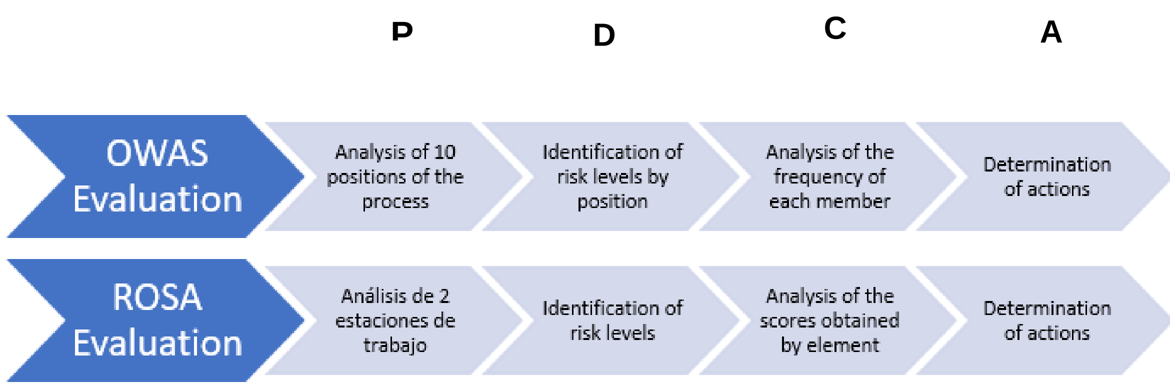
2. OBJETIVE

Establish proposals that allow the reduction of ergonomic risks associated with the purchase and sale of stationery items in a workplace.

3. METHODOLOGY

The subject under study covers the service area and copying of a stationery store in Cd. Obregón, Sonora, for the study the PDCA cycle (Plan, Do, Check and Act) established by Edward Deming was taken as reference, which was adapted leaving the following procedure:

1. Planning: The areas and tasks to be studied were identified using the checklist provided by Ergonautas (Ergonautas, 2000) in order to have an initial evaluation of the ergonomic risks present in the workplace.
2. Do: The work sites with the highest ergonomic risk were selected and the methods selected to assess the site were OWAS and ROSA. For its application, the work area was attended and an analysis was made of the way of working and the area in which the operator operates, emphasizing the positions adopted and the effort made in each task.
3. Check: The results of the evaluations applied by the two methods were analyzed and interpreted in order to implement improvements in the work site if this is the case, depending on the risk levels presented, decisions will be made that impact this work area and its operator.
4. Act: Various improvement proposals were generated to put into practice according to the work area and the level of risk presented.



4. RESULTS

Taking into account the general data provided by the checklist concentrated in the graph of figure 1, it was decided to study in depth the positions of the workers with the Ovako Working Analysis System (OWAS) and Rapid Office Strain Assessment (ROSA) methods. .

The first evaluation was carried out by means of the OWAS method, for its application an analysis was made of the different jobs and the different positions that the workers adopted and then, the selection of the 10 most significant positions was made to later study and apply them. the method.

Next, figure 2 is presented, which shows the 10 positions selected for the study.

Figure 2. Selected positions for the application of the OWAS method
Source: self made

Once the 10 positions had been selected, the methodology was continued by evaluating each of the positions in an Excel spreadsheet. The results of the study are shown below.

Table 1. OWAS method results table.

Evaluated positions: 10

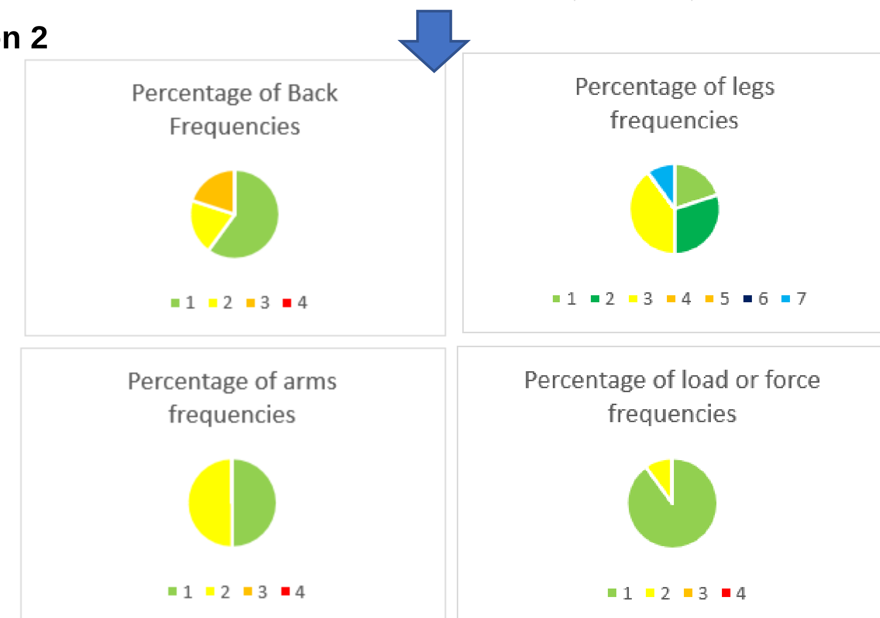
Section 1

Results table

Aspect to evaluate	Evaluated positions									
	1	2	3	4	5	6	7	8	9	10
Back	1	2	1	2	1	1	3	1	3	1
Arms	1	1	1	2	2	1	2	2	2	1
Legs	2	1	3	3	3	2	3	7	1	2
Load or force	1	1	1	2	1	1	1	1	1	1
Risk level	1	2	1	3	1	1	1	1	2	1

Risk level			
1	2	3	4
70%	20%	10%	0%

Section 2



As can be seen in section 1 of the table, with regard to the evaluation by postures, 70% have a level 1 risk, which represents a normal posture without damage to the musculoskeletal system, however, postures 2 , 4 and 9 have risk levels of level 2 and 3, so changes in the process or redesign of the task are required in the event of possible damage to the musculoskeletal system.

Section 2 shows the results by element of the positions evaluated and of which we have:

- Back: 6 have a low risk level; 2 medium level; 2 High level.
- Arms: 5 positions at low level and 5 at medium level.
- Legs: 5 have a low level of risk; 4 medium risk; 1 high risk.
- Load or force: 9 positions at low level and 1 at medium level.

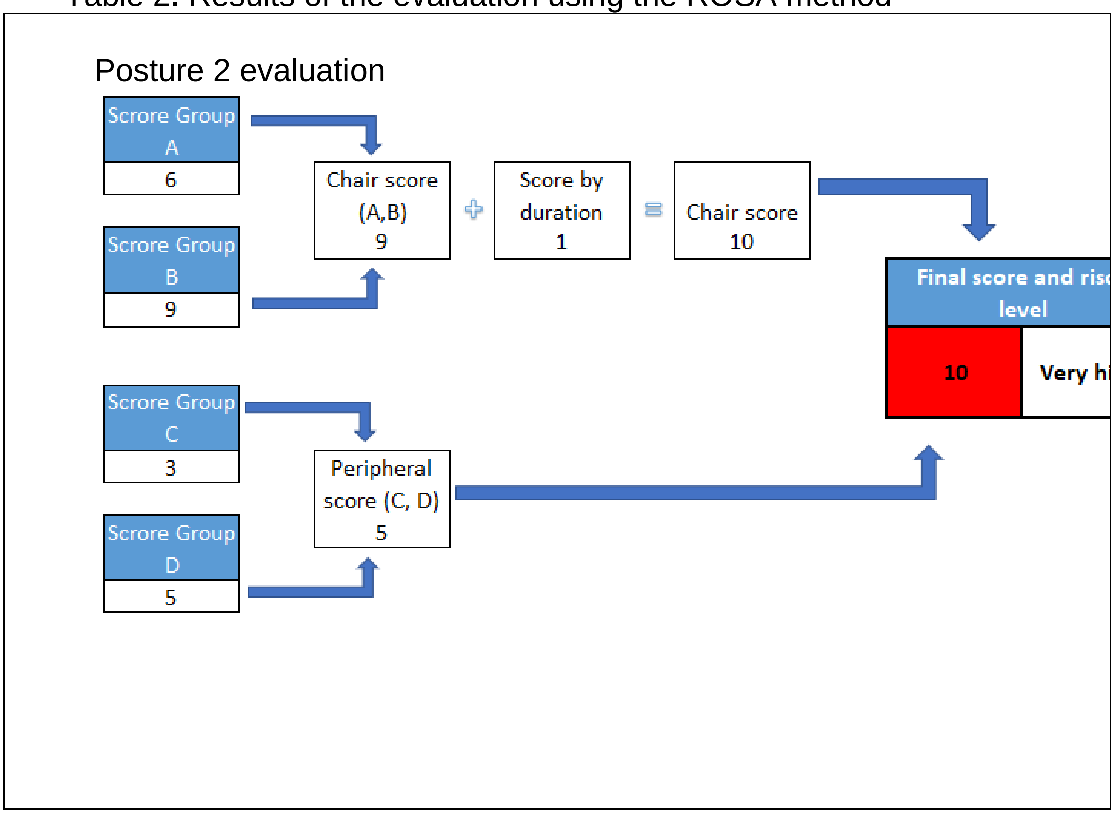
Based on the analysis, it is necessary to work on improving postures 2, 4 and 9, likewise, it must focus on scanning, document printing and guillotine cutting activities that have a High Back qualification, supervising the use of arms in 5 of the 10 postures, 5 legs and 1 load or strength.

To continue with the second evaluation of the ROSA method, 2 of the positions that were previously seen were selected and the ROSA method field sheet was applied to them to evaluate the ergonomic risk level of the office workstation.

Figure 3. Postures to be evaluated by the ROSA method

In the field sheet, each of the postures was evaluated individually and the levels of the chair and peripherals were scored, where a specific value was assigned to each box for consideration by the evaluator according to the posture of the worker.

Table 2. Results of the evaluation using the ROSA method



Summary of evaluations (2 and 9).

P osture	G roup A	G roup B	G roup C	G roup D	(A´,B´)	Du ration	(C´, D´)	F inal
2	6	9	3	5	9	1	5	1 0
9	6	8	3	5	8	-1	5	7

As can be seen in table 2, the level shown for position 2 is 10, therefore, it can be said that the evaluated position has a very high level of risk and it is necessary to make changes and adjustments urgently to avoid major damage to the worker.

Regarding position number 9, it shows a final level of 7, which is still a risk classified as high, which is why it is essential to make changes in both workstations since it does not allow the worker to perform their tasks optimally, in the same way, they are uncomfortable and risky positions that can lead to an MSD if urgent action is not taken.

Based on the results obtained by the checklist of ergonomic factors and the postural studies by the OWAS and ROSA method, the following proposals were generated to improve the workplace, seeking to reduce the ergonomic risks that may arise in workers:

-Make an anthropometric study of the worker to adapt the work station.

-Redesign the distribution of the work areas.

-Clear the roads to have a safe flow when traveling.

-Provide breaks between tasks to decrease fatigue.

-Alternate tasks.

-Change the type of tools used by the worker so that they adapt to him and not the other way around.

Regarding the office areas, there are:

-Based on postures 2 and 9, it was determined that the section of the back of the chair is the most worrying, so changing the chairs and benches for adjustable ones will greatly benefit the worker.

-According to the length of the seat and the peripherals section, a desk change is proposed for a wider one that adjusts to the worker's dimensions.

-Based on the peripherals section (use of the mouse), the aim is to replace the mouse with one that matches the measurements of the operator's hand

5. CONCLUSIONS

With the help of the ergonomic risk checklist, it was possible to make a diagnosis of the work site and it was possible to detect those factors that need to take improvement actions and be further studied with some method since they are affecting the safety and health of the worker.

Thanks to this, it was possible to conclude that the greatest risk that is present in the company are the positions adopted by the worker and the bad design of the job, since when using the OWAS method and the ROSA method, it could be observed that the greatest effort of the worker is made with the arms, in a standing posture and with the trunk bent, this in the long run can cause an MSD that can easily be avoided if the correct recommendations are followed.

By carrying out these recommendations, it is expected that the worker will have a lower risk of presenting a musculoskeletal disorder derived from the bad postures that he is forced to adopt due to the bad design of the job, in the same way the worker will make less effort since he will have the right tools and devices for him, which will lead him to increase his productivity and his satisfaction at the time of carrying out the activities.

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ERGONOMIC RISK REDUCTION OF THE LINER OPERATION OF THE PUSHER ONE PRODUCTION CELL THROUGH SEMIAUTOMATION IN A MEDICAL COMPANY

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Resumen. En la presente investigación se plantea el uso de la semiautomatización para la disminución del riesgo ergonómico en operaciones de producción. Para ello, se presenta un caso de estudio referente a una empresa médica, en la cual se detecta un riesgo ergonómico alto en una celda de producción, en la que se manufactura un catéter para tratar aneurismas cerebrales. Dicha celda de producción es denominada Pusher One y el estudio se enfoca en la operación Liner.

La investigación surge también, debido a que se detecta la necesidad de mejorar algunos métricos de productividad. Ante cuellos de botella, altos tiempos de producción, estrés y cansancio en el personal y no llegar a las metas de producción diarias, así como falta de calidad en los productos terminados, se concluye que existe un alto riesgo ergonómico en la operación. Con la situación antes descrita y ante la meta de la empresa de trascender hacia una mayor madurez, se planteó la hipótesis de si la semiautomatización podría mejorar el proceso productivo, pero sobre todo disminuir el riesgo ergonómico presente. Al ser afirmativa la hipótesis el proyecto tendría un gran potencial al ser replicado en otras líneas de producción de la misma empresa. Aunado a ello, podría demostrar la importancia de la automatización como herramienta para la disminución de riesgos ergonómicos.

Los resultados de la investigación reflejan que los resultados favorables para la empresa fueron evidentes y se rebasaron las metas planteadas. Sobre todo, el objetivo principal que fue hacer la operación en cuestión, más segura para sus colaboradores. El análisis ergonómico realizado, contribuyó a mejorar los estándares de producción beneficiando a la vez a los operadores. Para la empresa, representa una contribución a su política de seguridad, así como con las normas de control de riesgo laboral.

Palabras Clave: riesgo ergonómico, semiautomatización, Índice de esfuerzo laboral (JSI), producción, sector médico.

Áreas de trabajo: Evaluación del trabajo, diseño y análisis del trabajo.

Relevancia para la ergonomía. Este proyecto demuestra que, en el presente caso de estudio, la semiautomatización hizo un cambio radical no sólo en la mejora del proceso, sino también, en el objetivo principal que era la disminución de los riesgos ergonómicos en la operación en cuestión. Se comprobó la hipótesis planteada y se considera este trabajo puede ayudar a traer a la mesa del debate, a cerca de las ventajas de la automatización en la ergonomía.

Abstract. In this research, the use of semi-automation is proposed to reduce ergonomic risk in production operations. To do this, a case study is presented regarding a medical company, in which a high ergonomic risk is detected in a production cell, in which a catheter is manufactured to treat brain aneurysms. This production cell is called Pusher One and the study focuses on the Liner operation.

The research also arises, because the need to improve some productivity metrics is detected. Faced with bottlenecks, high production times, stress and fatigue in the personnel and not reaching the daily production goals, as well as a lack of quality in the finished products, it is concluded that there is a high ergonomic risk in the operation. With the situation described above and in view of the company's goal of transcending towards greater maturity, the hypothesis was raised as to whether semi-automation could improve the production process, but above all reduce the present ergonomic risk. As the hypothesis is affirmative, the project would have great potential when replicated in other production lines of the same company. In addition to this, it could demonstrate the importance of automation as a tool for reducing ergonomic risks.

The results of the investigation reflect that the favorable results for the company were evident and the goals set were exceeded. Above all, the main objective was to make the operation in question safer for its collaborators. The ergonomic analysis carried out contributed to improving production standards while benefiting the operators. For the company, it represents a contribution to its safety policy, as well as to occupational risk control regulations.

Keywords: ergonomic risk, semi-automation, Work effort index (JSI), production, medical sector.

Work areas: Work evaluation, work design and analysis.

Relevance for ergonomics. This project shows that, in the present case study, semi-automation made a radical change not only in the improvement of the process, but also in the main objective, which was the reduction of ergonomic risks in the operation in question. The hypothesis raised was verified and it is considered that this work can help to bring to the table the debate about the advantages of automation in ergonomics.

1. INTRODUCTION

This project was carried out in a medical business, located in Tijuana Baja California. Taking into account that the company is constantly growing and in search of continuous improvement, the improvement of the processes was derived by converting the lines to production cells. This led to the detection of some areas of opportunity that gave rise to this investigation. One of the overriding factors was the safety of its employees. Considering that operations are carried out in a safe work environment with a low risk of occupational diseases. In addition to this, the need to improve some productivity metrics is considered.

The general objective was to reduce the ergonomic risk of the Liner operation of the Pusher One production cell and to improve the productivity metrics through semi-automation. For this, the application of the JSI methodology to determine the ergonomic risk and reduce it were considered as short goals, as well as to analyze the production process to determine the level of semi-automation. The JSI method is chosen because the occupational safety regulators consider it a valid method. In the same way, it was planned to contribute to the productivity metrics, reducing the productivity time of the operation by 30% and reducing waste due to poor material handling by 40%. Therefore, and in the same vein of continuous improvement, it was considered to apply the DMAIC methodology as a basis for the development of the project.

The project had a greater scope than the proposed objective since it will be replicable for other areas of the company. Its application went to the Pusher One cell station of the operation called Liner and it demonstrates in the area of ergonomics how automation can benefit companies and their employees together to make work safer on the one hand and on the other hand the other, to raise their productivity rates.

2. DELIMITATION

The project was carried out in a company of the medical sector. It was focused on an operation called Liner of the Pusher One production cell. The project was limited to developing in six months and was applied as a professional residence for the Industrial Engineering career at the Tecnológico Nacional de México, Tijuana campus.

3. METHODOLOGY

The research was carried out from two axes, on the one hand, the use of the JSI methodology for ergonomic assessment, and on the other, through the DMAIC methodology. In addition, various industrial engineering tools were used to complement the resolution of the problem. Figure 1 shows the strategy used in a schematic way.

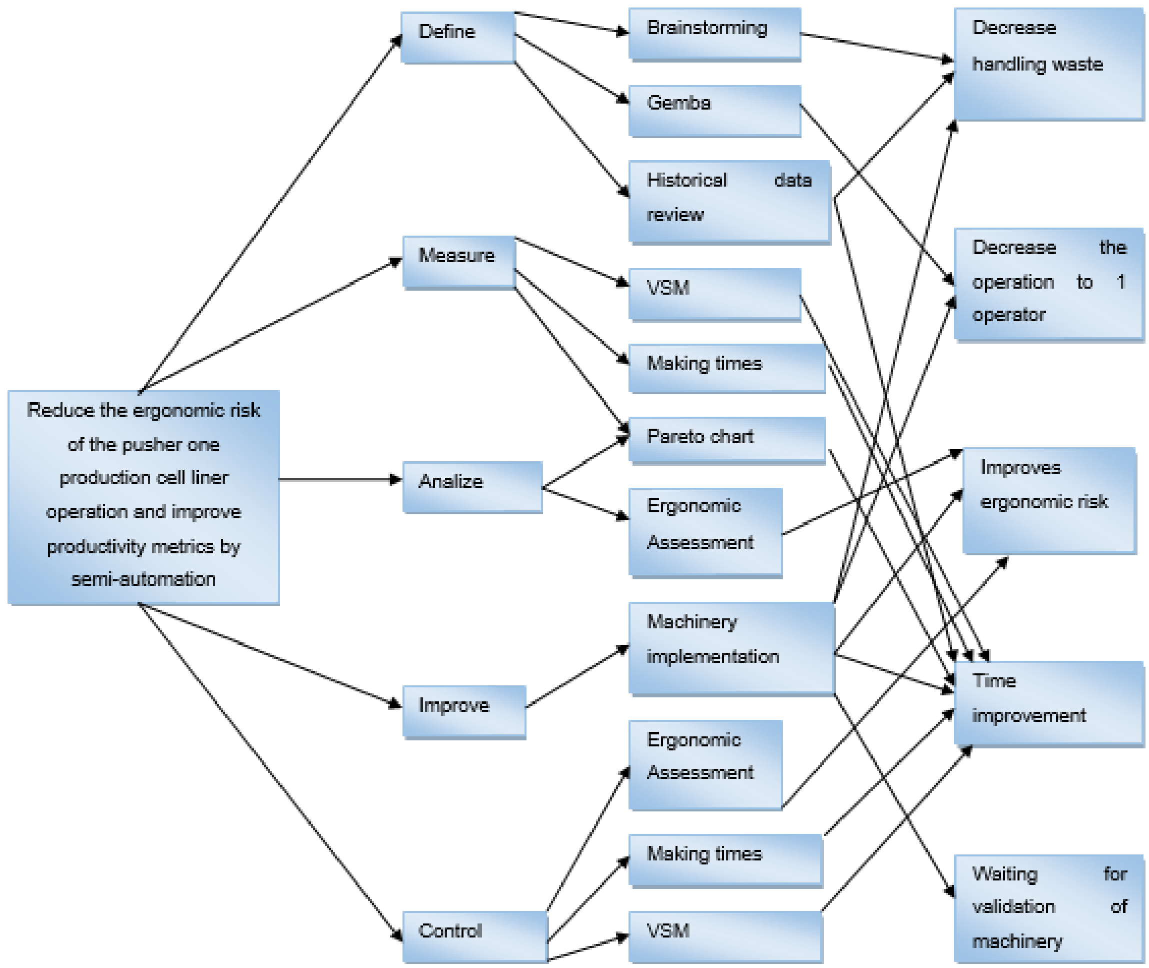

Figure 1. Represents the strategy for the development of the project

3.1. JSI methodology

On this occasion, the company decided to use the JSI method because the occupational safety regulators in the context in which it is found, consider it a valid method.

The JSI method "[…] is a job evaluation method that allows assessing whether the workers who occupy them are exposed to developing cumulative traumatic disorders in the distal part of the upper extremities due to repetitive movements. Thus, the hand, wrist, forearm, and elbow are involved in the assessment. The method is based on the measurement of six variables, which once assessed, give rise to six multiplying factors of an equation provided by the Strain Index. This last value indicates the risk of appearance of disorders in the upper extremities, the risk being greater the higher the index. The variables to be measured by the evaluator are: the intensity of the effort, the duration of the effort per work cycle, the number of efforts made in one minute of work, the deviation of the wrist with respect to the neutral position, the speed with which the task is carried out and its duration per working day" (Diego-Mas, José Antonio, 2015).

3.2 DMAIC methodology

The DMAIC methodology is a methodology used for improvement that addresses problems in a systematic and scientific way also known as Six Sigma and derived from it. The DMAIC methodology studies the processes to eliminate the different types of waste in a production process that do not add value to the customer, control the variation of the data and focus the process to the customer's specifications. In general, any methodology requires a general projection with specific tools for its application, with Six Sigma not being an exception. For this reason, this part will analyze the general methodology that it uses and the statistical methods necessary for its application. Any process within an organization can be understood as a function that, applied to certain input variables, provides a set of result variables. The Six Sigma methods propose to work to improve the processes, on those input variables that significantly influence the outcome variables. To decide on these issues, it is recommended not to be based on subjective criteria, but on objective facts deduced from the analysis of existing information or collected for that purpose. The development of a Six Sigma continuous improvement project arises from five basic and well differentiated stages, which constitute what has been called DMAIC Methodology (García, 2014, pg. 28).

The DMAIC methodology helps us to make decisions based on objective data for the improvement of processes, where with the help of quality tools the root cause of the problems is justified, as long as all the phases of DMAIC are used since a decision An unfounded decision does not allow you to visualize beyond your knowledge and experience, on the contrary, if DMAIC is used correctly, you can visualize a broader picture and make a decision that is not biased by the ideas of the person.

Regarding the aforementioned, Gutiérrez and De la Vera, 2009 argue that the data alone does not solve the problems of the client and the business, therefore a methodology is necessary. In 6σ, projects are rigorously developed with the five-phase methodology: Define, Measure, Analyze, Improve and Control.

4. RESULTS

The results are presented following the DMAIC methodology in each of its stages. Likewise, according to the diagram of the methodological strategy, ergonomic evaluation is presented from the stage of analyzing and improving.

4.1 Define

The main problems in the area were low productivity, waste due to material handling and possible fatigue of the right wrist of the person in the Liner operation, which could result in an injury, which would lead to an ST7 leading to an ST9 or illness. of work. A Gemba was used around the area and brainstormed.

4.2 Measure

The analyzes were carried out by means of graphs and time taking to measure the current state of the cell and its operation. Table 1 shows the measurements.

Table 1. Time taken from the cell.

Time Measurement Sheet

PROCESS:	Pusher One	RECORDED BY:	Luis Mendoza
SHIFT:	1	DATE:	feb 18 2021

No.	Element	1	2	3	4	5	6	7	8	9	10	Low Repeat (3)	Adjust	Adj. Low Repeat	MANUAL Wait	MANUAL Walk	MANUAL Work	AUTO (Unattended Machine)
1	Inser Outer Jacket	13.00	11.00	12.00	13.0	10.0	13.0	12.0	13.0	13.0	12.0	12.0		12.0	2.0	0.0	0.0	0.0
2	Inser Sac witre on liner	15.00	16.00	74.00	14.0	15.0	14.0	13.0	16.0	15.0	14.0	14.0		20.0	7.5	0.0	0.0	N/A
3	Strech and cut liner	13.0	9.0	39.0	10.0	13.0	13.0	10.0	11.0	11.0	12.0	11.0		11.3	5.6	0.0	0.0	0.0
4	Liner inserter	74.0	75.0	66.0	69.0	73.0	79.0	77.0	71.0	73.0	72.0	73.0		72.9	36.5	0.0	0.0	N/A
5	Inserter outer jacket tool	57.0	59.0	36.0	58.0	59.0	57.0	58.0	59.0	57.0	57.0	57.0		57.5	28.8	0.0	0.0	N/A
6	Shrinkage, cut and measure	56.0	53.0	116.0	53.0	54.0	51.0	53.0	59.0	56.0	52.0	53.0		54.1	27.0	0.0	0.0	N/A
	Total Best of 3											220.0	0.0	227.8	107.4	0.0	0.0	
	Total of Observations	228.0	223.0	343.0	217.0	224.0	227.0	223.0	229.0	225.0	219.0							
														Total Man	107.4			

Waste is shown in Figure 2. Through a Pareto diagram by seasons, it can be observed that the Liner operation is the largest contributor to waste, hence the object of study.

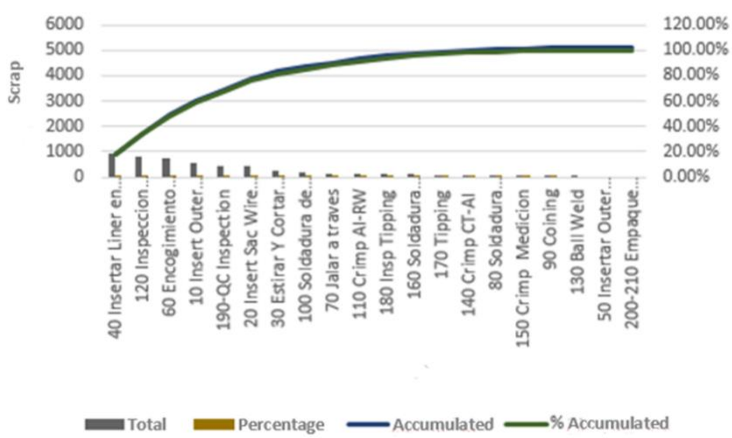

Figure 2. Shows the Pareto Waste-Operations Diagram, observe the Liner operation.
Source: Prepared by the authors.

When making the previous Pareto Chart, with the operations with the most waste, it was decided to make another Pareto Chart with the types of defects, as shown in Figure 3.

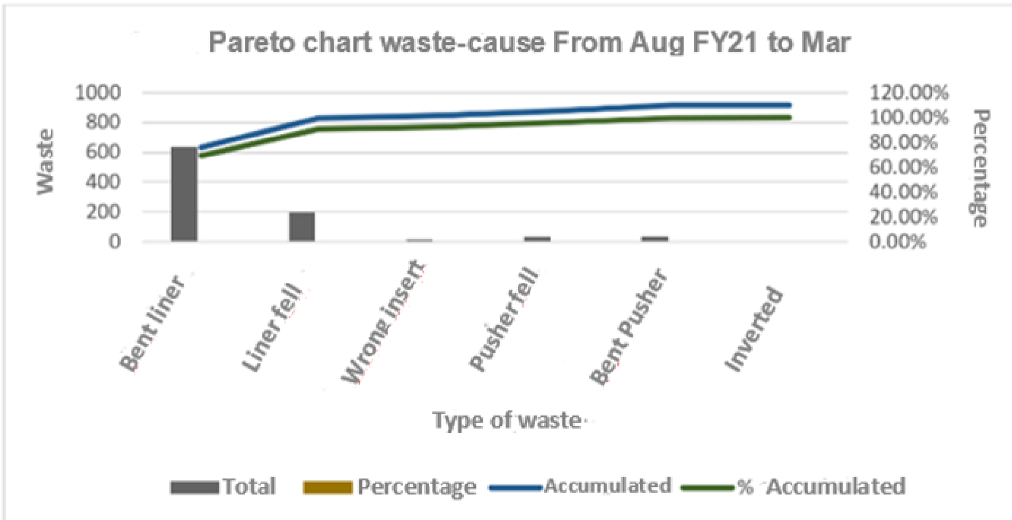

Figure 3. Pareto Waste-Operations Diagram, shows the types of defects.
Source: Prepared by the authors.

For its part, due to the repetitive movement of the wrist, which was demonstrated in the operation and complaints from the workers. It was decided to carry out an ergonomic evaluation and use the JSI method, supported by the company's recommendations since it is considered a valid method by the authorities in the area of occupational safety. When carrying out the evaluation, which was carried out with the criteria of the company and the researcher, it was concluded that this operation produced an unsafe condition for the worker, as can be seen in Figure 4

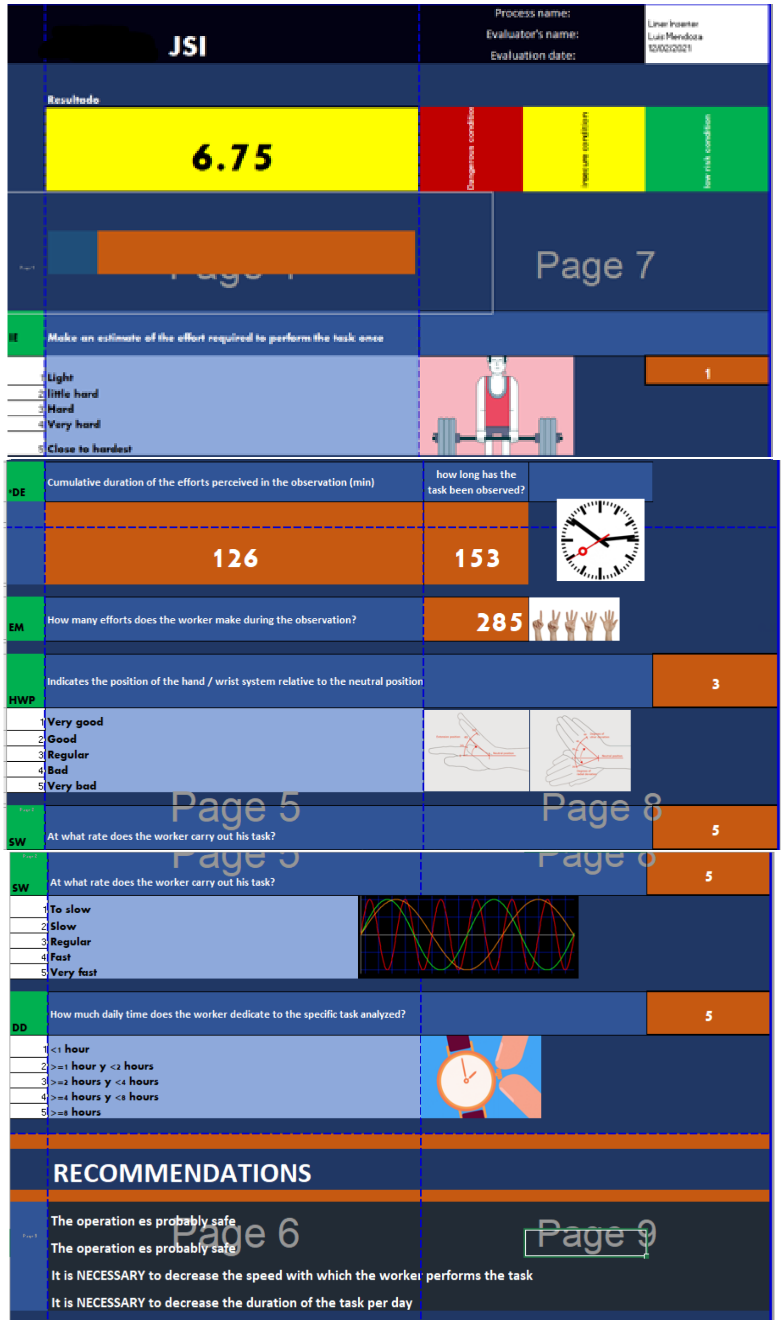

Figure 4. Ergonomic evaluation before improvement.
Source: Format extracted from the company and evaluation carried out by author.

Figure 5 shows the operation in its initial state, in which the position of the wrist and hand can be appreciated, denoting the repetitive movement in the left hand.

Figure 5. Shows the Liner feature where the repetitive wrist movement is found.
Source: Image taken at the medical company in question.

Figure 6 shows the current value flow of the cell, that is, before the improvement, where the points to be attacked are identified.

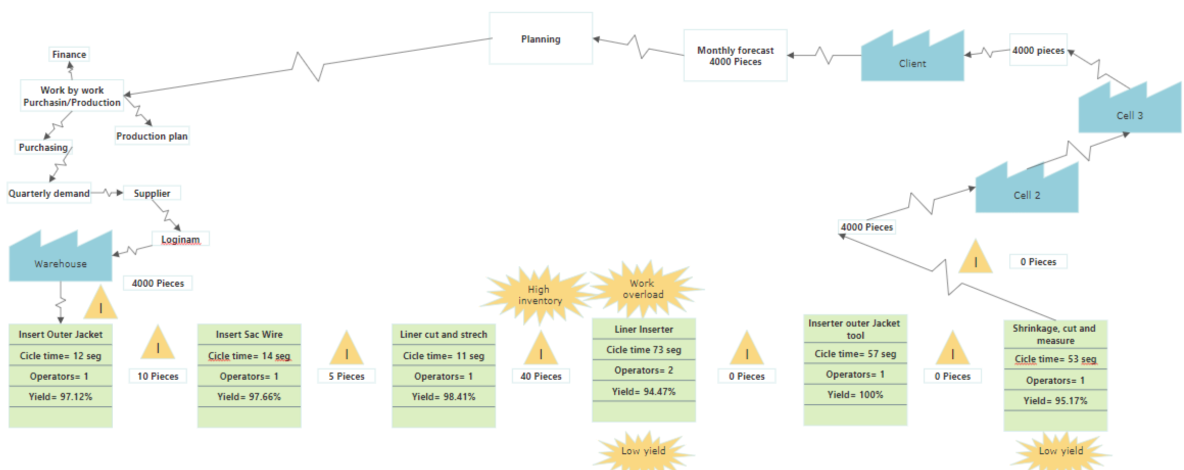

Figure 6. Cell value flow map before enhancement.
Source: Own elaboration with company data.

4.3 Analyze

According to the variables raised in the research, it was decided to carry out a 5 whys, considering it as the initial method to reach the root cause of the problem. It is presented in Table 2.

Table 2. The 5 whys of the variables found in the measurement phase.

	W1	W2	W3	W4	W5
High lead time	High waste by rework	Fragile and small material	Material is bent or thrown	High speed to meet the goal	Lack of fixture to insert it
	Uneven workload	Long liner process	By inserting liner into pusher	It has to be done carefully	Lack of machinery to assist operator with insertion
	Tiredness due to dysergonomics	Perform the operation around the clock every day	Perform repetitive wrist movement	Lack of machinery to help insert the liner	N/A

After the implementation of the semi-automated machinery, it was decided to perform the ergonomic evaluation again with the same operator, to analyze the changes and the relationship between these two variables, that is, between the Liner operation and the implemented machinery. Thus, with the implementation of the insertion machinery, the results were analyzed and presented in Figure 7.

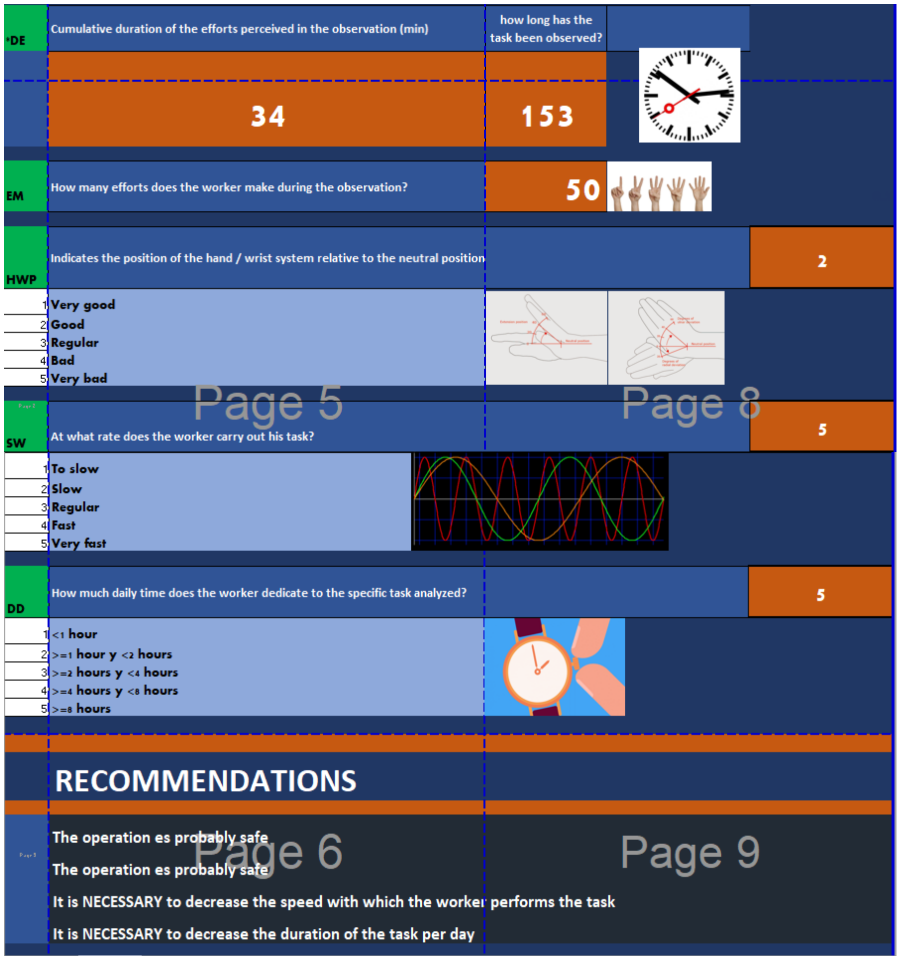

Figure 7. JSI ergonomic evaluation after improvement in Liner operation.
Source: Format extracted from the company, evaluation carried out by the author.

4.4 Improve

In this phase, the metrics that were improved through the implementation of the machinery and that have their relationship with productivity are graphically presented. Figure 8 shows the improvement in terms of cycle time.

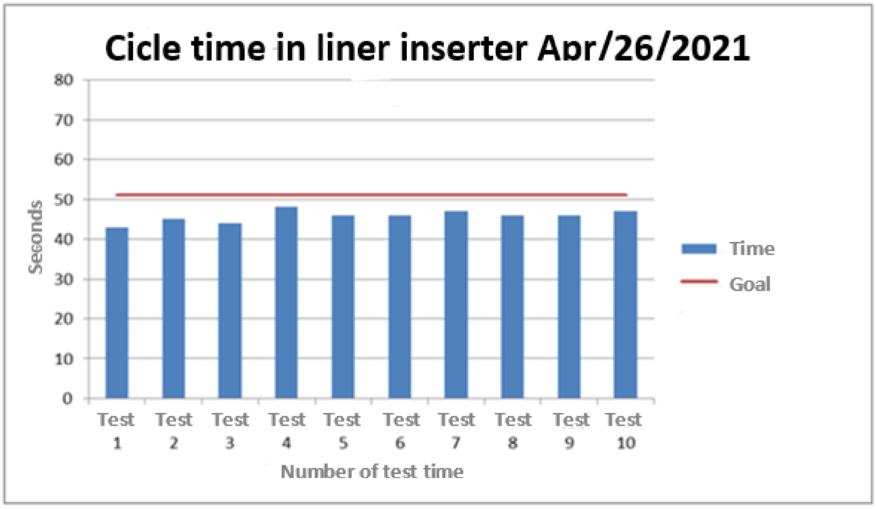

Figure 8. Graphic representation of the improvement in the cycle time to Liner. Source: Prepared by the authors.

Table 3 shows the measurement of the time taken already with the operation of the semi-automated machinery.

Table 3. Liner time taken with improvement implementation.

Time Measurement Sheet

PROCESS:	Pusher One	RECORDED BY:	Luis Mendoza
SHIFT:	1	DATE:	Apr 18 2021

No.	Element	1	2	3	4	5	6	7	8	9	10	Low Repeat (3)	Adjust	Adj. Low Repeat	MANUAL Wait	MANUAL Walk	MANUAL Work	AUTO (Unattended Machine)
1	Inser Outer Jacket	13.00	11.00	12.00	13.0	10.0	13.0	12.0	13.0	13.0	12.0	12.0		12.0	2.0	0.0	0.0	0.0
2	Inser Sac witre on liner	15.00	16.00	74.00	14.0	15.0	14.0	13.0	16.0	15.0	14.0	14.0		20.0	7.5	0.0	0.0	N/A
3	Strech and cut liner	13.0	9.0	39.0	10.0	13.0	13.0	10.0	11.0	11.0	12.0	11.0		11.3	5.6	0.0	0.0	0.0
4	Liner inserter	43.0	45.0	44.0	48.0	46.0	46.0	47.0	46.0	46.0	47.0	46.0		58.0	22.9	0.0	0.0	N/A
5	Inserter outer jacket tool	57.0	59.0	36.0	58.0	59.0	57.0	58.0	59.0	57.0	57.0	57.0		57.5	28.8	0.0	0.0	N/A
6	Shrinkage, cut and measure	56.0	53.0	116.0	53.0	54.0	51.0	53.0	59.0	56.0	52.0	53.0		54.1	27.0	0.0	0.0	N/A
	Total Best of 3											193.0	0.0	212.9	93.8	0.0	0.0	
	Total of Observations	197.0	193.0	321.0	196.0	197.0	194.0	193.0	204.0	198.0	194.0							
														Total Man	93.8			

.

In Figure 9 you can see the value flow map with the implementation of the machinery, where you can see the difference to the one previously presented.

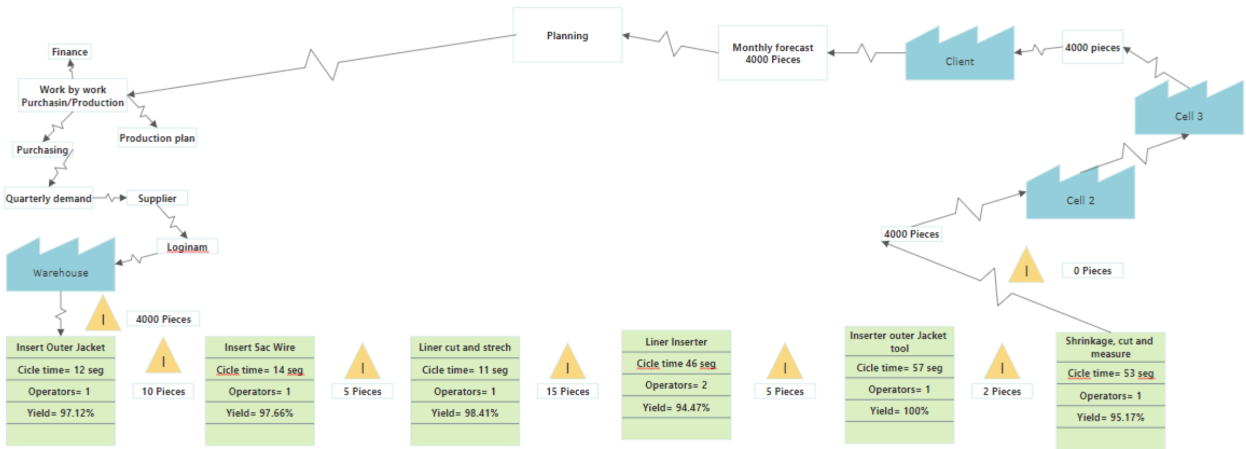

Figure 9. Value stream map with the Liner insertion machine implementation.
Source: Prepared by the authors.

4.5 Control

The fulfillment of the objectives was demonstrated by means of the graphs previously analyzed. To keep control of this improvement and visualize the variability of the process, measurements of the metrics will be carried out daily and the procedure will be changed to add the new correct steps.
Thanks to the semi-automated design shown in Figure 10, the insertion point of the component is easier and variable and erroneous movements are eliminated, all this contributes to the elimination of waste, but above all to the ergonomic part that was wanted to improve in this project.

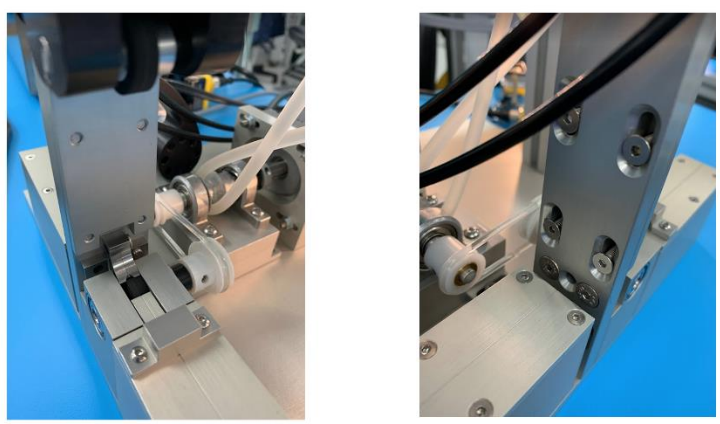

Figure 10. Shows the machinery for the semi-automated process.
Source. Own elaboration taken from the company.

In Figure 11 you can see the performance of the Liner operation and the fulfillment of the objective of eliminating 40% of waste, which has remained constant.

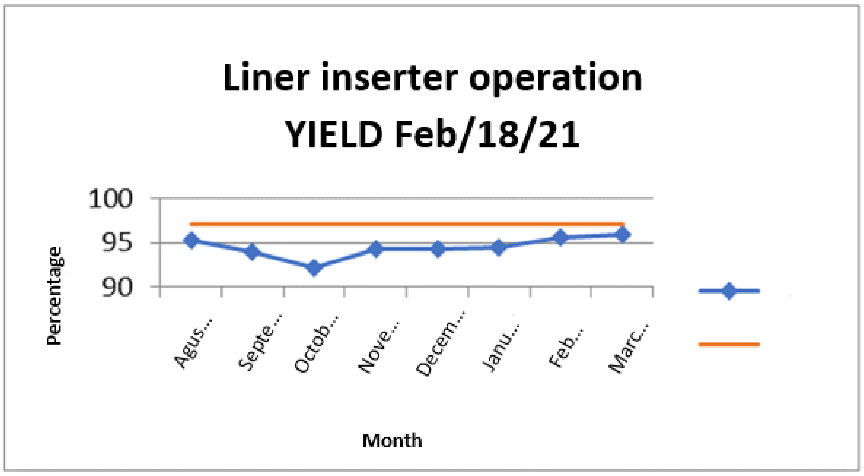

Figure 11. Graphical representation of the last months of the Liner operating performance
Source: Prepared by the authors.

Another objective was to reduce the cycle time by 30%, which led to a 37% reduction in time. In Figure 12 you can see how the goal was reached and is being maintained.

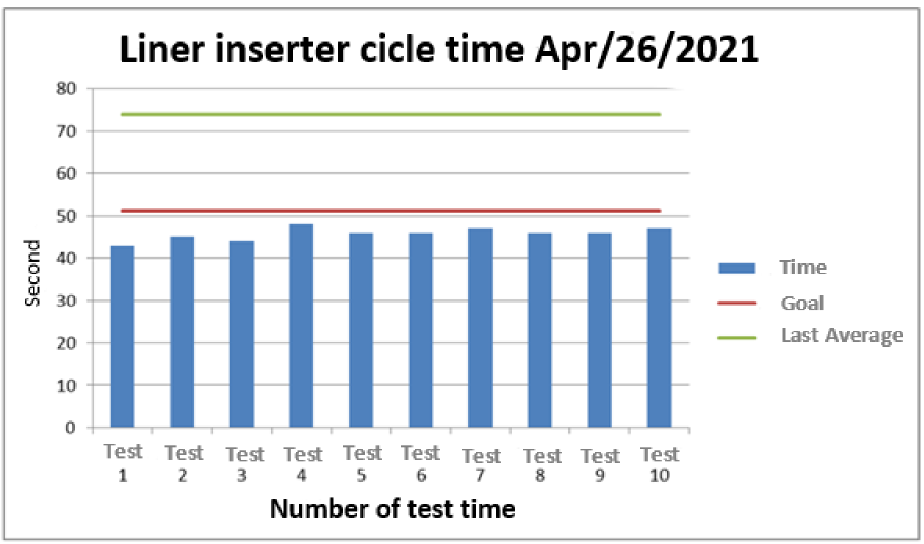

Figure 12. Graphic representation of current times.
Source: Prepared by the authors.

In Figure 13 an improvement in the Yield is observed, it is concluded that the improvement implemented was successful.

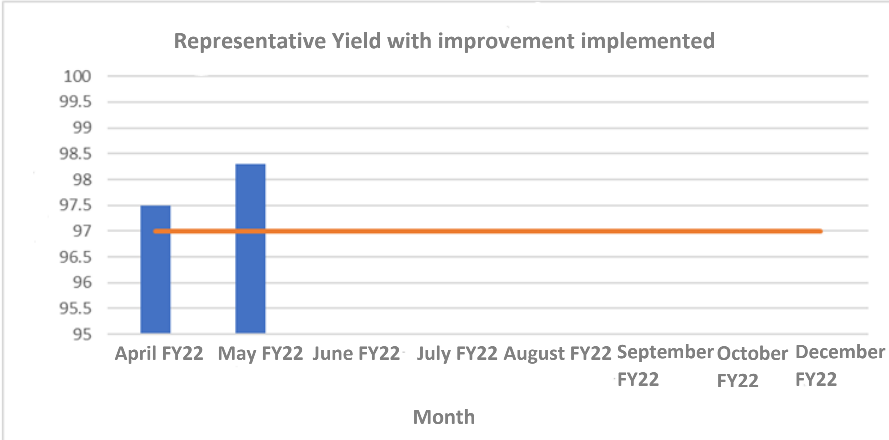

Figure 13. Representation of the Yield increase exceeding the goal
Source: Prepared by the authors.

For the results of the ergonomic analysis, the risk for wrist fatigue was reduced to 1.5 as shown in Figure 7, the risk low from medium almost high to very low fulfilling the main objective.

5. CONCLUSIONS AND RECOMMENDATIONS

This research represented a plausible project for the company since the results were evident and the goals set were exceeded. Above all, the main one that was to carry out the safest operation for its collaborators. In addition, it is a project that, given the results, will be replicable.

The ergonomic analysis carried out contributed to improving production standards while benefiting the operators. For the company, it represents a contribution to its safety policy, as well as to occupational risk control regulations.

For the ergonomic analysis results shown, the risk for wrist fatigue was reduced to 1.5, which means that the risk was low from medium to high to very low meeting the objective of the investigation. In general, it is considered that thanks to the performance of the objectives achieved, the production process was improved by the implementation of a semi-automated machinery, which makes the Liner operation a safer and more efficient operation. Specifically, in the insertion time, the objective of which was to reduce the cycle time by 30%, with the implementation of the machinery the insertion speed was greatly increased. It is worth mentioning that the insertion time takes most of the liner process, therefore this led to a 37% reduction in time.

Regarding the cell performance metric, this was below the expected goal, the measurement of the last months before implementation was taken and it can be concluded that the performance of the line is affected and thanks to the implementation of the DMAIC methodology, it was possible to get to the root of the problem. In addition, an implementation was made to root out what was causing the poor cell performance.

To verify compliance with the goal of minimizing waste by 40%, in the tests carried out with the insertion machine, no waste due to handling (bending or pulling) was observed, thanks to the design of the machinery where the Liner is inserted. It is conical in shape, this way makes the insertion point easier. In addition, due to the rollers that move the component in a uniform and fluid way, the hem is eliminated, due to variable and erroneous movements, all this contributes to the elimination of waste that was mainly due to handling.

Thanks to the improvement, it was concluded that the waste due to handling does not always belong to the operator; in this case, it was the need for an implementation that helps the operator to carry out his work. Which brings us to the ergonomic part of the project and on which the hypothesis is raised. It was stated that semi-automation could improve the production process, but above all reduce the present ergonomic risk, which was verified when the project was developed.

This research also shows that through the DMAIC methodology any production process can be improved, reaching the root cause of the problem, which in this case, has a direct relationship with the low effectiveness of how the process was carried out. Also that through this methodology each objective set out in the project was met. Improve production times, specifically reduce cycle time by 30%, which was achieved and not only that, but the goal was exceeded, reaching a reduction of 37%.This contributed to the improvement of several factors such as, firstly, the stress of the operator, being pressured to reach the daily production standard. The same situation that forced the operator to do the job with low care and poor quality, focusing only on the goal, this led us to another factor for improvement, which was waste.

One of the main recommendations is that given the importance of occupational safety and also having found areas of opportunity in the company, do not let yourself be overlooked by replicating this research, or, where appropriate, applying ergonomic methods according to the context of work cells. It is also recommended to look at other ergonomic methods that, although they are not yet considered by the regulatory authorities, if their effectiveness and plausible results have been demonstrated.

Another recommendation is to carry out control actions, since in this way the production process can be monitored and followed up, in order to meet and maintain production standards.

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EVALUATION OF RISK FACTORS TO AVOID INJURIES IN WORKERS WHEN PERFORMING MANUAL ACTIVITIES OF LOADING AND UNLOADING OF MATERIAL IN A MEAT TRADING COMPANY.

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Resumen: En el presente estudio se muestra una evaluación de las actividades manuales durante la carga y descarga del producto en el área de almacén de una empresa comercializadora y distribuidora de carne, con la finalidad de obtener un análisis completo del área e identificar y valorar los factores de riesgo existentes en cada operación. Para realizar este estudio se tomó como base las posturas ergonómicas según la Norma Oficial Mexicana NOM-036-1-STPS-2018 Factores de riesgo ergonómico en el trabajo-Identificación, análisis, prevención y control. Posteriormente se aplicó el método de evaluación ergonómica The MAC tool (Manual handling assesment chart) para las actividades levantar, cargar y transportar con la finalidad de ayudar al operario a identificar actividades de manejo manual de alto riesgo en el lugar de trabajo. Este método está diseñado para ayudar al trabajador a comprender, interpretar y categorizar el nivel de riesgo de los diversos factores conocidos asociados con las actividades de manejo manual. Incorpora un sistema de puntuación numérico y de codificación por colores para resaltar las tareas de manipulación manual de alto riesgo.

Los resultados obtenidos por el método The MAC tool permitieron identificar los principales factores de riesgo durante la carga y descarga del producto, planteados en las actividades de levantamiento, transporte y manipulación manual del equipo. Dentro de los factores más críticos se encontraron: Peso y ascenso de la carga/frecuencia de transporte, Distancia horizontal entre las manos desde la parte inferior de la espalda, Región de levantamiento vertical, Torsión y flexión lateral del torso; Carga asimétrica sobre el torso (transporte), Restricciones posturales (posturas incómodas, forzadas, o restringidas), Acoplamiento mano-carga (elemento de sujeción) Superficie de trabajo, Distancia de transporte, Factores ambientales y Obstáculos en la ruta (sólo en transporte), donde tres de estos factores resultaron con una codificación de color de **BANDA ROJA**, por lo que la puntuación para el nivel de riesgo obtenido fue ALTO (banda roja), por ende, la Determinación de nivel de acción para cada factor de riesgo obtenido también fue ALTO, esto requiere de una **ACCIÓN RÁPIDA**, por lo que se deben establecer medidas de control mediante un programa de Ergonomía que ayude al trabajador a evitar posibles lesiones musco esqueléticos.

Palabras clave: Manipulación manual de materiales, Riesgo ergonómico, Lesiones, El método de la herramienta MAC.

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 en el manejo manual de cargas con el fin de realizar rediseños y mejoras que aseguren el bienestar del trabajador, de manera que las tareas se encuentren en niveles aceptables de exposición al riesgo.

Abstract: This study shows an evaluation of the manual activities during the loading and unloading of the product in the warehouse area of a meat marketing and distribution company, in order to obtain a complete analysis of the area and to identify and assess the risk factors existing in each operation. This study was based on the ergonomic postures according to the Mexican Official Standard NOM-036-1-STPS-2018 Ergonomic risk factors at work-Identification, analysis, prevention and control. Subsequently, the ergonomic evaluation method The MAC tool (Manual handling assesment chart) was applied for lifting, loading and transporting activities in order to help the operator identify high-risk manual handling activities in the workplace. This method is designed to help the worker understand, interpret and categorize the level of risk of the various known factors associated with manual handling activities. It incorporates a numerical scoring and color-coding system to highlight high-risk manual handling tasks.

The results obtained by The MAC tool method allowed the identification of the main risk factors during product loading and unloading, posed in the activities of lifting, transporting and manual handling of equipment. Among the most critical factors were found: Weight and load lift/frequency of transport, Horizontal distance between hands from the lower back, Vertical lifting region, Torsion and lateral bending of the torso; Asymmetrical load on torso (transport), Postural restrictions (awkward, awkward, or restricted postures), Hand-load coupling (restraint element) Work surface, Transport distance, Environmental factors, and Obstacles on route (transport only), where three of these factors resulted in a color coding of RED BAND, so the score for the risk level obtained was HIGH (red band), therefore, the Determination of action level for each risk factor obtained was also HIGH, this requires a QUICK ACTION, so control measures must be established through an Ergonomics program that helps the worker to avoid possible musculoskeletal injuries.

Key words: Manual material handling, Ergonomic risk, Injury, The MAC tool method.

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 manual handling of loads in order to make redesigns and improvements that ensure the welfare of the worker, so that the tasks are at acceptable levels of risk exposure.

1. INTRODUCTION

Manual handling of loads is a fairly frequent task in many processes, whether of productive, administrative or service origin, and in most cases it causes physical fatigue or musculoskeletal injuries. These can occur suddenly or by the accumulation of trauma.

The new production trend incorporates ergonomics into the manual material handling process. Existing manual material handling tasks are now evaluated and improved with specific procedures. Ergonomic risk factors, such as poor posture and repetitive movements, are now taken more seriously in assessments.

Around 160 million people worldwide suffer from non-fatal occupation-related diseases annually according to the International Labor Organization (2013). This is largely due to technological, social and economic changes that have contributed to the creation of new risks, or exacerbated existing ones, including musculoskeletal disorders (MSDs). These disorders represent one of the most frequent occupational ailments, both in industrialized and developing countries (Riihimäki & Viikari, 2014).

The following is a study where the manual material handling process was analyzed in the loading and unloading of cardboard boxes of 25 to 33 kilograms, in the warehouse area of a meat marketing and distribution company, this activity is performed by a group of workers who move and arrange the boxes manually. Historically, injuries have been presented in workers when constantly performing this operation, for this reason it was necessary to analyze the activities and determine the high risk factors that occur when performing the work, to carry out this research it was proposed to apply an ergonomic evaluation methodology called The MAC tool (Manual handling assesment chart), which is a technique developed to evaluate the manual handling of loads based on NOM-036-STPS-2018, for the tasks: lifting/lowering and transporting.

Objectives: To evaluate the activities with risk factors and movements of workers when loading and unloading product daily in the warehouse area, in order to identify those manual material handling activities with high or very high risk, to avoid inadequate postures and musculoskeletal injuries.

1.1 Analysis of Musculoskeletal Disorders

In 2004, the World Health Organization (WHO) defined MSDs as health problems of the locomotor system that include: muscles, tendons, bone skeleton, cartilage, ligaments and nerves. Individuals may present from mild and temporary discomfort to irreversible and disabling injuries, many of them caused or intensified by work. In this regard, WHO (2004) points out the following as factors that influence the development of MSDs: exerting too much force, manual handling of loads for prolonged periods, handling objects repeatedly and frequently, working in awkward postures, static muscular effort, muscular inactivity, repetitive movements, exposure to vibrations, environmental factors, physical risks and psychosocial factors.

1.1.1 Manual handling assesment chart method (the MAC tool)

The ergonomic assessment method for manual handling of loads on which NOM-036-STPS-2018 is based, for lifting/lowering and carrying tasks is Manual handling assessment charts - the MAC tool, this technique was developed by the Health and Safety Executive (HSE - UK) and published in 2003. The MAC tool was developed to help the user identify high risk manual handling activities in the workplace and can be used to assess the risks posed by manual lifting, carrying and handling of equipment. It is designed to help the user understand, interpret and categorize the risk level of the various known risk factors associated with manual handling activities. It incorporates a numerical scoring and color-coding system to highlight high-risk manual handling tasks (Occupational Safety and Health Consultants Register, 2018).

2. METHODOLOGY

To develop this study it was necessary to identify and define the existing risk factors in the manual handling of materials in the loading and unloading of cardboard boxes in a meat marketing and distribution company, to subsequently apply The MAC tool method and specify which of these factors belong to a Low, Medium, High or Very High risk level according to the classification table, this study was complemented with the information established in the NOM-036-STPS-2018.

1. At the beginning of this research it was necessary to perform a detailed observation of the loading and unloading operation of the product, to define the risk factors that would be analyzed later (see Table 1).

Table 1: Format for recording risk factors

Risk factors found
Load weight and lift/carrying frequency
Horizontal distance between hands from the lower back
Vertical lifting región
Torsion and lateral bending of the torso; Asymmetrical load on the torso (transport)
Postural restrictions (awkward, awkward, awkward, or restricted postures)
Hand-load coupling (restraining element)
Work Surface
Other environmental factors
Transport distance
Obstacles on the route (transport only)

2. A thorough analysis of the risk factors encountered was performed to ensure that what was observed was representative of the normal work procedure.

3. The type of activity was identified, whether it was lifting/lowering with a single worker, lifting/lowering in a team, or transporting loads.

4. The MAC tool was then applied following the evaluation guide to determine the level of risk for each risk factor identified;

5. Finally, it was classified according to Table 2:

Table 2: Risk Level

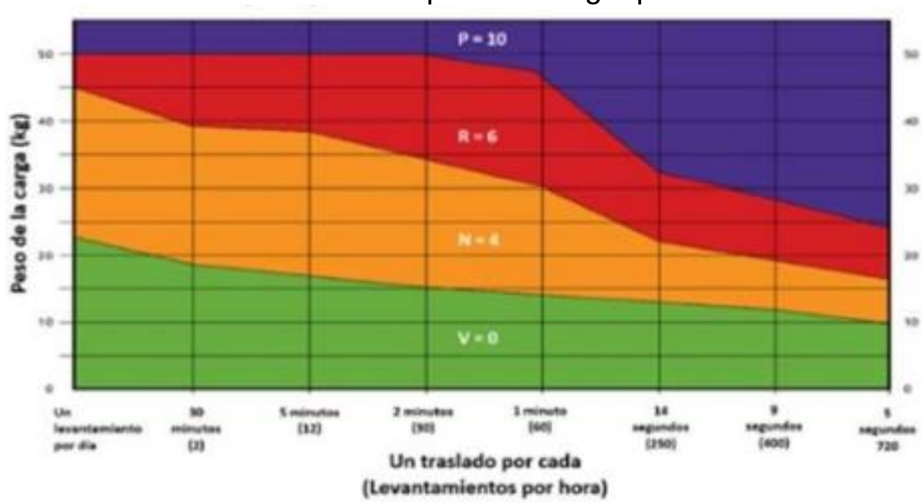
Risk level (The MAC tool)
Low: Although the risk is low, it is considered acceptable.
Medium: Although there is no high risk situation, activities should be examined in more detail.
High: A significant proportion of workers may be exposed to the risk of an occupational musculoskeletal disorder.
Very high or unacceptable: Such operations may pose a serious risk of injury and should be examined in detail and improved.

3. RESULTS

With respect to the risk estimation of activities involving lifting/lowering of loads, the following results were found.

a) Weight and load lifting/carrying frequency. When recording the weight and lifting frequency of the load, it was compared with Table 3 resulting in a yellow risk activity.

Table 3: Graph for Lifting Operations



b) Horizontal distance and distance between the hands and the lower back: when observing the task and examining the horizontal distance between the worker's hands and the lower back, the scenario was high risk red, since the arms are leaning away from the body and the torso is leaning forward. As indicated in Figure 1 red box.

Figure 1: Horizontal distance between hands and lower back.

c) Asymmetric load on the torso: Worker postures and load stability are risk factors associated with musculoskeletal injuries. Therefore, the analysis of this factor shows a yellow evaluation of the activity, since the load and the hands are asymmetrical, and the body is in a vertical position.

d) Postural restrictions: According to the criteria established in the method, a red band color was defined since the worker's posture when carrying the load is bent forward in an area with a low ceiling (see figure 2).

Figure 2: Postural restrictions

e) Work surface: This factor considered the properties of the surface where the worker walks or stands, which is wet, uneven or unstable surface, so the color of the band was defined as red. (see figure 3).

Figure 3. Work Surface

f) Other environmental factors: It was observed that the crate lifting operations are carried out under lighting conditions that are too dark, so the color of the band is yellow.

g) Obstacle on the route: The transfer of the load from one point to another is done through narrow doors with a risk of tripping, which corresponds to a yellow band color as indicated in the classification chart (see Figure 4).

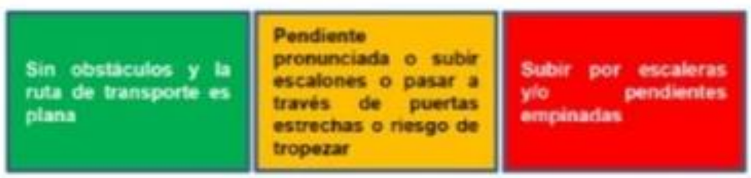


Figure 4: Obstacle on the route

Below is the Final Concentrate of the risk factors analyzed in this study, classified according to the type of activity and the band color assigned in the evaluation (see Table 3).

Table 3: Final concentration of risk factors

Risk Factors	Band color (green, yellow, red or purple)		
	Raise	Transport	Team
Weight and load lift/frequency of transport			
Horizontal distance between hands from the lower back			
Vertical lifting region			
Torsion and lateral bending of the torso; Asymmetrical load on the torso (transport)			
Postural restrictions (awkward, awkward, awkward, or restricted postures)			

Hand-load coupling (restraining element)			
Work Surface			
Other environmental factors			
Transport distance			
Obstacles on the route (transport only)			

Subsequently, the risk level score was estimated according to Figure 4 and compared with the information in Figure 5, in order to perform the coding as established by The MAC tool methodology applied in this analysis. It can be seen that the risk level score of the factors is "High", since 3 of the evaluated factors obtained a RED band color, 5 in YELLOW and only 2 in green (see figure 5).

SCORE FOR THE LEVEL OF RISK OBTAINED	
Low:	It is obtained when ALL the factors have a green band color, and there is no record of incidents or accidents in the activities and the workers do not show signs that the activity is heavy.
Medium:	It is obtained when the factors have a green and/or yellow band color.
High:	It is obtained when the factors have a green and/or yellow and/or red band color.
Very high or unacceptable:	It is obtained when SOME factor has a purple band color.

Figure 5: Scoring for risk level

Once the score was defined according to the color coding for the entire operation, it was determined that the RISK LEVEL is HIGH, which indicates that a significant proportion of workers may be exposed to the risk of an occupational musculoskeletal disorder, as established in Table 2 (Risk Level The MAC tool).

To conclude the study, the level of action was defined for each risk factor, where activities such as: weight and load lifting/frequency of transport, vertical lifting region, torso twisting and lateral bending, asymmetric load on the torso, other environmental factors and obstacles on the route, were evaluated with a YELLOW color band, "Medium" level of action, it is required to examine the tasks in greater detail, through the application of a specific evaluation, or to implement control measures through an ergonomics program.

On the other hand, factors such as the horizontal distance between the hands from the lower back, postural restrictions (awkward, forced, or restricted postures) and work surface resulted in RED band color "High" action level, these activities require FAST ACTION, so control measures should be established through an ergonomics program (See Figure 6).

DETERMINATION OF THE ACTION LEVEL FOR EACH RISK FACTOR OBTAINED	
Low:	Only the most vulnerable groups, such as pregnant women or underage workers, need to be monitored.
Medium:	The tasks should be examined in greater detail, through the application of a specific evaluation, or control measures should be implemented through an ergonomics program.
High:	Quick action is required, so control measures should be established through an ergonomics program.
Very high or unacceptable:	Activities should be stopped and control measures implemented through an Ergonomics Program.

Figure 6: Level of action for each risk factor

4. CONCLUSIONS

The present work demonstrated that The MAC tool Methodology is an ergonomic tool that contributes to the definition and evaluation of the risk factors present in material loading and unloading activities, identifying work postures, repetitiveness problems, environmental conditions, etc. In turn, it was found that manual material handling activities (such as lifting/lowering and carrying) expose a significant proportion of workers to the risk of an occupational musculoskeletal disorder, hence the importance of designing an appropriate ergonomic program for the task.

To determine each score and coding of the risk factors, it was of vital support the consultation of the Mexican Official Standard NOM-036-1-STPS-2018, the ergonomic principles, but above all the application of the Manual Method handling assessment chart, which allowed the correct classification of each activity, as well as the opportunity for the worker to understand, interpret and categorize the level of risk of the movements he/she performs when executing the daily task. It was possible to realize that, if bad postures, box grips, work surface conditions, etc., are not corrected soon, they run the risk of suffering musculoskeletal injuries, as has already happened to several workers of the same company.

With the development of this research it is concluded that the risk factors analyzed in the activity of loading and unloading cardboard boxes, present a HIGH risk level in the workers, which sooner or later will end up affecting their health if a plan of action is not followed, especially with those activities that resulted in Medium risk factor (yellow band) and High risk factor (red band).

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CHALLENGES OF ERGONOMICS IN THE SUPPLY CHAIN: COGNITIVE SYSTEMS DEVELOPMENT AND SOCIAL SUSTAINABILITY

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Resumen: A nivel mundial, la Ergonomía juega un papel importante para mantener a los trabajadores en óptimas condiciones, logrando con esto el aumento de la productividad en las organizaciones. Para esta ciencia surge un nuevo campo (contexto) de implementación, derivado de la integración de diferentes elementos que permiten a una red de empresas llevar a cabo la elaboración del producto o servicio, con la finalidad de satisfacer las necesidades del cliente final, denominada cadena de suministro, las cuales están sometidas a mayores exigencias de carácter laboral y social para cumplir con su función dentro de los sistemas productivos. El objetivo de este capítulo fue discutir y presentar los nuevos retos de Ergonomía en la Cadena de Suministro en el Desarrollo de Sistemas Cognitivos y en la Sostenibilidad Social por medio de la reflexión sobre la importancia y presencia de estas nuevas líneas de investigación en la literatura, a través de una revisión sistemática de literatura, por medio del método PRISMA y antecedentes de los diferentes retos analizados. Una vez realizada la búsqueda en las bases de datos de la Association for Computing Machinery (ACM) Guide to the Computing Literature, ACM DL, IEEE Xplore, ScienceDirect, ProQuest, Springer Link y Emerald Insight, aplicando los criterios de inclusión y exclusión, se obtuvieron 61 artículos relacionados con Sistemas Cognitivos y 56 de Sostenibilidad Social, publicados entre los años del 2010 y 2021. Los hallazgos más importantes permitieron evidenciar la relevancia y pertinencia de ambas líneas de investigación. Esto debido a que se observó la carencia de Desarrollo de Sistemas Cognitivos, así como la necesidad de esfuerzos para la comprensión y caracterización del dominio que se quiere representar. En cuanto a la Ergonomía y la Sostenibilidad Social, la evidencia demostró que hoy en día este enfoque es un tema de importancia por el impacto que produce en la sociedad y en la calidad de vida en el trabajo, pero existen retos en cuanto a la unificación de los sistemas de medición relacionados con los indicadores y métricas de Ergonomía utilizados en las organizaciones, así como también los aplicables en la evaluación global de la cadena de suministro.

Palabras clave: Ergonomía, Sistemas Cognitivos, Sostenibilidad Social, Cadena de

Suministro, Revisión Sistemática de Literatura

Relevancia para la Ergonomía: Como aportación se identifican dos nuevas líneas de investigación, las cuales son relevantes, pertinentes y de alto impacto en la calidad de vida del personal que labora en la cadena de suministro. Ambas líneas están sustentadas a partir de una revisión de literatura, por lo que se consideran áreas de oportunidad para la implementación de la Ergonomía.

Abstract: Worldwide, Ergonomics plays an important role in keeping workers in optimal conditions, thereby achieving increased productivity in organizations. For this science, a new field (context) of implementation arises, derived from the integration of different elements that allow a network of companies to carry out the development of the product or service, to satisfy the needs of the end customer, called chain supply, which are subject to greater labor and social demands to fulfill their function within the production systems. The objective of this chapter was to discuss and present the new challenges of Ergonomics in the Supply Chain (SC) in the Cognitive Systems Development (CSD) and Social Sustainability (SS) through reflection on the importance and presence of these new lines of research in the literature, through a systematic review of the literature, using the PRISMA method and antecedents of the different challenges analyzed. After searching the databases of the Association for Computing Machinery (ACM) Guide to the Computing Literature, ACM DL, IEEE Xplore, ScienceDirect, ProQuest, Springer Link, and Emerald Insight, applying the inclusion and exclusion criteria, obtained 61 papers related to CSD and 56 to SS, published between the years 2010 and 2021. The most relevant findings made it possible to demonstrate the relevance and pertinence of both lines of research. This is because the lack of CSD was observed, as well as the need for efforts to understand and characterize the domain to be represented. Regarding ergonomics and SS, the evidence showed that today this approach is an important issue due to the impact it produces on society and, on the quality of life at work, but there are challenges regarding the unification of the measurement systems related to Ergonomics indicators and metrics used in organizations, besides those applicable in the global evaluation of the supply chain.

Keywords: Ergonomics, Cognitive Systems, Social Sustainability, Supply Chain, Systematic Literature Review

Relevance to Ergonomics: As a contribution, two new lines of research are identified, which are relevant, pertinent, and have a high impact on the QOL of the personnel working in the SC. Both lines are supported by literature review, which is why they are considered areas of opportunity for the implementation of Ergonomics.

1. INTRODUCCIÓN

Ergonomics is the scientific discipline concerned with the understanding of interactions among 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 (IEA, 2000). Also, it contributes to solving the complex global problems of humanity, to find solutions that promote a better quality of life (QOL) at work and in other contexts. Thus, new challenges arise for which efforts must be made by researchers and ergonomists to identify, study, analyze and propose solutions to current needs.

Hasle & Jensen (2012) and Gómez (2021) show the obstacles faced by companies participating in the Supply Chain (SC). Among them are:

1. The globalization of markets.
2. The SC faces frequent changes in products, manufacturing systems, suppliers, and distributors of different companies and nationalities, which leads to organizational and administrative changes and the adaptation of new production philosophies.
3. The lack of legislation and/or its application that guarantees health and good working conditions.
4. The lack of international standards that cover health and safety aspects in the SC, this challenge was identified in the United Nations Global Compact.
5. Since the beginning of the pandemic in 2020, humanity has undergone constant changes in all areas: At the work level, teleworking began, and with this, it is essential to study what are the new risks to people's health, from the point of view of the design of the workstation, but it is essential to monitor the psychosocial risk factors (Gómez, 2021).
6. Cognitive Systems Development (CSD)
7. Social Sustainability (SS)

Although there is a diversity of them, this document develops a systematic literature review (SLR) focusing on two challenges for Ergonomics in the Supply Chain: The Cognitive Systems Development and social Sustainability. These challenges are of interest to the authors because these lines of research are currently being cultivated by them in their doctoral dissertations.

As problem statement, the Supply Chains are subject to greater labor and social demands to fulfill their function within the productive systems. Accordingly, Ergonomics contributes with solutions aimed at developing the sustainability of the SC (Radjiyev et al., 2015; Tortorella et al., 2017; Costa et al., 2018), considering human capacities and limitations (AEE, 2015). For this reason, it is necessary to reflect the importance and presence of these new lines of research in the literature.

1.1 Objective

Discuss and present the new ergonomic challenges in the SC in the CSD and SS, based on the findings of the Systematic Review of Literature and antecedents of the different challenges that arise, to confirm these lines of research

1.2 Delimitation

This research only addresses the challenges of CSD and SS in the Social Sustainability through a literature review.

2. METHODOLOGY

Regarding the methodology used, it is made up of three phases, as shown in Figure 1.

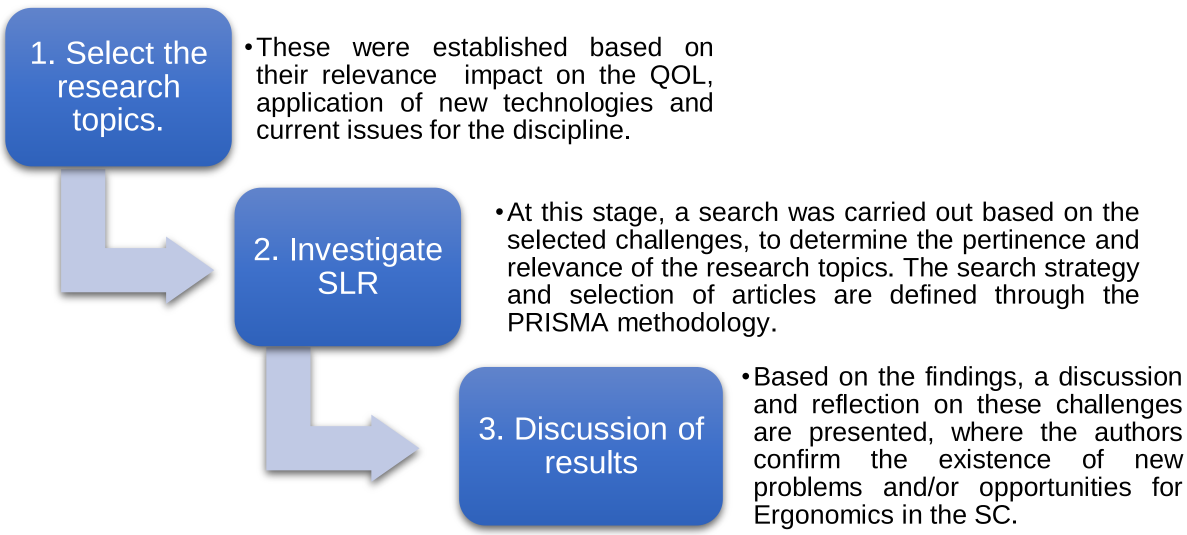

Figure 1. Description of the Methodology

3. RESULTS

3.1 Select research topics

Based on the ergonomic challenges in SC, the following were selected:

1) Cognitive Systems Development
2) Social Sustainability

3.2 Investigate: Background and SLR

The results of phase 2 of the proposed methodology are presented below.

3.2.1 CSD Background

Organizations need tools that allow them to manage knowledge efficiently. This knowledge can come from distinct kinds of data from structured to unstructured, images, sensors, voice, and video. Likewise, it can come from several sources, be ill-explicit and complex to represent, as happens with the demands in Informally Structured Domains (ISD) (informal and unstructured information) that require new solutions (Olmos-Sánchez & Rodas-Osollo, 2017), among others, are solutions to complex psychosocial problems at work such as work stress, as well as risks of lack ergonomics design. In this class of domains, it is necessary to adequately manage knowledge to build a solid knowledge base for the benefit of the same organizations, health professionals, administrators, and ergonomists.

3.2.2 Challenges in the CSD

Some challenges present in this research topic are:

Work Stress and Burnout

Thus, chronic, and prolonged stress produces an emotional, physical, and mental exhaustion called Burnout syndrome, which significantly reduces the person's mood, consequently impacting their health. Burnout is a syndrome that produces a feeling of emptiness and mental exhaustion (Macias-Velasquez et al., 2019). Generally, this syndrome is caused by excessive workloads. In addition, the working conditions derived from the position and responsibilities in the organization bring with them occupational diseases that can also aggravate other health problems (WHO | Workers' health, 2020).

Managing work stress

There are investigations and applications of Machine Learning (ML), such as those of Padmaja et al., (2018), Koldijk et al. (2018) and Hagad et al. (2016) for the detection and diagnosis of mental disorders such as Work-related stress, in addition to implementing ML algorithms, highlights the advantages of using user-centered CSD to support the taking of the health domain with successful results (Lee et al., 2020). However, there is a lack of research focused on the fusion and characterization of knowledge from multiple sources in scenarios as complex as job stress.

3.2.3 Social Sustainability Background

Nowadays, the sustainability strategy in SC is necessary, which within a social approach, includes Ergonomics Management (EM), as a crucial parameter for this strategy (Costa et al., 2018). In this sense, in SSC, the main actor is the human factor (Serdarasan, 2013), therefore, it is relevant to evaluate the ergonomic aspects inherent to working conditions.

3.2.4 Challenges present in social sustainability

Some challenges present in this research topic are:

The sustainable approach in SC: the lack of a social approach

This lacks sufficient attention both in supply chain management (GCS) and in SS issues (Korkulu & Bóna, 2019). Likewise, there is no accepted framework to evaluate ergonomics and SS in SC, there is inconsistency and lack of information (Simões et al., 2014). Additionally, Seuring (2012) stated that social and ergonomic problems have been avoided in CSS design. (Hong et al., 2018).

Lack of reliable and effective I&M of Ergonomics in the Supply Chain

Cantor (2008) and Perttula (2011) point out the need to carry out comprehensive studies and a holistic view of ergonomics throughout the SC, as well as to determine the scope of the metrics available to date, these being those of a microergonomic and macroergonomic nature.

3.2.5 SLR Results: CSD

The PRISMA methodology was used as a strategy for the identification and selection of papers. In the CSD, 61 papers were detected for study in the electronic database Association for Computing Machinery (ACM) Guide to the Computing Literature. Because it integrates publishers such as ACM, IEEE, Springer, Elsevier, John Wiley & Sons, IGI, Inderscience, Kluwer, among others (ACM, 2021). The parameters and Booleans used were: ("Cognitive systems" OR "Cognitive computing systems" OR "machine learning" OR "Cognitive models" OR "Cognitive applications" OR "smart agent") AND (health OR "mental health") AND (stress OR "work stress" OR "job stress").

Additionally, manual processes were carried out through which it was possible to identify relevant investigations to consider.

Inclusion criteria for CSD:

1. The paper is published between January 1, 2011, to May 11, 2021.
2. The paper is published in a scientific journal.
3. The paper is available in English.
4. The paper reports on a mental health prevention method or application.
5. The paper reports on a method or application for detecting work stress or individual or organizational burnout.
6. Manually screened papers were included by means of references to other papers.

Regarding the exclusion criteria for CSD:

1. The paper does not make an original contribution.
2. The subject of the paper is in another domain.
3. The contribution of the paper is through social networks or online support.

Below is the diagram of the PRISMA methodology for CSD's RSL.

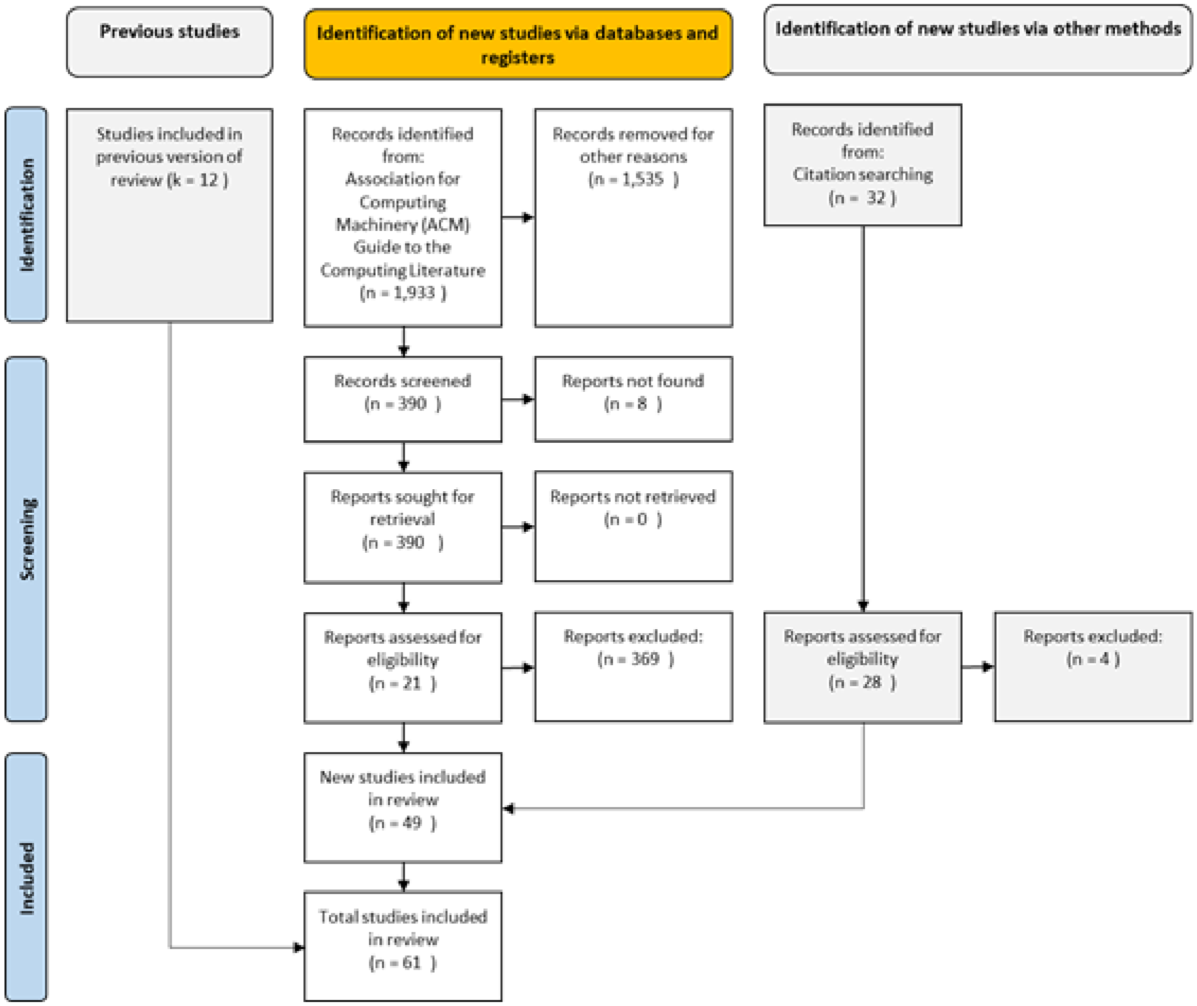

Figure 2. PRISMA methodology diagram for CSD.

Figure 3 shows an extract of the total of the articles selected for reasons of the length of the chapter, if it is of interest to the reader, he can ask the author for the complete table.

Year	Autors	Article	Journal
2021	Sarah Masud Preum, Sirajum Munir, Meiyi Ma, Mohammad Samin Yasar, David J. Stone, Ronald Williams, Homa Alemzadeh, and John A. Stankovic.	A Review of Cognitive Assistants for Healthcare: Trends, Prospects, and Future Directions.	ACM Comput. Surv.
	Megh Marathe and Kentaro Toyama.	The Situated, Relational, and Evolving Nature of Epilepsy Diagnosis.	Proc. ACM Hum.-Comput. Interact.
	Liuping Wang, Dakuo Wang, Feng Tian, Zhenhui Peng, Xiangmin Fan, Zhan Zhang, Mo Yu, Xiaojuan Ma, and Hongan Wang.	CASS: Towards Building a Social-Support Chatbot for Online Health Community.	Proc. ACM Hum.-Comput. Interact.
	Jue Wu, Junyi Ma, Yasha Wang, and Jiangtao Wang.	Understanding and Predicting the Burst of Burnout via Social Media.	Proc. ACM Hum.-Comput. Interact.
	Henrietta Lyons, Eduardo Velloso, and Tim Miller.	Conceptualising Contestability: Perspectives on Contesting Algorithmic Decisions.	Proc. ACM Hum.-Comput. Interact.
	Aftab Khan, Alexandros Zenonos, Georgios Kalogridis, Yaowei Wang, Stefanos Vatsikas, and Mahesh Sooriyabandara.	Perception Clusters: Automated Mood Recognition Using a Novel Cluster-Driven Modelling System.	ACM Trans. Comput. Healthcare
	Garg, Prerna, Jayasankar Santhosh, Andreas Dengel, and Shoya Ishimaru.	Stress Detection by Machine Learning and Wearable Sensors	In 26th International Conference on Intelligent User Interfaces
	Pabreja K., Singh A., Singh R., Agnihotri R., Kaushik S., Malhotra T.	Stress Prediction Model Using Machine Learning	Advances in Intelligent Systems and Computing
	Ladakis, I., & Chouvarda, I.	Overview of Biosignal Analysis Methods for the Assessment of Stress	Emerging Science Journal
2020	Varun Mishra, Sougata Sen, Grace Chen, Tian Hao, Jeffrey Rogers, Ching-Hua Chen, and David Kotz.	Evaluating the Reproducibility of Physiological Stress Detection Models.	Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.
	Varun Mishra, Gunnar Pope, Sarah Lord, Stephanie Lewia, Byron Lowens, Kelly Caine, Sougata Sen, Ryan Halter, and David Kotz.	Continuous Detection of Physiological Stress with Commodity Hardware.	ACM Trans. Comput. Healthcare
	Min Hun Lee, Daniel P. Siewiorek, Asim Smailagic, Alexandre Bernardino, and Sergi BermÃºdez i Badia.	Co-Design and Evaluation of an Intelligent Decision Support System for Stroke Rehabilitation Assessment.	Proc. ACM Hum.-Comput. Interact.
	Hsien-Te Kao, Shen Yan, Homa Hosseinmardi, Shrikanth Narayanan, Kristina Lerman, and Emilio Ferrara.	User-Based Collaborative Filtering Mobile Health System.	Proc. ACM Interact. Mob. Wearable

Figure 3 Extract of the total of the articles selected

3.2.6 SLR Results: Social Sustainability

The scope of the literature for the advanced search was defined from 2010 to 2020 for all databases (ACM DL, IEEE Xplore, ScienceDirect, ProQuest, Springer Link, and Emerald Insight), concentrated in journal papers, in addition, the words were identified key, for the collection of the papers and these are related through logical operators, as shown in Figure 4.

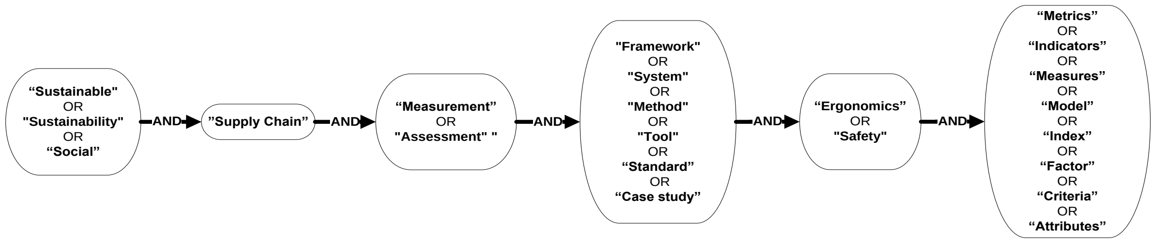

Figure 4. Relationship between keywords and logical operators used for search in the different databases

Once the search parameters had been defined, it was carried out, identifying 56 papers. Figure 5 shows the development of the systematic literature review.

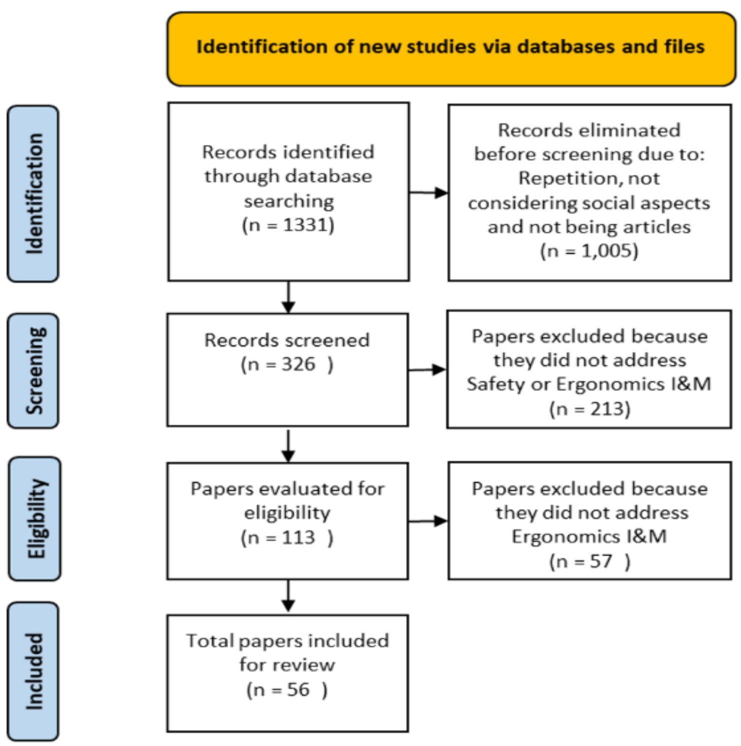

Figure 5. Flowchart of systematic review execution

Figure 6 shows an extract of the total of the articles selected for reasons of the length of the chapter, if it is of interest to the reader, he can ask the author for the complete table.

Year	Author	Title	Journal
2020	Hossan Chowdhury, Md Maruf	Supply chain sustainability practices and governance for mitigating sustainability risk and improving market performance: A dynamic capability perspective	Journal of Cleaner Production
	Hoque, et al.	Lean meeting buyer's expectations, enhanced supplier productivity and compliance capabilities in garment industry	International Journ of Productivity and Performance Management
	Gul Muhammet; Fatih, Ak M	Assessment of occupational risks from human health and environmental perspectives: a new integrated approach and its application using fuzzy BWM and fuzzy MAIRCA	Stochastic Environmental Research and Risk Assessment
	Getasew, et al.	Sustainability performance indicators for additive manufacturing: a literature review based on product life cycle studies	The International Journal of Advance Manufacturing Technology
	Dehdasht, et al.	A hybrid approach using entropy and TOPSIS to select key drivers for a successful and sustainable lean construction implementation	PLoS One
	Bhanot, et al.	An Integrated Decision-Making Approach for Cause-And-Effect Analysis of Sustainable Manufacturing Indicators	Sustainability
	Lin, Chiuhsiang Joe; et al.	Development of Sustainability Indicators for Employee-Activity Based Production Process Using Fuzzy Delphi Method	Sustainability
	Chandra, Dheeraj; Kumar, Dinesh.	Evaluating the effect of key performance indicators of vaccine supply chain on sustainable development of mission Indradhanush: A structural equation modeling approach	Omega
	Vegter, D.; Hillegersberg, J. V.; Olthaar, M.	Supply chains in circular business models: processes and performance objectives	Resources, Conservation and Recycling
2019	Kudelska, I; Pawłowski, G	Influence of assortment allocation management in the warehouse on the human workload: CEJOR	Central European Journal of Operations Research
	Watterson, et al.	The neglected millions: the global state of aquaculture workers' occupational safety, health and well-being	Occupational and Environmental Medicine
	Yu, Chunxia; Zhao, Wenfan; Li, Ming	An integrated sustainable supplier selection approach using compensatory and non-compensatory decision methods	Kybernetes
	Li, Yongbo, et al.	Risks assessment in thermal power plants using ISM methodology	Annals of Operations Research
	V. Navajas-Romero, R. Díaz-Carrión, A. Ariza-Montes	Decent Work as Determinant of Work Engagement on Dependent Self-Employed	Sustainability

Figure 6 Extract of the total of the articles selected

3.3 Discuss results

Based on the findings of the RSL and considering the antecedents of the issues, where the authors confirm that they represent new problems and opportunities for ergonomics in SC.

3.3.1 Cognitive Systems Development Findings

- About 80% of the investigations were found in the last 6 years. Therefore, the growing interest in this topic is observed.
- In addition, CSD have been used to support successful decision-making (Lee et al., 2020). These investigations were conducted to be applied on an individual basis, that is, user-centered. It represents an increasing challenge to formally characterize ISD domains.
- Regarding work stress, projects were found for the diagnosis and detection of mental disorders, for example: Padmaja (2018), Koldijk (2018) and Hagad (2016). Also, user-centered developments.
- However, the research trends found involve user-centered CSD, that is, for personal use. In such a way that there is an important opportunity area in CSD directed to organizations for organizational strategies of work stress and burnout.

3.3.2 Social Sustainability Findings

- In the SLR there is a growing interest in the subject, as confirmed by Sohrabi (2021), since the number of papers published increased during the period analyzed, it is important to comment that the number of them is still scarce and insufficient.
- 163 different Ergonomics indicators and metrics were identified, which are shown in Figure 7 from a cloud diagram. This suggests that there is a wide variety in the publications, but in some cases, they are only used once, which represents 68.94%, while in 48.21% of the publications only between 1 and 3 Indicators and Metrics are used, this shows considerable variability in implementation. These considerations show that there is a lack of an established consensus or approved and applicable evaluation scheme in all the links of the SC, in the same way, it happens for social measures in the Sustainable Supply Chain (Ahi & Searcy, 2015).
- The lack of an Ergonomics index that comprehensively evaluates CS is confirmed. Because only 5.35% of the papers evaluate 4 or 5 links of the Supply chain. On the other hand, the least evaluated links under this approach are distribution and customers.

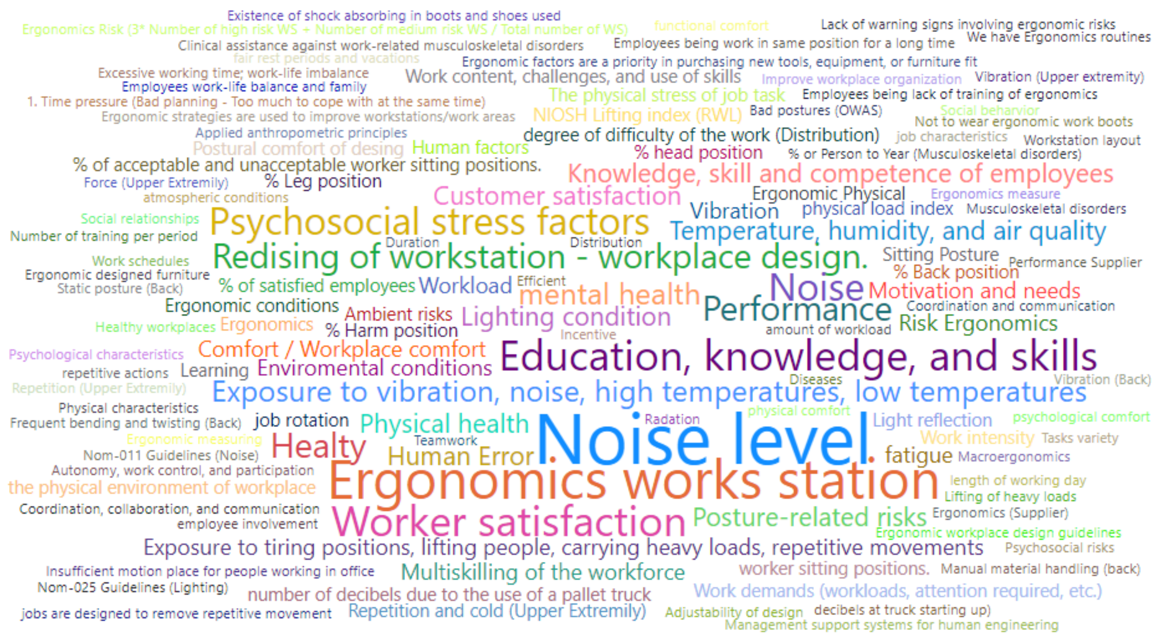

Figure 7. Ergonomics metrics and indicators frequency

4. CONCLUSIONS

In conclusion, according to the literature review both challenges are considered relevant lines of research for the implementation of Ergonomics. The objective of the SLR and methodology has been fulfilled since the lack of CSD was observed, as well as the need for efforts to understand and characterize the domain to be represented. Regarding Ergonomics and SS, the findings identified are evidence that today this approach is an important issue due to the impact it produces on society and the quality of life at work, but there are challenges regarding the standardization of its indicators applicable to the Supply Chain as a whole. On the other hand, it is recommended that the research community develop and/or provide solutions to these problems raised in these lines of research.

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ESTIMATION OF THE ERGONOMIC RISK OF A PACKAGE LOADER USING APPENDIX I OF NOM-036-1-STPS 2018

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RESUMEN: La presente investigación se llevó a cabo en una empresa dedicada a el proceso de formulación y envasado de mezclas liquidas (Fertilizantes), que busca resolver el problema de manipulación manual de cargas y cumplimiento de la normativa vigente; analizar y estimar el nivel de riesgo ergonómico en el puesto de trabajo de acuerdo con los criterios del apéndice I de la NOM-036-1-2018, para mantener a los trabajadores seguros en un entorno libre de riesgos, cumpliendo así con las regulaciones. Se consideró a todo el personal de la planta, que consiste en una población de 7 empleados, de los cuales se encontraron 3 que realizan manipulación manual de cargas ubicadas en 2 posiciones diferentes que implican el manejo manual de cargas, (producción y envasado) que realizan un total de 4 actividades (recepción de materia prima, proceso de producción, envasado manual y acomodo de producto terminado). Se obtuvo de la evaluación de riesgos que, de las 3 actividades, 2 son de riesgo medio y 1 de ellas son de alto riesgo. Con base en estos resultados, se propone un programa de ergonomía para el manejo manual de cargas, en el que la descripción de la técnica correcta para realizar las actividades de las posiciones en las que se realiza la manipulación manual de la carga, las medidas de control son presentadas a realizar y acciones de prevención.

Palabras claves: DTA´s. Lesiones musculoesqueléticas. Manejo manual de cargas. Fertilizantes.

CONTRIBUCIÓN A LA ERGONOMÍA: Busca concienciar a los empresarios que el trabajo con cargador en la industria de fertilizantes requiere de estudios sobre la necesidad de aplicar la ergonomía en las actividades de sus trabajadores ya que están expuestos a una alta carga de trabajo en su jornada laboral. Así como los beneficios de cumplir con la normativa federal vigente.

ABSTRACT: The present investigation was carried out in a company dedicated to the process of formulation and packaging of liquid mixtures (Fertilizers), which seeks to solve the problem of manual handling of loads and compliance with current regulations; analyze and estimate the level of ergonomic risk in the workplace in accordance with the criteria of appendix I of NOM-036-1-2018, to keep workers safe in a risk-free environment, thus complying with regulations. All plant personnel were considered, consisting of a population of 7 employees, of which 3 were found who perform manual handling of loads located in 2 different positions that involve manual handling of loads, (production and packaging) that They carry out a total of 4 activities (reception of raw material, production process, manual packaging and arrangement of the finished product). It was obtained from the risk assessment that, of the 3 activities, 2 are medium risk and 1 of them are high risk. Based on these results, an ergonomics program is proposed for the manual handling of loads, in which the description of the correct technique to carry out the activities of the positions in which the manual handling of the load is carried out, the measurements of control are presented to carry out and prevention actions.

Keywords: CTD´s. Skeletal muscle injuries. Manual handling of loads. Fertilizer.

CONTRIBUTION TO ERGONOMICS: It seeks to make employers aware that loader work in the fertilizer industry requires studies on the need to apply ergonomics in the activities of their workers since they are exposed to a high workload in their working day. As well as the benefits of complying with current federal regulations.

1. INTRODUCTION

The problem of musculoskeletal injuries of workers who work in industries caused by multiple causes is a matter that is of great importance, since they are the ones who carry out the primary activities so that companies meet their economic objectives and be able to satisfy the needs and expectations of customers and / or end consumers.

Currently, in the face of continuous change processes, companies are forced to be more competitive to survive and grow in the market, this leads them to achieve quality products and services, they must also promote the safety, health and development of their workers. Faced with these rapid changes, the ILO (2020) reports that: … *Every day many people die as a result of work-related accidents and* *illnesses. These deaths are estimated to number at least 1.9 million each year. It is also estimated that 90 million disability-adjusted life years (DALYs) are attributable to exposure to 19 major occupational risk factors. In addition, each year there are about 360 million non-fatal work accidents that result in more than 4 days of sick leave*.

According to recent estimates published by the International Labor Organization (2019) citing (Hämäläinen and other authors, 2017; Takala and other authors, 2014), 2.78 million workers die each year from occupational accidents and diseases (of the 2.4 million are disease-related) and 374 million workers suffer non-fatal occupational accidents. Lost workdays are estimated to account for about 4 percent of global GDP and, in some countries, up to 6 percent or more. In addition to the economic cost, there is also an intangible cost, which these figures do not reflect, of impossible to measure human suffering caused by occupational accidents and diseases. This situation is sad and regrettable because, as research and practice over the past decade have repeatedly shown, it can be largely prevented.

The ILO (2021) safety and health in the workplace is a shared responsibility. Employers should provide workers with OSH information and training to ensure that they understand the risks that may exist and the relevance of the safety measures taken, including the use of personal protective equipment (PPE). For their part, workers should comply with safety measures, including the use of PPE. Managers and workers should give top priority to the principle of prevention.

López M. (2020) citing the WHO (2016) points out that: … *In the low- and middle-income countries of the Americas, 11 daily occupational ergonomic risk factors per 100,000 workers were registered in 2004.*

For Castro G. (2018) citing Bernal G. and Cantillo C. (2004) comments that:

Musculoskeletal disorders are currently constituting a global, national and even regional public health problem due to their high incidence in recent years. Bernal refers that these disorders are the most frequent cause of absenteeism and loss of productivity, which generally affects the individual's ability to carry out their usual activities. These mainly affect the soft parts of the locomotor system: muscles, tendons, nerves and other structures near the joints, showing that, in certain tasks, small mechanical aggressions such as stretching, friction, compressions occur, which when repeated during long periods of time (months or years), their effects accumulate until they cause a manifest injury.

The Pan American Health Organization (2000) considers the workplace as a priority environment for health promotion in the 21st century. Individuals, communities and countries consider occupational health and healthy work environments to be among their most precious assets. A healthy work environment is essential, not only to achieve worker health, but also to make a positive contribution to productivity, work motivation, work spirit, job satisfaction and quality of life for everyone.

A primary resource for personal, social and economic development is the workplace. Numerous factors manage to benefit or deteriorate the health of workers, including economic, social, political, cultural and environmental factors, however, if the work environment is already healthy, there will be spaces that collaborate in the progress and promotion of health in the workplace. job.

For the above reasons, it is necessary to train and measure the appropriate physical characteristics of the employees, studying and evaluating the ergonomic risk factors present in the work area.

Quesada F. (2017) citing Mahecha M. (2009) comments that low back pain is considered a public health problem in many parts of the world. This condition has been growing as a socioeconomic vicissitude. Statistics from the United States of North America estimate that approximately two-thirds of the adult population suffered or suffers from low back pain at some point in their life, making low back pain one of the most common causes of outpatient medicine. general and specialized.

In specific functional needs related to work, there are bone, muscular, ligamentous structures and the lumbar intervertebral discs, in addition to their movement, they can be medically compromised as a consequence of the work carried out by the worker. This cause favors that the work activities associated with low back pain are the subject of different studies, highlighting that there are different occupational factors in work low back pain in addition to being associated with other variables referring to the worker himself.

Low back pain is one of the main occupational diseases that need to be addressed since it is considered that manual lifting can increase your risk and occurs in various occupational fields López M. (2020) citing Kudo, Yamada and Ito (2019) . Hence the importance of doing this type of research using occupational ergonomics tools to solve it. The current regulation in Mexico is NOM-036-1-STPS-2018: Ergonomic risk factors at work Identification, analysis, prevention and control. This rule arises from the need to safeguard the life and health of workers and must be complied with by employers, as well as by workers.

Part 1:

Manual Handling of Loads, which aims to establish the elements to identify, analyze, prevent and control ergonomic risk factors in workplaces derived from manual handling of loads, in order to avoid alterations in the health of workers. Also, to comply with this rule, the obligations of the employer and also of the workers are established, jointly with prevention, training and education measures. Although it is true that there are laws, regulations and norms, as well as public institutions that have under their jurisdiction the implementation of health actions, the reality is that these actions are not enough to prevent occupational risks. For success, it is necessary to have the commitment and support of both employers and workers to develop a culture of prevention, and thus have a healthier work environment. In the fertilizer company that was the object of study, it was based on the premise of knowing the ergonomic conditions of the worker since this is essential to guarantee the safety and health of the loaders. The risk assessment for handling loads was carried out, this due to the nature of the company as a manufacturer of liquid fertilizers since it presents activities of manual handling of loads, repetitive movements and other ergonomic risk situations, which could lead to accidents, injuries and / or illnesses.

What is the ergonomic risk level for manual handling loads according to appendix I of NOM-036-STPS? The objective was to estimate the risk level of bag loaders according to the criteria of appendix I of NOM-036-1-2018, in order to maintain these insurances, within a risk-free environment, thus giving compliance of the federal regulations on safety and health at work 2014 and the standard NOM 036 STPS 2018.

DELIMITATIONS
Fertilizer formulation companies that do manual handling of loads.

2. METHODOLOGY

Subject under study

The subject under study is a company dedicated to the manufacture of liquid fertilizers, considering all those operators whose tasks involve manual handling of loads, with a total of 7 employees, of which 3 were found who perform manual handling of loads located in 2 different positions that involve the manual handling of loads, (production and packaging) that perform a total of 4 activities (reception of raw material, production process, manual packaging and arrangement of finished product).

Procedure

Looking for the proposed objective, the order of the steps to follow is shown below:

System characterization

At this stage, the identification of activities that involve ergonomic risk factors due to manual handling of loads is carried out, which means that they must involve lifting, lowering, transporting, pushing, pulling and / or stacking materials.

Description of activities

Make a description of the identified activities, involving exposed workers, frequency in which they carry out the activity and the duration of the activities.

Estimation of the level of risk

An estimate of the level of risk due to manual handling of loads must be carried out.

a) activities that involve lifting, lowering or carrying loads and
b) activities that involve pushing and pulling or dragging materials, with or without the aid of auxiliary equipment, should be considered:

1. Risk estimation of manual load handling operations with a single worker. (From NOM-036-1-STPS-2018; it does not indicate the following in the risk estimate)
    a) Load weight and frequency.
    b) Horizontal distance between hands and lower back.
    c) Vertical elevation region.
    d) Torso twisting and lateral flexion
    e) Postural restrictions
    f) Manual load coupling (fixing elements)

g) Work surface
h) Other environmental factors

2. Estimation of the risk of cargo transport operations.
a) Load weight and frequency.
b) Horizontal distance between hands and lower back.
c) Asymmetric load on the torso.
d) Postural restrictions.
e) Manual load coupling (fixing elements)
f) Work surface.
g) Other environmental factors.
h) Transport distance.
i) Obstacles on the route.

The process of manual loading of raw materials is carried out as follows:

a) 20-kilogram bags, grip and lift uncomfortable See figure 1 and 2.

Figure 1.

Figure 2.

b) Horizontal distance between hands and back, (the effort is greater, the load is done on one side of the body). See figure 3.

Figure 3.

c) Vertical elevation region. See figure 4.

Figure 4.

d) Torso lateral bending and twisting and e) Postural restrictions. See figure 5.

Figure 5.

f) Manual load coupling (fasteners)
It is restricted, as the grip on the bag and uncomfortable.
g) Work surface:
The surface is stable, but there are obstacles in the process, other bags, containers.
h) Other environmental factors:
Stable light and noise levels, doors open for air circulation.

2. Estimation of the risk of cargo transport operations.

a) Load weight and frequency.

Estimated load in bags of 20 kilos.
b) Horizontal distance between hands and lower back.
An intricate body adjustment is observed to be able to lift and fully grasp the load.
c) Asymmetric load on the torso.
The body receives the full load even only on the side or shoulder.
d) Restricciones posturales.
Es restringida ya que la actividad de levante y constante esfuerzo implica una restricción.
e) Manual load coupling (fixing elements).
The load corresponds to non-rigid bags, constant effort by clamping or gripping.
d) Work surface.
Irregular obstructed by the presence of objects or / or other bags.
e) Other environmental factors.
Stable environment, noise, temperature and ventilation.
f) Transport distance.
The distance traveled involving stairs falls in the range of 4 -10 meters for the manual transport of loads.
g) Obstacles on the route. See figure 6.
Obstacles, steep slopes due to the use of stairs to the second level.

Figure 6.

For any type of activity, you must:
a) Record the color and value obtained in each of the factors analyzed for each type of activity.
b) Determine the level of risk.
c) Define the actions, according to the level of risk obtained.
Information required for the estimate:
For the purposes of this estimate, it is necessary to have the information on the work carried out by the operators in their workplace and the NOM-036-1-STPS-2018, which is applicable throughout the Mexican Republic.

2. **Results**.

The understanding of the tasks of the production operator position and its analysis based on the standard indicates that it has a medium-significant to a significant high ergonomic risk. Due to live activities that involve lifting, stowing or moving heavy loads and also manually transporting them from one place to another in the production area. See the figure 7 and 8.

The table 1, shows the estimation of the risk level for the manual loading and transport activity.

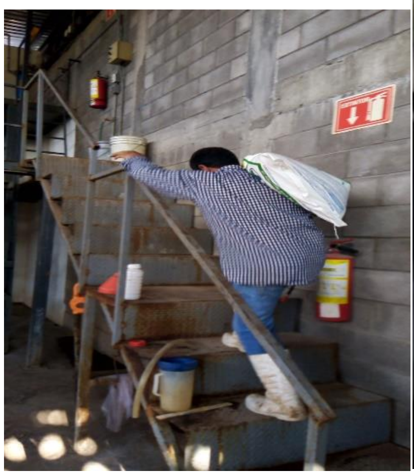
Figure 7.


Figure 8.

Table 1. The estimation of the risk level for the manual loading and transport activity.

Actividad: carga de sacos
peso kg 20
Aplicación apendices Al.2,Al.3 y Al.4 para estimar nivel de riesgo

Factores de Riesgo	Levantar		Transportar		Equipo	
	color	valor	color	valor	color	valor
Peso y ascenso de la carga/ frecuencia transporte	Naranja	4	Naranja	4	NA	NA
Distancia horizontal entre las manos desde la parte inferior de la espalda	Naranja	3	Naranja	3	NA	NA
Region de levantamiento vertical	Rojo	3			NA	NA
Torsion y flexion lateral torso carga asimetrica sobre torso (transporte)	Verde	0	Morado	3	NA	NA
Restriccions posturales	Naranja	1	Naranja	1	NA	NA
Acoplamiento mano carga	Naranja	1	Rojo	2	NA	NA
Superficie de trabajo	Verde	0	Naranja	1	NA	NA
Otros facotres ambientales	Verde	0	Verde	0	NA	NA
Distancia de transporte			Naranja	1	NA	NA
Obstaculos en la ruta(solo transporte)			Rojo	3	NA	NA
Comunicación coordinacion y control (equipo)					NA	NA
Puntuacion	12		18		NA	NA
Nivel de Riesgo	**Medio- posible**		**Alto significativo**		NA	NA

Table 2. Risk level and priority.

NIVEL DE RIESGO	PRIORIDAD	PUNTAJE TOTAL
Bajo â Aceptable	No se requieren acciones correctivas	0 a 4
Medio â Posible	Se requieren acciones correctivas a corto plazo	5 a 12
Alto â Significativo	Se requieren acciones correctivas pronto	13 a 20
Muy Alto - Inaceptable	Se requieren acciones correctivas inmediatamente	21 a 32

Table 3. Required Actions.

NIVEL DE RIESGO	ACCIONES
Bajo â Aceptable	**Sólo se requiere dar seguimiento a los grupos más vulnerables, como mujeres en periodo de gestación o trabajadores menores de edad.**
Medio â Posible	Se debe examinar las tareas con mayor detalle, mediante la aplicación de una evaluación específica, o bien implantar medidas de control mediante un Programa de ergonomía para el manejo manual de cargas.
Alto â Significativo	Se requiere una acción rápida, por lo que se deben establecer medidas de control mediante un Programa de ergonomía para el manejo manual de cargas.
Muy Alto - Inaceptable	Se deben detener las actividades e implementar medidas de control mediante un Programa de ergonomía para el manejo manual de cargas.

After the analysis of these activities (see the table2 and 3), the following were detected:

- 1 medium-possible risk activity.
- 1 significant high-risk activity.

To have an overview of all the estimation results, the table 4, shows the position evaluated, the area to which it corresponds, what type of manual handling of loads is carried out in the position and the degree of risk with which this is carried out. exercise.

Table 4, shows the position evaluated.

#	Area	personal de area	Atividades relacionadas	Nivel de riesgo de acuerdo a actividad
1	Oficina	1	propias de oficina	Riesgo no significativo
2	Recepcion de materias primas			
3	Almacen de materias primas	1	Descarga y carga	Riesgo no significativo
4	Produccion de fertilizantes	2	Carga manual y transporte	Riesgo significativo manejo manual y transporte manual
5	Envasado de fertilizantes			
6	Area de produto terminado	3	Cargas monores o igual a 1 lt o kg	Riesgo no significativo envasados de litro
7	Baños	0	NA	Riesgo no significativo

After carrying out the analysis of the activities that involve manual handling of loads, manual transportation of loads; It was concluded that, although the company is young in terms of its working time in the line of business, it currently already applies measures to prevent risks due to manual handling of loads, but these are still present in some activities, even if there is a significant high risk , due to the fact that due to the nature of the production process and the rotation involving fertilizers, said loading maneuvers are concurrent or repetitive.

Some of the recommendations and prevention and / or control actions carried out are:

- Training in correct manual handling techniques for all exposed personnel.
- Use of auxiliary equipment: in the case of the high-risk activity of the Production Operator Station, the implementation of auxiliary equipment proposes a team to help the operator to lift the loads, since one of the main risks of the activity It is the region of vertical lifting or through stairs, with this simultaneously we help reduce the risk of the operator of the production station. An example of the equipment that could be used is the elevator with a second level key or mixing tanks.
- Technical and / or administrative control measures: reinforce the security measures that the company currently has, the security measures indicated in NOM-036-1-STPS-2018 and the recommendations for prevention and / or control actions, as well as a follow-up to the proposed ergonomics program.

3. DISCUSSIONS

The characterization of the jobs and the analysis of the activities allowed to identify that, of the total number of stations in the plant, there are 3 stations that perform manual handling of loads located in 2 different positions, which involve manual handling of loads, (production and packaging) that carry out a total of 4 activities (reception of raw material, production process, manual packaging and arrangement of the finished product). It was obtained from the risk assessment that: of the 3 activities, 2 are medium risk and 1 of them is high risk. Based on these results, an ergonomics program for the manual handling of loads is proposed, in which the description of the correct technique to carry out the activities of the positions in which the manual handling of the load is carried out, the measurements of control are presented to be carried out and prevention actions.

The estimated results are similar to those found by López M. et al. (2020) in an investigation in Navojoa, Sonora with a larger population and in the automotive industry, in addition to that with the estimation results they evaluated them supported with the MAC Tools evaluation method and already evaluated with it, they proceeded to propose an ergonomics program for manual handling of loads. Also, Castro F. et al (2020) applied Appendix I of NOM 035 STPS 2018 in a bakery in Mexicali, Baja California and their estimates are very similar to that of this research and once the risk was estimated, they evaluated them with the support of the RAPP method and WERA method and with these evaluations they also proposed an ergonomic program for the evaluated workers in the bakery.

4. CONCLUSIONS

The number of activities and positions that represent risks for workers are identified based on the information of the process and after its estimation, it is concluded that the company does not currently comply with all the points evaluated by the regulations, however, it is not far of complying with this because it already had a culture of attention to the worker.

The activities of the positions in which there is manual handling of loads are described, as well as the control measures to be adopted and the prevention actions; Therefore, in applying such a program, in addition to complying with regulations, we benefited 2 out of a total of 7 employees.

Achieve the prevention of occupational hazards, the reduction of physical discomfort of workers, injuries, accidents and diseases, such as tendinitis, back pain, neck and shoulder pain that are present in workers. Taking the situation of the company under study, in the case of the high-risk position, which is carried out by 2 workers, if they present neck and joint pain, the company was asked to carry out studies on its two workers occasionally exposed to driving. of loads on the spine and chest radiograph that must be presented to a work doctor and thus avoid diseases generated by this type of work and effort.

In addition, compliance with this regulation will avoid the imposition of fines for non-compliance, ranging from 25,670 to 513,400 Mexican pesos, (STPS, 2017). Maintaining the care and safety of workers is imperative since, on the one hand, we avoid damage to the health of human resources and, on the other, we avoid the serious impositions or fines that are reflected by non-compliance with the regulations applicable to these companies.

For the purposes of this research, it was necessary to have ergonomic database files for workstations, risk estimation formats from Appendix I of NOM-036-1-STPS-2018.

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ERGONOMIC EVALUATION IN AN OFFICE USING THE ROSA METHOD (RAPID OFFICE STRAIN ASSESSMENT): A CASE STUDY IN A MAQUILADORA INDUSTRY

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Resumen: Este trabajo presenta una evaluación ergonómica en un puesto de oficina mediante el método ROSA existente en una empresa maquiladora. El objetivo del estudio es evaluar los riesgos por disergonomía en un caso de estudio. Como métodos, se determinaron molestias musculoesqueléticas con el mapa del cuerpo de Marley y Kumar, se analizó el trabajo y se aplicó antropometría para finalmente aplicar el método ROSA (Rapid Office Strain Assesment). Como resultados, 7 partes del cuerpo se encuentran en la zona de mayor riesgo y es muy probable que requieran tratamiento entre ellas glúteos y espalda baja. Las puntuaciones del método ROSA para el asiento, pantalla y ratón indican riesgo con un valor global de entre 5 y 7 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 una alternativa más ergonómica en este puesto de trabajo.

Palabras clave: Antropometría, Ergonomía, Molestias Musculoesqueléticas, método ROSA.

Relevancia para la Ergonomía: Este trabajo aporta una propuesta ergonómica en área de oficina para que el equipo se encuentra al alcance, en buenas condiciones y ajustable, con la finalidad mejorar la salud del oficinista.

Abstract: This paper presents an ergonomic evaluation in an office using the ROSA method existing in a maquiladora company. The objective of the study is to assess the ergonomics risks of in a case study. As methods, musculoskeletal discomfort was determined with the map of the body of Marley and Kumar, the work was analyzed and anthropometry was applied to finally apply the ROSA (Rapid Office Strain Assesment) method. As a result, 7 parts of the body are in the area of greatest risk and are very likely to require treatment including buttocks and lower back. The scores of the ROSA method for the seat, screen and mouse indicate risk with an overall value of 7 and that immediate action is required, so a proposal for changes in the distribution of the work area and scopes is presented in such a way that the new design can be a more ergonomic alternative in this workplace.

Words key: Anthropometry, Ergonomics, Musculoskeletal Discomfort, ROSE method

Relevance for ergonomics: This work provides an ergonomic proposal in the office area so that the equipment is within reach, in good condition and adjustable, the important thing is to keep the employees in these areas comfortable and safe to avoid possible risks of injury in the future.

1. INTRODUCTION

The idea arises from the need of the office worker the way in which he must adapt his body to the work equipment, such as the screen, mouse, seat, and keyboard. Figure 1 shows the way in which the office worker adopts his body to carry out his activities, since he spends long periods of time sitting in front of the screen capturing information, a dysergonomics design is observed on the desk, screen, and lack of adjustment in the seat design. Diego, (2019) states that:

The evaluation considers the most common elements of these workstations (chair, work surface, screen, keyboard, mouse, and other peripherals). As a result of its application, an assessment of the measured risk is obtained and an estimate of the need to act on the position to reduce the level of risk.

Figure 1 Posture of the office worker.

2. OBJECTIVES

General objective: Evaluate the risks of dysergonomics in office areas using the ROSA method.

Particular objectives

1.- Determine musculoskeletal complaints.
2.- Apply anthropometry.
3.- Carry out a job analysis.
4.- Apply the ROSA method.
5.- Propose changes.

3. METHODOLOGY

This section briefly explains the method that was carried out and the seven stages into which it was divided. Figure 3.8 shows the stages that were carried out.

The first stage refers to the application of Marley and Kumar formats to the office user who works in the area, the second is to analyze the data obtained after applying the format and by creating statistical tables that show the user's concern. , the third stage consists of taking measurements of the work area, the fourth stage is to make the body measurements of the office user, the fifth stage is to make video recording and photographs of the user performing the tasks in the position, the sixth stage is to implement the ROSA method and finally the seventh stage consists of proposing possible changes to the office position.

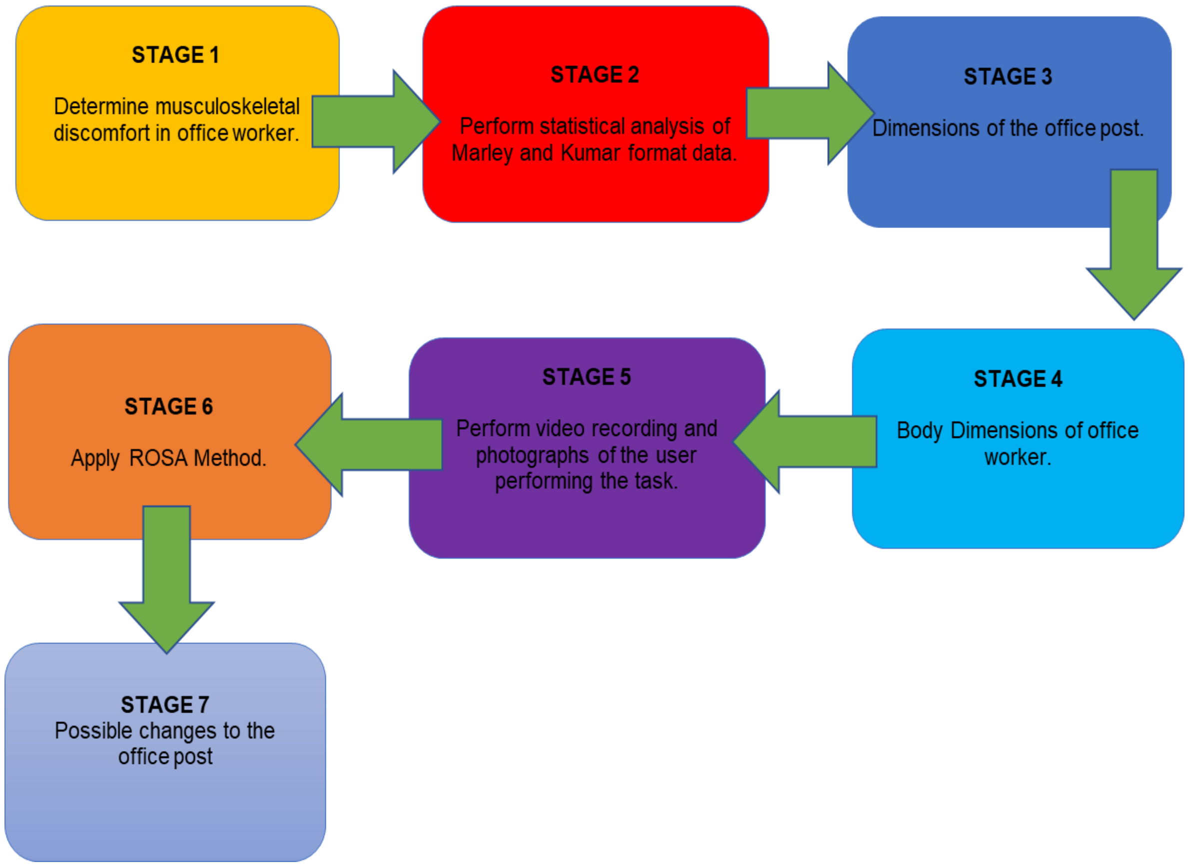


Figure 3.8 ROSA Method Stages.

3.1 Determine musculoskeletal complaints

In this stage, it consists of determining musculoskeletal discomfort, by applying Marley and Kumar formats such as the one shown in Figure 3.9, in this part a general and detailed vision of the user's concerns is obtained.

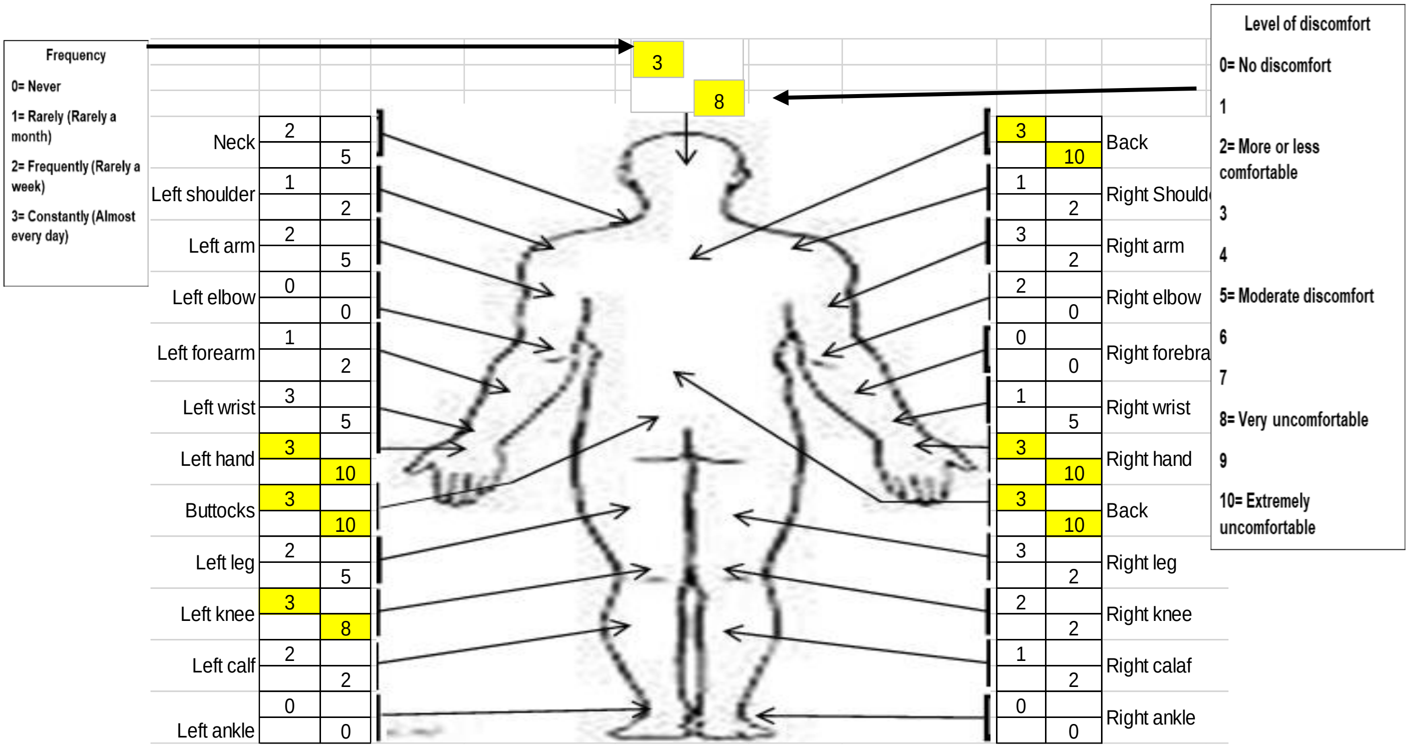


Figure 3.9 Body Discomfort Map, (Jeffrey E. Fernandez, 2008)**.**

The body discomfort map diagram shows the discomfort on the part of the office worker, but to have a better overview of the situation, Figure 4 shows the continuation of the Marley and Kumar format, which helps to know which extremities of the body are in treatment areas and those that do not require treatment.

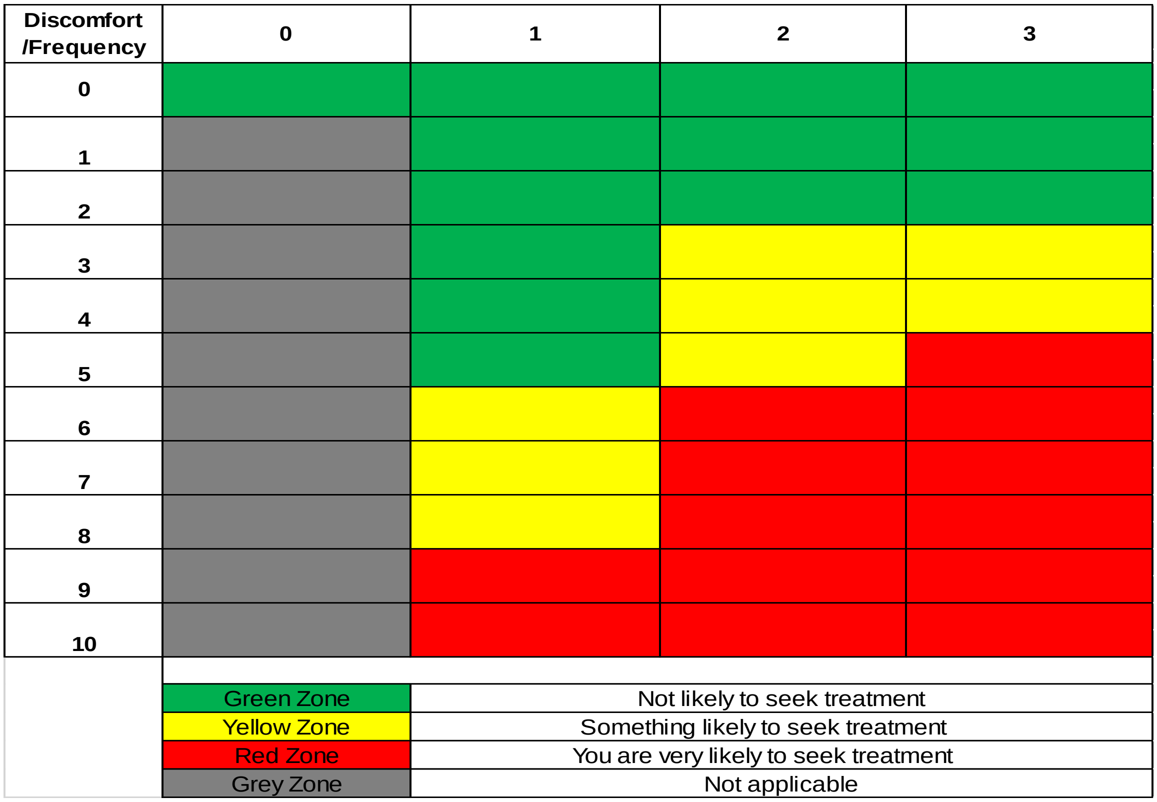


Figure 4 Body Map Scoring Sheet, (Jeffrey E. Fernandez, 2008).

Finally, Figure 4.1 shows the green area where 14 parts of the body are found, which represent 56% of conditions, but do not need treatment. The second percentage with 28% represented by the red zone in which there are 7 parts that are at risk of injury, among them are the buttocks and back, to name a few, they are very likely to seek treatment. With 16% in the yellow zone with only 4 parts which are somewhat likely to seek treatment.

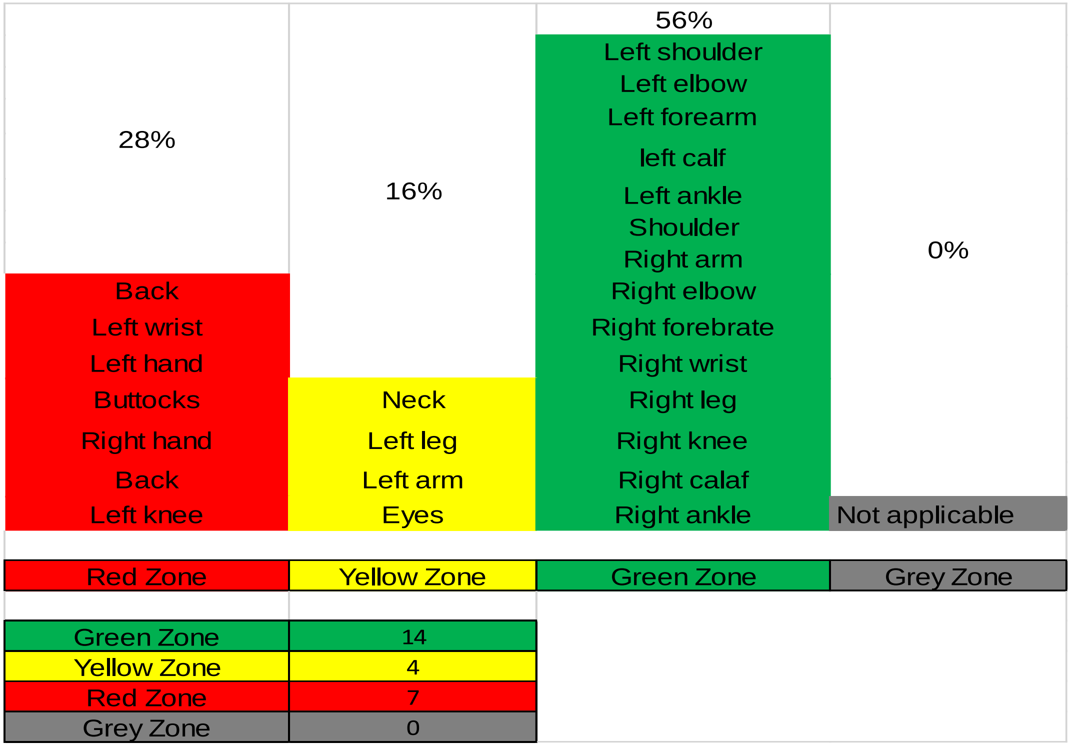


Figure 4.1 Affected areas.

3.2 Statistical analysis of data from Marley and Kumar formats

The above information is compiled for statistical analysis and a bar graph represents the discomfort in the red zone, such as the one shown in Figure 1, since they occur more frequently and with a high level of discomfort.

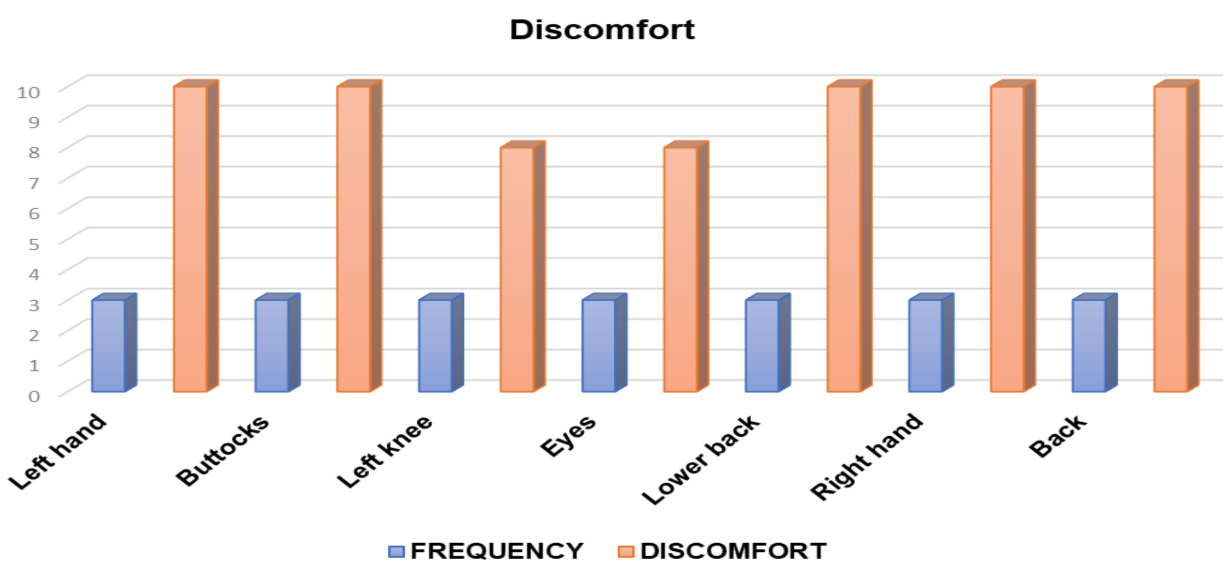


Figure 1 Red Zone Discomfort.

3.3 Workstation dimensions

Figure 2 shows the dimensions of the work area consisting of 1.80 meters (m) long by 1.55 (m) wide, space available to the office worker to make screen, keyboard and mouse adjustments.

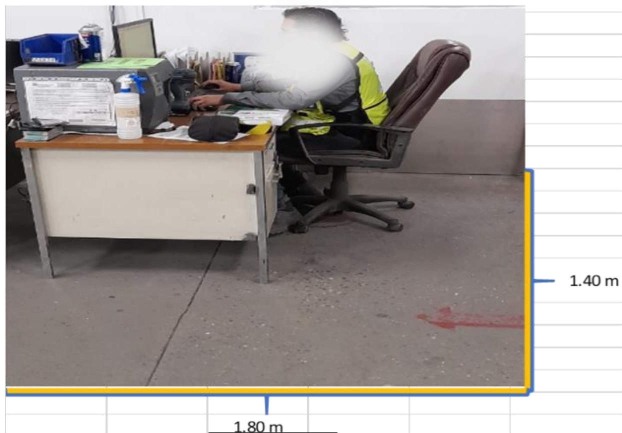


Figure 2 Di 1.80 **Work area.** 1.55

3.4 Body dimensions

The next section deals with the quantitative study of the physical characteristics of man whose object is the measurement of static dimensions, that is, those that are taken with the body in a fixed and determined position. Table 1 shows the participant's measurements, it is worth mentioning that the units of measurement are in meters.

Table 1 Participant body dimensions (Enrique de la Vega B., nd).

Kg							
920	67 Kg	122	0.56 m	595	0.22 m	914	1.21 m
805	1.65 m	223	0.45 m	441	0.22 m	912	1.18 m
328	1.62 m	457	0.70 m	420	0.15 m	200	0.48 m
23	1.50 m	32	0.75 m	656	0.10 m	194	0.23 m
309	1.15 m	639	0.37 m	411	0.10 m	2fgm	1.15 m
949	1.05 m	230	0.95 m	402	0.03 m	4fgm	0.33 m
398	0.80 m	931	0.85 m	859	0.42 m	529	0.66 m
973	0.78 m	178	0.38 m	758	0.93 m	678	0.55 m
265	0.65 m	430	0.60 m	330	0.68 m	381	0.45 m
797	1.51 m	144	0.20 m	25	0.55 m	507	0.45 m
798	0.75 m	165	0.14 m	312	0.20 m	459	0.44 m
80	0.66 m	427	0.22 m	856	0.14 m	775	0.26 m
752	0.50 m					776	0.11 m
						777	0.088 m

3.5 Making video recording and photos

Through a video, the postures that the user adopts at the time of carrying out the activities are observed. Figure 4.3 shows the video made, in order to determine the risks involved in the office worker during the execution of their activities.

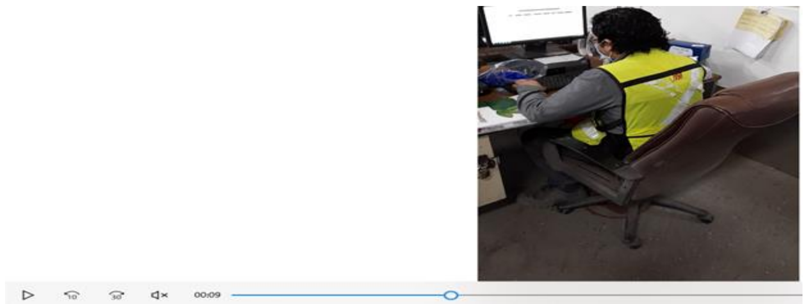


Figure 3 Video capture.

The frames are a process to decompose an activity into its different elements, the video is 5 (min) for which 100 frames will be made and all will be considered, now what follows is to determine the time interval in which they will go taking captures during video playback.

The first thing is to convert the 5 (min) of the video to seconds since the GOM PLAYER program works in (s), the following is to divide the seconds obtained between the recommended frames for the amount of time the video lasts, in this If it is divided between 100 frames and the result obtained will be the time interval to be used, then the calculations are presented.

5 (min) * 60 seconds = 300 seconds (s).

300 (s) / 100 frames = 3 (s).

3 (s) time interval.

Of the 100 frames already selected, those positions in which there is a similar risk are grouped into activities that are repeated more than once. Figure 4.4 shows the tasks performed by the participant, which must be analyzed.

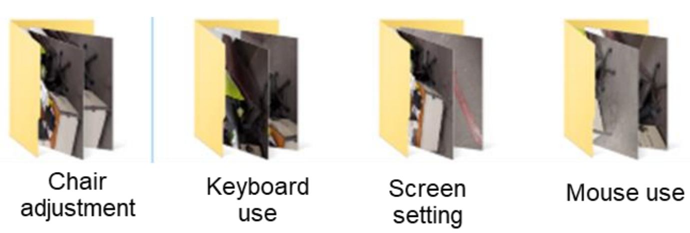
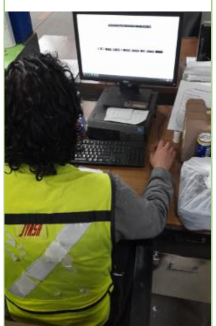
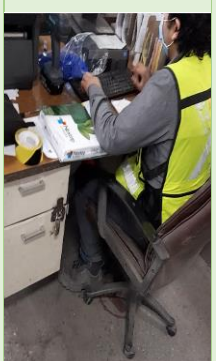


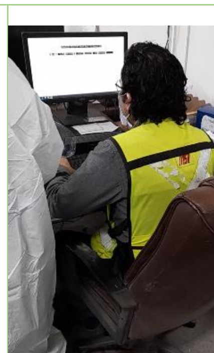
Figure 4 Tasks to analyze.

The next thing is to count the number of frames (Frequency) and make a table like the one below, where the activities with the highest frequency are classified. Once the movements have been classified, they are analyzed, but only those positions in which the percentage of frequencies is 10% or higher.

In this case, the activities are presented in a frequency greater than 10%, therefore they are considered for their analysis.

Table 2 Frequencies.

Exercise	Photos	Number of Frames	Frequencies	% Frequencies	Cumulative frequency
Chair adjustment		**27**	**20,21,22,23, 24,25,26,40, 41,42,43,55, 56,57,64,65, 66,67,68,69, 70,74,75,76, 77.78.79**	**27%**	**27%**
Use from Mouse		**22**	**4,5,6,7,8,9, 10,11,12,44, 45,46,84,85, 86,87,88, 91, 92.97.98.99**	**22%**	**22%**
Use keyboard		**3. 4**	**1,2,3,27,28, 29,30,31,32, 47,48,49,50, 51.52.53.54 58,59,60,61, 62.63,80,81, 82.83.89.90, 93,94,95,96, , 100**	**3. 4%**	**3. 4%**

Screen setting		**17**	**13,14,15,16, 17,18,19,33, 34,35,36,37, 38,39,71,72, 73**	**17%**	**17%**

3.6 ROSA method

The ROSA method makes it possible to quantify the ergonomic risk in the office workstation, for this purpose the scoring diagram is used that assigns a score to each of the elements of the post: chair, screen, keyboard, mouse.

Figure 5 shows the results of the application of the ROSA field sheet and in Table 3 the results obtained from its application, it is worth mentioning that the value of the score can range between 1 and 10, being greater the greater the risk for the office worker, taking in activity. As can be seen, the evaluated elements are between 5 and 7, resulting in the need for immediate action, considering the exposure time.

Rodillas flectadas 90° aproximadamente.

Asiento muy bajo. Ángulo de la rodilla < 90°.

Asiento muy alto. Ángulo de la rodilla > 90°.


Sin contacto de los pies con el suelo.

Respecto a la **profundidad del asiento**, indica la situación

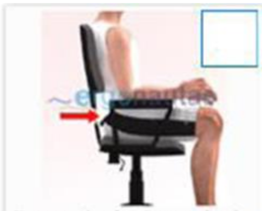
proximadamente 8 cm de espacio entre el asiento y la parte trasera de las rodillas.

Asiento muy largo. Menos de 8 cm de espacio entre
el asiento y la parte trasera de las rodillas.

Asiento muy corto. Más de 8 cm de espacio entre
el asiento y la parte trasera de las rodillas.

Además, indica si

Respaldo reclinado entre 95 y 110°y apoyo lumbar adecuado.


Sin apoyo lumbar o apoyo lumbar nosituado en la parte baja de la espalda.

Respaldo reclinado menos de 95° o más de 110°.

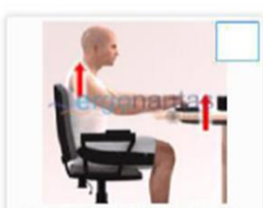

Sin respaldo o respaldo no utilizado para apoyar la espalda.

Además, indica

Las muñecas están rectas y los hombros relajados.

Las muñecas están extendidas más de 15°.

Además, indica



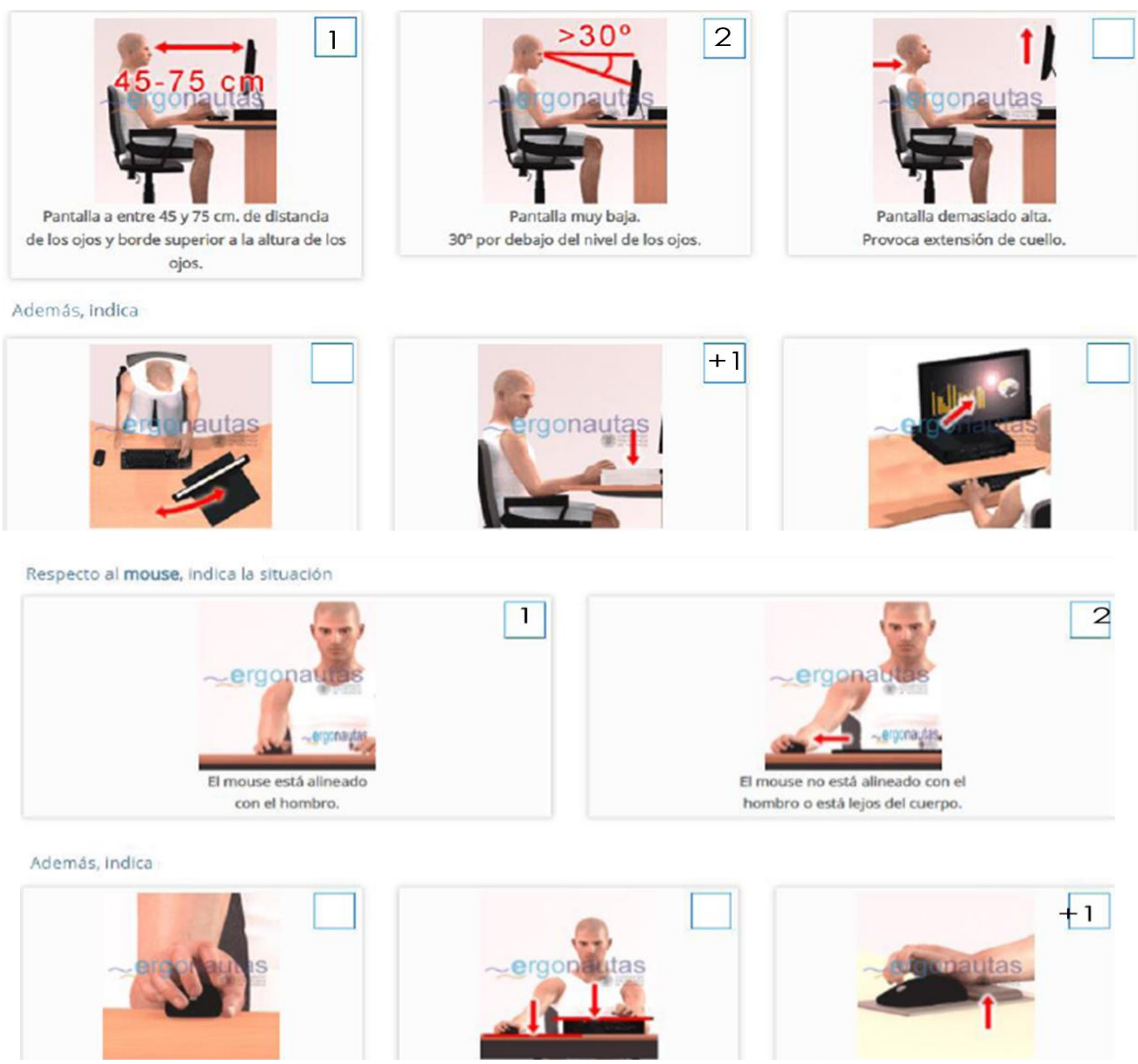


Figure 5 ROSA Field Sheet, (Diego-Mas JA, 2019).

Table 3 ROSA results.

Element to evaluate	Punctuation
Seat height	7
Armrests	5
Back	6
Screen	5
Mouse	5
Keyboard	5
Daily wear time	Punctuation
Less than 1 hour total or less than 30 minutes interrupted.	-1

Between 1 and 4 hours in total or between 30 minutes and 1 hour interrupted.	0
More than 4 hours or more than 1 hour interrupted.	+1

3.7 Propose changes

- Vertical reach 63.3 cm.
- Horizontal reach 71.6 cm.
- Optimal zone 39 cm.
- Maximum area 73.5 cm.

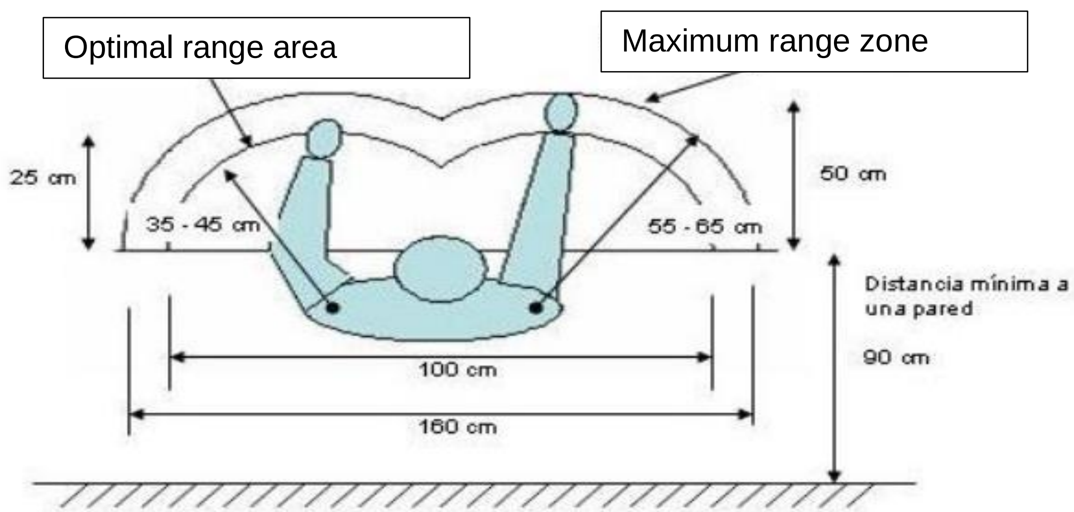


Figure *6* **Reach areas.**

Finally, Figure 7 shows the proposal for the workstation with the following dimensions.

- Height from seat to elbow 24 cm
- Height from seat to eye 68.1 cm
- Height from seat to shoulder 58.5 cm
- Popliteal height 44.5 cm

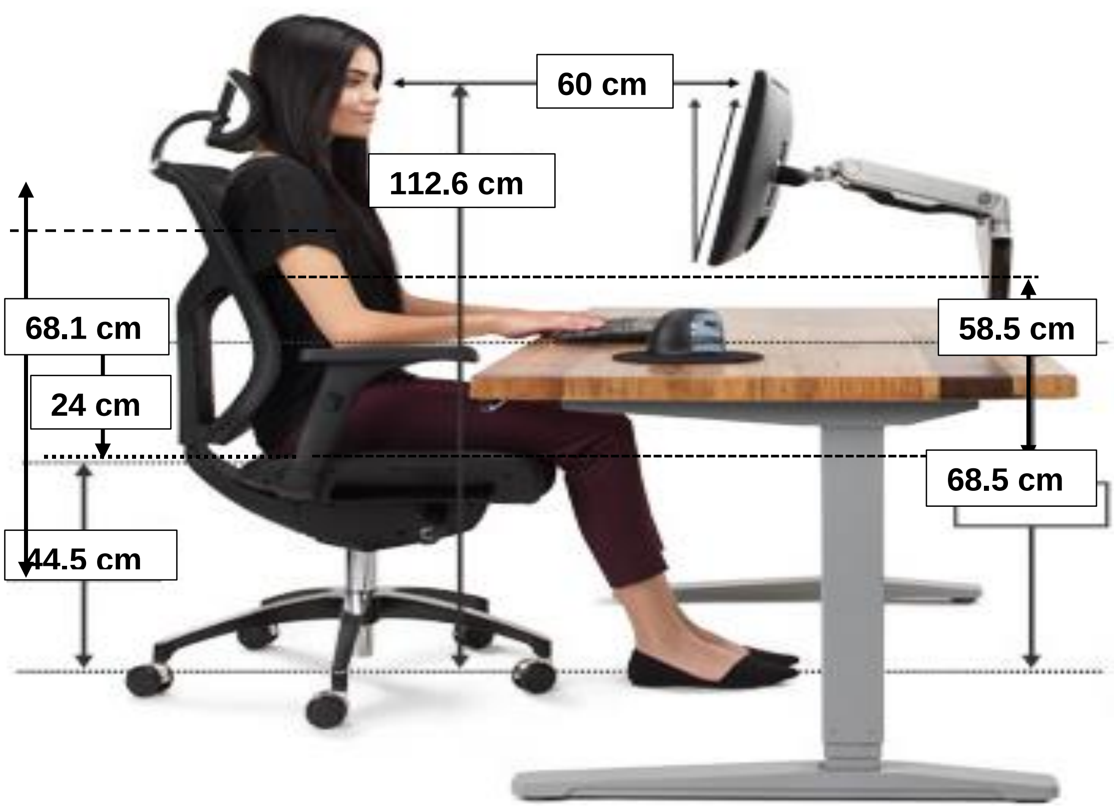


Figure 7. Proposal.

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