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Prefacio

La Sociedad de Ergonomistas de México A.C. (SEMAC), como parte relevante de su actividad e interés en la difusión, promoción y apoyo a la ergonomía, ha organizado desde 1999 y de forma anual, su Congreso Internacional de Ergonomía. En Abril de 2014, la hermosa ciudad de Mérida, y en especial la Universidad Anahuac-Mayab, nos abre sus brazos para recibir el XVI Congreso Internacional de Ergonomía, con la participación de ergonomistas profesionales e interesados en esta área.

Este año está lleno de retos y esperanzas. Tenemos una nueva legislación laboral que aun no comprendemos sus alcances, pero también tenemos un Proyecto de Reglamento Federal de Seguridad y Salud en el Trabajo que esperamos que sea publicado en el primer semestre de este año. Este nuevo Reglamento tiene como novedad, a propuesta de SEMAC, un artículo dedicado a la Ergonomía en los centros de trabajo y aunque parece muy poco, tendrá un gran impacto en la salud de los trabajadores debido a que los centros de trabajo deberán evaluar los puestos de trabajo y realizar las mejoras cuando sea necesario. Aunado a este Reglamento, se está trabajando en una Norma Oficial Mexicana para la aplicación adecuada del mismo.

Se reúnen en este libro una selección de los trabajos, presentados en este congreso, más representativos de las diversas áreas que participan en la ergonomía, aportando diferentes investigaciones y soluciones a problemas específicos, con la finalidad de contribuir a la difusión, apoyo en la educación e investigación, de temas de interés para la ergonomía.

Los editores, árbitros y comité académico, a nombre de la Sociedad de Ergonomistas de México, A.C., agradecemos a los autores de los trabajos aquí presentados su esfuerzo, e interés por participar y compartir su trabajo y conocimientos en el XVI Congreso Internacional de Ergonomía de SEMAC. También agradecemos a los participantes y asistentes, provenientes de muy diversos lugares y formaciones, así como a todo el equipo de organización de este congreso, su valiosa aportación que estamos seguros derivará en el avance de la ergonomía en las Instituciones de Educación Superior y en la planta productiva nacional y mundial.

Enrique de la Vega Bustillos

Presidente SEMAC 2002 – 2004

SOCIEDAD DE ERGONOMISTAS DE MÉXICO A.C.

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ANTHROPOMETRY IN HAND: A COMPARATIVE STUDY BETWEEN WORK AND NOT WORKING CONTEXTS

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Summary: It is essential to know the dimensions of the hands of the members of a population, to properly design the hand tools they use in their daily activities. This study aims to Perform Hand anthropometric survey in a population of workers and students in the Gustavo A. Madero, DF and is part of an observational design, descriptive and cross sectional case control workers in a population of type and other students, using the parameters of the UNE EN ISO 7250:1998. The universe of study consists of a total of 520 individuals. Of which 67.3 % are students (not work) and 32.6 % owned by the employees. The working population has a slight increase in the parameters mentioned in the UNE EN ISO 7250 with respect to the sample of students. Except for the category corresponding to the length of the index finger, the student population had higher numbers. The dimensions obtained as maximum and minimum in each measurement parameter taken both samples, we provide a framework for the design of a hand tool with ergonomic features.

Keywords: Anthropometry, Ergonomics , Workers

Relevance to Ergonomics: The dimensions obtained as maximum and minimum in each measurement parameter taken both samples, we provide a framework for the design of a hand tool with ergonomic features

1.- INTRODUCTION.

Anthropometry studying measures of man. It refers to the study of human dimensions and measures in order to understand the physical changes of men and the differences among ethnic groups. Also the knowledge and skills to carry out the measurements (1).

Anthropometry divided competence in two areas: static and functional anthropometry. The first relates to the measurements made on the human body dimensions in a certain position, while the second describes the ranges of movement of the body parts, scopes, measures paths (2)

2.- OBJETIVE

Perform an anthropometric survey hands in a population of workers and students in the Gustavo A. Madero, DF This will involve the design of the survey , identification of anthropometric dimensions relevant to the use of hand tools , data collection in the field and finally the organization and interpretation of anthropometric data. This research is justifiable as it may consider necessary to know the dimensions of the hands of the members of a population, to properly design the hand tools they use in their daily activities. Improper design of hand tools has generated musculoskeletal problems in people who use and reduced productivity thereof.

For this study the statistical universe is formed by the inhabitants of the delegation Gustavo A Madero in Mexico City. The probabilistic sample is obtained through a random selection of subjects sampling strategy were surveyed to follow has been established taking into account the employed population of both genders , age and are healthy , normally constituted . Finally as strict inclusion criteria that were students and workers.

This study is part of an observational design, descriptive and transversal. A study case control study was conducted in a population of workers and other students as mentioned above. With both samples anthropometric assessment was performed the following sequence[3]

1. Hand length
2. Length of the palm
3. Width of the palm in metarcarpianos
4. Length of the index finger
5. Finger width proxima
6. Distal width of the index finger

The collection of field data was conducted randomly among students and workers. It was explained to the person to assess the reasons and purpose of the study and measurements. From the data log record identification and measurement of anthropometric parameters included hand and marked. He was subsequently asked to sign a letter of informed consent.

The area consists of data collection with the characteristics of appropriate illumination with light of day, each individual was comfortable and supporting hand to measure firm support. The posture assessment protocol is in standing position with elbow flexion 90 degrees with arm attached to the trunk and wrist joint without ulnar or radial deviation.

Measuring instruments were reviewed neat and calibrated before each sampling. Far only the dominant hand of each participant using anthropometric tape which is not extensible and flexible material, 7mm width was noted. these measures were set out with the help of a dermographic pencil to mark the anatomical points and other reference marks.

3.- RESULTS

STUDY GROUP consists of a total of 520 individuals. Of which 67.3 % are students (not work) and 32.6 % owned by the employees Students (not working) This sample of 350 senior high students include 140 women (40 %) and 210 men (60%).

WORKERS This sample consists of 170 employees, of which 91son men representing 53.5% and 46.5 % with 79 women. The average age was 34.1 years (with a range of 23 to 56 years).Workers in various socio-economic sectors (ceramic, public administration, informal commerce and various trades), selected according to the criteria.

4.- ANALYSIS OF RESULTS

A universe of study was identified, between work and no work, from which they derive different variables such as age and routine activity with the hands.

It was found that the anthropometric measure for length hand (LM) of the sample of workers is greater than that of the sample of students (not working), both in the field of media , fashion, and the maximum and minimum . Likewise, the same trend is observed in the length of the palm (LPM), the width of the palm on the metacarpals (WMPA), proximal width of the index finger (APDI) , distal width of the index finger (ADDI) . For the length of the index finger (LDI) sample of students (not working) provided an average maximum and minimum slightly higher, and fashion of the same value that the sample of workers.

5.- CONCLUSIONS

Anthropometric survey in the Gustavo A. wood workers and students, showed that the population of workers is a slight increase in the parameters mentioned in the UNE EN ISO 7250 with respect to the sample of students. Except for the category corresponding to the length of the index finger, the student population had higher numbers.

The feature ID that presents the population of workers with a greater length in the measurements allows us to orient ourselves to two aspects, the first and foremost reflects the constant and continuous use of at least 8 hours of muscle mass hand for performing work activities, which can be assumed as hypertrophy (increase in the size of muscle cells) and the second but not less important the presence of obesity and increased size to be given at the expense of adipose tissue.

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TRADITIONAL ANTHROPOMETRIC MEASURES VS. DIGITAL ANTHROPOMETRIC MEASURES USING SCANNER NX16.

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RESUMEN: La ergonomía busca crear espacios de trabajo adecuados, herramientas y equipo apropiados para cada una de las personas. Esta ciencia tiene una de sus bases en la antropometría la cual es responsable de las medidas de las dimensiones del cuerpo humano, los conocimientos y técnicas para llevar a cabo las mediciones, así como su tratamiento estadístico. En los últimos años se han creado equipos para desarrollar o desplazar a las formas tradicionales medir, es decir hay equipo y software que ayudan a determinar las dimensiones antropométricas. Este trabajo presenta una comparación utilizando ambos métodos, tradicional y con el equipo digital NX-16, se hizo un análisis estadístico de los resultados para ver la variabilidad.

Palabras claves: Antropometría tradicional, Antropometría digital, Ergonomía y variabilidad.

ABSTRACT: Ergonomics aims to create appropriate workspaces, tools and equipment for each person. This science has its bases in anthropometry, which is responsible of measure the dimensions of the human body, knowledge and techniques to measure, such as statistic treatment. In recent years, equipment has been created to develop or displace traditional ways of measure, per say there's equipment and software that helps to determine anthropometric measures. This job presents a comparison using both methods, traditional and using digital equipment NX16, statistical analysis has been made from the results to see variability.

Keywords: Traditional Anthropometric, Digital Anthropometric, Ergonomics & Variability.

Relevance to Ergonomics: Definitely one of the technological advances that has used ergonomics anthropometry area is the use of software (digital anthropometer NX-16) dedicated to image processing and photographic equipment purchased such images , these being better quality every day, helping with this science of health, work study, and safety, among others, as they have more anthropometric measurements in less time.

1. INTRODUCTION.

Today is highly important to consider design and anatomic structure of each individual to understand and develop all areas were human performance is involved to increase productivity, said (Vink, Koningsveld & Molenbroeck, 2006); this isn't new, research has been made in some countries like (Samani, Holtermann, Sogaard & Madeleine, 2012) that study muscular activity, cardiovascular and load posture during cleaning. With all the technological advances we can have a better living standard (Garcia Lizana, 2012). The introduction of new technologies has develop innovative studies, one is anthropometry which determines dimensions of human body, there's some research in this area , such is the case of (Castellucci, 2010), who studied assembly design of school furniture for students where its main objective was to realize an anthropometric register, considering main anthropometric dimensions of Portuguese students of elementary education.

In history, we see a lot of research that had develop anthropometry. In today day's these researches have increased, becoming an important support in ergonomic, such is the case of (Adreasi, Michelin, Rinaldi & Burini, 2010) were they analyze the association between physical condition related to health and anthropometric indicators and demographic in children of three elementary schools in Botucatu, Brazil same as (Brown, Gotshalk, Katzmarzik & Allen, 2011) who compared measures of adiposity between two cohort of children in the school zone of Hillo, Hawaii and the measures related to information given by parents of the ethnicity, family economy and level of elementary education, same way Mendonca (2013) develop a comparative study of cranial anthropometric measurement using traditional tweezers, computed tomography, three-dimensional photometry to quantify the morphology of the cranial cavity and new ways of digital images. In Mexico this researches have increased due to recommendations made by the Federal Rules of Safety, Hygiene and Environment of Work in article 102 of associations like SEMAC (Sociedad de Ergonomistas de Mexicana A.C.) which organize meetings were research jobs are presented like:

Preliminary study of anthropology and ergonomics to determine if push or pull a car loaded with materials may cause back pain, presented by Contreras (2013). The research presented by De la Vega (2004).

Design of anthropometric letters referenced to the working population of the city of Caborca, Sonora, Mexico of (Vazquez, Guzman & Vega, 2010).
Anthropometric tables of adults with dwarfism between the ages of 18 and 45 to design furniture, presented by Bautista (2006).

This studies are an example of the how important is the use of ergonomics in performance and prevention of disease in population, like said by (Paula, Ribeiro, Rosado, Abranches & Franceschini, 2012) on the anthropological analysis of measurement of corporal composition and his potential to prevent Metabolic Syndrome (MS) on mature women's, that's why sometimes a lot of manager often associate ergonomics to health and job safety and legislation, and not to business performance (Dui & Newman, 2009).

The research made by (Joe, Lto, Shih, Oestenstad & Lungu, 2012) compare traditional way of measure versus three-dimensional (3D) this means a change pretended to make on anthropological studies, although there's a distrust towards the new method, says (Sousa, Vasconcelos, Janson, Garib & Pinzan, 2012) however the results show the opposite, the new technologies created for this, found the opportunity to develop the study of (Fourie, Damstra, Gerrits & Ren, 2001) which found that the 3D scan system has proved being reliable, compared to physical measures same as (Schranz, Tomkinson, Olds, Petkov & Hahn, 2012).

2. OBJECTIVE.

The purpose to make a comparison between the register of measures made in traditional way and digital is to verify if there's difference between the data taken, and give security to the user of this information and innovative methods to study anthropology, different from the traditional, to help understand and make improvements of design for the worker in all areas where is involved, it could be designing workspaces appropriate for each person, the design of tools, safety equipment and personal protection, clothing, as well having dimensional references of the population.

3. DELIMITATION.

The developing of this research took place in the city of Caborca, Sonora, with 6th semester students of ergonomics of an educational institution of higher level.

4. METHODOLOGY.

According to Cavassa (2004) there are two types of anthropometry: Static anthropometry or structural, referred to dimensions when the body is in static state, as an example: size, weight, etc.

The other kind is dynamic anthropology: referred to take measures when the body is working, as an example: stretching an arm to reach something.

At the time of designing there're some factors influencing the anatomic structure of the human body, some are: age (until mature), gender (male or female), race, occupation, clothing (especially on cold weather) and including the time of the day (in the morning we measure 6mm more, because the spinal discs are not compressed) (Konz 1999).

Due to these considerations and the intense changes needed and the innovative way of register traditional anthropometric measures like the ones mentioned, new digital techniques came out, like the ones used in the study made by (Bretschneider, Koop, Schreiner, Wernck & Jaspers, 2009) of the corporal scanner VITUS, this system based in laser, supporter by a base called triangulation, the exploration produced describes the distance to the surface in each point of the image. The body scanner has multiple application such determination of body measure for tailoring research, anthropometry and cosmetic surgery, same as the study by (Hemami & Dariush, 2012). There's also an intense research to the effect of gaining weight therefore body shape over health risk as said by (Daniell, Olds, Tomkinson, 2012). Other research is the one of (Garlie, Obusek, Corner & Zambraski, 2010) that used three-dimensional laser for the exploration of surface of all the body (3DS) to obtain specific anthropometric measures to estimate the percentage of body fat. Taking anthropometric measures is a complex process like the research made by (Paul & Wischniewski, 2012) who used Digital Human Body (DHM) as a useful tool to design an ergonomic workplace and develop new products or personal protection equipment made by (Yu et al., 2012). Jobs like this are changing the way we use flex meter or anthropometric meter to measure the human body, this reduces the possibility of error as commented by (Tomkinson & Shaw, 2012) when repeating the measure.

In the process of measure, to develop the research, this equipment was used:

- Three anthropometric meter model 01140, 01290 & 01291 Lafayette brand.
- Two flex meter Powerlock Stanley brand.
- Digital scanner NX16.
- Minitab software.
- A computer to register information.

The methodology to take measure was:

We designate a special area for the process of capacitation and normalization of the two helpers, with the purpose to obtain uniform measures.

The measuring took place on a private room, quiet, where only the person, the analyst and the helper where present.

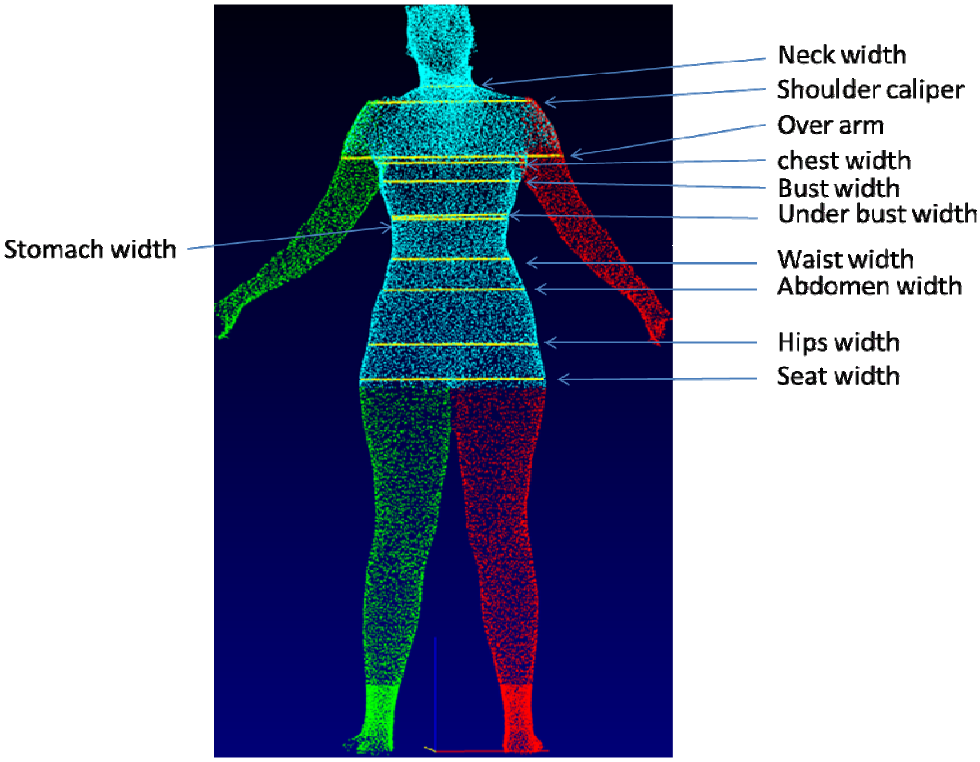
The people that were measure were treated with care and respect trying to gain their confidence.

Measurements were paired.

Before the measuring we gave an explanation of the steps, procedures and requirement needed for the measurement with the anthropometric meter and the scanner NX16.

We prepare and calibrate all the equipment needed to take anthropometric measures, making sure all materials needed were available. At the time of measuring, breathing must be calm and easy.

The measures registered of each person are:



5. RESULTS.

Staring from the observation that the data obtained with the scanner apparently where greater than the anthropometric meter, paired test hypotheses were proposed for each of the measures where the hypotheses was null. The numbers obtained with both measures are equal µscanner = µantropómetro, the alternative hypotheses was that the measures from the scanner were greater than anthropometric, µscanner > µantropómetro.

The analysis of data was realized using the software Minitab 16 and the calculus obtained are shown in the table where we can see the value of P for each hypothetic test realized, and if we consider to accept the hypotheses null, if P>0.05 the decision will be the ones shown in last column of the same table 1:

Table 1. P-value for each hypothesis test performed.

Hypotheses Testing	**Ho µscanner = µantropómetro** **H_1 µscanner > µantropómetro**		
Measure	**P**	**Accepted Ho if p > 0.05**	**Measurements**
Neck width	0.028	non-acceptance	Different

Shoulder caliper	0.057	Acceptance	Same
Over arm	0.093	Acceptance	Same
chest width	0.001	non-acceptance	Different
Bust width	0.007	non-acceptance	Different
Under bust width	0.052	Acceptance	Same
Stomach width	0.012	non-acceptance	Different
Waist width	0.176	Acceptance	Same
Abdomen width	0.001	non-acceptance	Different
Hips width	0.059	Acceptance	Same
Seat width	0.070	Acceptance	Same

We can see that in 5 of the paired hypothetic tests, null hypotheses is rejected, which means measures are not equal, however we have the same number of measures that are equal, and when we analyze the results we didn't find evidence that either the rejected or the accepted had a relation that we can think that there is any pattern on this behavior.

6. CONCLUSION.

Now, the tools and techniques used will improve their sophistication and precision. Technological innovation has made possible the register and process of data to obtain immediate result in a form of clear graphics and simulations. The results obtained from the investigation show no evidence to reject the hypotheses null which ensures that there's no difference anthropometric measures and the scanner NX16, although in some cases presented slightly evidence that there's difference but minimal, which can be attributed to an error of reading on manual measures or the fact that when scanning the person gets nervous or tense causing a slight variation on electrical readings.

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ANTHROPOMETRIC VARIABILITY IN THE PERSONAL SPACE AS NON STANDARDIZED DESIGN FACTOR

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RESUMEN: Las personas se caracterizan por la diferencia en sus dimensiones. Los hábitos que satisfacen necesidades particulares requieren dimensiones diferenciadas de espacio. La estandarización es un procedimiento de control para sistematizar procesos desde su diseño. En el diseño de espacios habitables la reducción dimensional a estándares trae consigo experiencias que convertidos en hábitos, derivan en acostumbrarse a la incomodidad en un sistema Hombre-Objeto-Entorno (HOE).

El espacio personal, esa especie de burbuja virtual versátil alrededor del cuerpo, configurado con indicadores antropométricos, se propone como el módulo regulador de magnitudes apropiadas.

En un paradigma alternativo se busca sensibilizar al diseñador de espacios a involucrarse en el detalle antropométrico de los usuarios durante su actividad cotidiana.

Palabras Clave: antropometría, variabilidad, diseño diversificado.

ABSTRACT: People are characterized by differences in their dimensions. Habits that meet particular needs require different dimensions of space. Standardization is a control procedure to systematize process during the design process. In the design of living spaces to dimensional reduction standards brings experiences that turned into habits, used to derive the discomfort in a Human-Object -Environment system (HOE).

Keywords: anthropometry, variability, diversified design.

RELEVANCE TO ERGONOMICS: The need to focus opportunity areas in architectural design and interior design is emphasized in this article. It denotes users' physical characteristics variability in conventionally standardized design situations. In ergonomic design solutions, standardization must be flexible, or there must be a alternative variety of standards for a specific design solution

1. INTRODUCTION

In house design one of the factors causing dissatisfaction in the house built, the inadequate dimensions related to the users physical characteristics. During design process, a stereotyped metric data pattern about Human-Object-Environment relations was used.. In many cases the designer copy such models without considering human variability.

In this paper anthropometric sizing criteria as an alternative to conventional criteria was analyzed. The personal space is set as regulatory reference for minimum habitable space measurements in basic activity stations. Then it presents a general population sample study and evidence from specific users' testimonies. Anthropometric variability in space should be factor analysis of a non standardized design process.

1.1. Anthropometric variability.

Anthropometry is the branch of human sciences which deals with human body measurement (Pheasant, 1996). It can be defined broadly as the anthropological technique that measures the human body. The measurement can be performed in a single individual, in a group or in a population; the meaning or conclusion arising from each of these approaches will be logically different, especially considering the intention with which the evaluation is performed in particular.

According Roebuck (1995), anthropometry is the measurement science and art of the application that provides physical geometry, mass properties and capabilities of the human body effort. The term is derived from *anthropos*, meaning human, and *metrikos*, meaning be related to a measurement. Anthropometry applied in design is the use of scientific methods of physical measurement, applied to human subjects for the development of engineering and design standards, in order to ensure comfort, efficiency and safety in living spaces and work for future user population.

Unlike inanimate entities, where it can be find some uniformity in their structure, content and behavior, humans and other biological spices, is distinguished by its variability (Prado et al., 2005). These variations results from biological and sociocultural evolution of man, and have very specific functions at the same levels of organization, to ensure the continuity of our species.

People around the world differ in size and shape. It has been suggested that variations in height have been to about 40 inches between the average height of the groups of highest and lowest adult world (Government Consumer Safety Research, 1998).

1.2. Measurement Systems.

Among the measurement catalogs more mentioned in the spaces design were the following. Neufert (1975) presents measurements of the human body, the metric relations, and proportions of the human body. Sets space dimensions required for housing, classifying service rooms and master rooms. Also in this manual like Panero and Zelnik (1983), anthropometric tables for fixed and functional positions are developed in the context of human variability and its possible application in basic activities, such as: living, eating, sleeping, cooking, and bathing.

However, others like Tilley and Dreyfuss (2002), from the creation of a package of reference tools applied to the design, presents alternative detailed diagrams of the human dimensions in the context of everyday life. Significantly study of people, man, woman, young or old, tall or short, in different environments and in many positions. The studies were based on 1 and 99 percentiles. As a frame of reference these authors review several anthropometric studies (Pheasant, 1996; Roebuck, 1995) and computerized techniques for three-dimensional images.

For example, the *CAESAR* is a collaborative project that is using the technology of 3D anthropometric surface to capture hundreds of thousands of points in three dimensions, on the surface of the human body. *JACK* developed at the University of Pennsylvania allows users to position digitized humans of various sizes in virtual environments, assign them tasks and analyze their performance. *JACK* can provide information about what "he" can see and reach, how comfortable it is, when and why hurt, and even when his effort is excessive.

Another important system is the RAMSIS used in the automotive industry. It is a 3D-CAD ergonomic tool, designed in collaboration with the German automotive industry to develop vehicles and cockpits. It integrates three key dimensions for analysis:

- Body height
- Waist circumference, chosen for sizing horizontal measures, is called corpulence
- the ratio of seat height and leg length, chosen as a measure of proportion

Using the dimensions height, corpulence and proportion, a three-dimensional space can be defined. The height is divided into the following five groups: very small, small, medium, high, very high, considering that the average body height of these groups correspond to the percentiles 5, 25, 50, 75 and 95. With this model forty five types of body shapes that can be used in ergonomic developments are created. See figure 1.

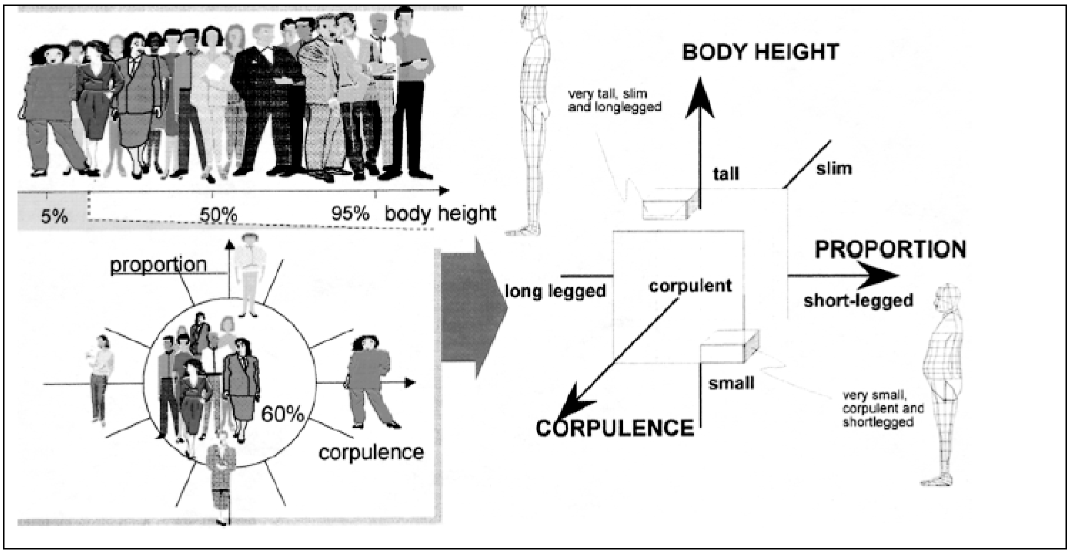

Fig. 1. Sistema RAMSIS. Fuente: Bubb (2004)

Prado and Avila (2006) presents anthropometric and socio-cultural factors, analyzing domestic living spaces from ergonomics. Prado, Avila and Herrera (2005) present aspects, factors and anthropometric methods for the population in Mexico. Prado, Avila and González (2007) collect anthropometric data for populations in Latin America in tables. Describe the methods and tools for anthropometric measurement. Suggest solutions for application design in Mexico. Importantly, based on percentiles 5 and 95

A characterization of population's anthropometric extremes is a study of Haslegrave (1986), based on data from MIRA (Motor Industry Research Association, 1985). Due to the complexity of certain design problems where various body dimensions involved. Analyzes measures 5 percentile female and 95th percentile male, regularly limits set by design. Also consider the relationships and interactions between body measurements.

As it is not possible to combine dimensions of 5 to 95 percentile, it is need to choose certain key measures. These are the height and weight. Overall vertical dimensions are more related to height, while horizontal body measures are more related to weight.

Such variability is so significant for the inherent metric interaction, which should not be conceived design workspace as a one-dimensional problem. Haslegrave (1986) found that there is not a sufficient trend in any of the relationships between body proportions or dimensions, which can be associated with different groups of population size.

The body proportions of a petite woman have a similar degree of variability with those of tall women, and those heavy women are similar to those of light women. The best way of representing a 5th percentile woman (or a man 95 percentile) is to measure a group of women or men in your height and weight, and calculate the median or 50th percentile for the other measures in the sample.

1.3. Personal Space.

The study of personal space has received increased attention from environmental psychologists, as is the basis for the study of overcrowding. Personal space is that which an invisible boundary surrounding a person's body is delimited, which cannot be penetrated by intruders. It does not extend equally in all directions nor is spherical. When someone experiences the space invasion anxiety or stress occurs, and can result in escape or attack.

The size of this virtual bubble is modified according to four basic distances, which are involved in this case the first two:

- Intimate distance in its distant stage, 15 to 45 centimeters approximate radius.
- Personal distance, in two stages, from 45 to 120 centimeters (Hall, 1998).

While the territory remains fixed and immobile in a region, personal space is carried everywhere. The regulation of personal space is a dynamic process that allows differential access depending on situations or people interacting. See figure 2.

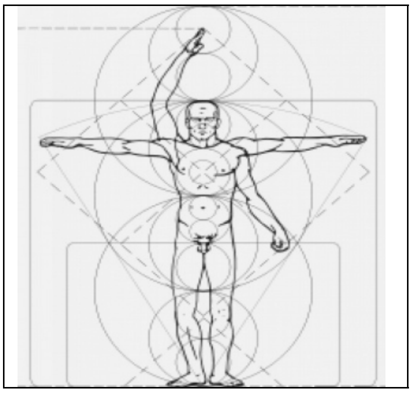

Fig.2. Ranges of Personal Space

Researchers have shown that personal space increases its size when the individual is in tight spaces. A general finding in this research is that the more a place is locked, more space is needed by the occupants (Holahan, 2000).

Another study found that personal space is made larger as the ceiling height was decreased (Savinar, 1975). Still others found that the need for personal space tends to be greater when the individual is in the corner of a room rather than in the center (Dabbs, Fuller and Carr, 1973; Tennis and Dabbs, 1975). It has been found that individuals use a larger personal space in indoor environments where space is enclosed (Little, 1965; Pempus, Sawaya and Cooper, 1975).

According to Higuchi et al. (2006) action can determine the representation of the space. Its main findings are:

a) The representation of the body (body schema) itself is deeply involved in the personal representation of space.
b) The space representation is modified in response to the changed capacity for action, although this is probably only for well-learned actions, regardless of their type;
c) The representation of space centered on the hand differs somewhat from that focused on the whole body.

The peripersonal space does not necessarily imply areas around the physical position of the hand or an object physically connected with the body. If an external object located in a remote area is recognized as an artificial extension of the body, the peripersonal space can be projected to this remote area.

2. DEVELOPMENT.

People are characterized by differences in their dimensions. Habits that meet their particular space needs are dimensioned in differential mode. Standardization is a control procedure for systematizing processes in housing development that brings uncomfortable experiences in a Man- Object-Environment System (HOE).

Personal space, a kind of versatile virtual bubble around the body, configured with anthropometric indicators, is proposed as the appropriate regulator module magnitudes. An alternative paradigm seeks to sensitize the designer of spaces involved in anthropometric details of the users during their daily activities.

2.1. OBJECTIVES.

Contrast the variability of human dimensions within personal space regarding basic activity stations in a system HOE: habitable living space.

2.2 DELIMITATION.

Convenience sample was established from the student population, located in the Faculty of Architecture, Design and Urbanism of the Autonomous University of Tamaulipas, extended to friends and family members.

Registration of anthropometric data is performed between February 2012 and September 2013.

The tables are made with sufficient data to specify for each individual spatial volume. Flexible tape is employed for measurements.

2.3. METHODOLOGY.

2.3.1. Getting the size of the personal space of the subject based on anthropometric data.

Theoretical sampling, which is deliberately used to locate subjects whose physical characteristics correspond visually somatotipológicos profiles. With this criterion, individuals of small, medium and large build are located, with varying lengths and widths The purpose is to obtain various combinations regarding their personal characteristics, such as weight, height, body mass, lateral extent and vertical reach. Volunteers were requested in groups of people known to the researcher, to gradually expand the sample in circles of friends, even family members.

The following personal information was requested:

Age, in years.
Sex, male or female.
Weight, in kilograms (Kg).
Height, in meters.
Body Mass Index, is calculated with high weight divided by height squared, p/L2 (BMI).
Lateral Extent in meters. Measurement in standing, in the frontal plane. Distance between tips of the index finger of each hand, with the upper limbs in abduction

(arms raised horizontally).
Vertical Reach, in meters. Measurement standing. Distance between the floor and the fingertips of the upper limb in full flexion.
Personal Space, volume in cubic meters; result of multiplying the lateral rextent by the vertical reach.

Direct measurements of height, lateral extent and vertical reach, were performed using flexible measuring tape.

2.3.2. Subjects-environment contrasting cases. Validation through qualitative ethnographic research.

Each person was requested to describe experiences regarding housing by written narrative, supplemented by drawings; also about the favorite place where remains longer, including themselves, other people and objects.

The participation of members follows this methodological sheet.

A1 **Draw the inside of the house** (view from above; plant), with all rooms and spaces, indicating significant details: nomenclature, doors, windows, furniture, objects, people: yourself, pets, etc. Narrative. How do you use the space? A2) **View from the outside (facade)** indicating significant details: nomenclature, doors, windows, furniture, objects, people: yourself, pets, etc. Narrative. How do you use the space? A3 **Draw the preferred place** to live in the house, considered as personal domain, indicating significant details: nomenclature, doors, windows, furniture, objects, people: yourself, pets, etc. Narrative. How do you use the space?
Methodological sheet for expression of users.

2.4. RESULTS.

A sample of 110 people was delimited Not differ between women and men, since the study is aimed at users in general, irrespective of the use of living space by gender.

Data from the overall sample was segmented from the dimensions of space (ESP) at ranges for each 0.50 m3. The number of subjects in each range can be recognized. The highest and lowest data for all indicator sets, and the difference between extreme measures is also marked.

ESP data are ordered from lowest to highest in Table 1, comparable with the lengths (in linear meters) of height, lateral extent and vertical reach. So also with BMI (no units).

For example, in the range between ESP 3.50 and 3.99 m3, 5 subjects were found, the height may vary between 1.45 and 1.60 m, and the difference between them of 0.15 m. The greatest weight in this range was 100 kg., against 40 kg for the lower, the difference between them, 60 kg. The greatest BMI is 47.56, corresponding to an obese person, and lower is 19.02, a normal person. The lateral extent in this group of people has a difference of 0.05 m., fluctuating between 1.45 and 1.40 meters. The vertical reach is between 1.86 and 1.79 m., with a difference of 0.07 m.

Table 1. Space and physical indicators. General sample.

ESP (m3)	Subjects	Height (ml)			Weight (kg)			BMI		Lateral Extent			Vertical Reach		
		>	<	Dif	>	<	Dif	>	<	>	<	Dif	>	<	Dif
3.50-3.99	5	1.60	1.45	0.15	100	40	60	47.56	19.02	1.45	1.40	0.05	1.86	1.79	0.07
4.00-4.49	8	1.53	1.45	0.08	120	35	85	57.07	19.56	1.54	1.48	0.06	1.93	1.80	0.13
4.50-4.99	29	1.75	1.52	0.23	90	40	50	37.53	16.65	1.65	1.50	0.15	2.20	1.75	0.45
5.00-5.49	15	1.66	1.54	0.12	84	45	39	32.01	18.59	1.65	1.60	0.05	2.10	1.93	0.17
5.50-5.99	20	1.72	1.62	0.10	85	43	42	31.99	15.79	1.70	1.63	0.13	2.11	2.01	0.10
6.00-6.49	12	1.80	1.68	0.12	110	56	54	36.33	18.71	1.76	1.68	0.08	2.21	2.05	0.16
6.50-6.99	7	1.80	1.69	0.11	99	54	45	34.26	18.91	1.79	1.75	0.02	2.25	2.10	0.15
7.00-7.49	8	1.82	1.70	0.12	88	63	25	29.40	19.02	1.81	1.77	0.04	2.26	2.16	0.10
7.50-7.99	5	1.86	1.78	0.08	102	77	25	31.56	22.99	1.86	1.80	0.06	2.40	2.20	0.20
8.00-8.49	3	1.87	1.82	0.05	115	86	29	34.72	25.45	1.92	1.84	0.12	2.40	2.27	0.13

There are no equalities. When there are matches, for example heights, variations appear in any other indicators. Variability prevails.

The Personal spaces (ESP), a virtual volume around the body, generated by the horizontal extent and vertical reach, shows that each subject occupies different dimensions related to their complexion. This single dimensionality requires a suitable container in order to inhabit the space. But not in the sense of avant-garde habitats designed to fit passively the body, but with the appropriate clearance for the basic natural movements in a satisfactory interface for the specific activity.

As an example of contrasting is the case of a nuclear family integrated by five persons: Father, *Apa*; mother, *Sm*; a son, *Al*; and two daughters, *So* y *Ad*. They have eleven pets. By their heights, *Apa* is located in an P50; *Sm* in P95; *Al* in P95; *So* in P50;

Ad in P95. By their BMI, are located: *Apa* in pre-obesity; *Sm* within the limits of normal range; *Al* in obesity class I; *So* in slight thinness; *Ad* in normal range. Vary their heights: *Apa*, 1.75, BMI=26; *Sm*, 1.65, BMI=24.98; *Al*, 1.80, BMI=32.41; *So*, 1.53, BMI=17.94; *Ad*, 1.60, BMI=23.44.

Table 2. Physical indicators nuclear family.

Subjet	**Age**	**Heght**	**Weight**	**BMI(kg/L^2)**	**Lateral Extent**	**Vertical Reach**	**ESP (m^3)**
Apa	50	1.75	80	26.12	1.65	1.75	4.76
Sm	49	1.65	68	24.98	1.56	1.95	4.75
Al	29	1.80	105	32.41	1.76	2.05	6.35
So	20	1.53	42	17.94	1.57	1.90	4.68
Ad	11	1.60	60	23.44	1.40	1.80	3.53

Most physical dimensions vary. See table 2. The volume of space is numerically the same for *Apa* y *Sm*; variations occur in stature and scope. However, this family members complexion requires a different amount of living space.

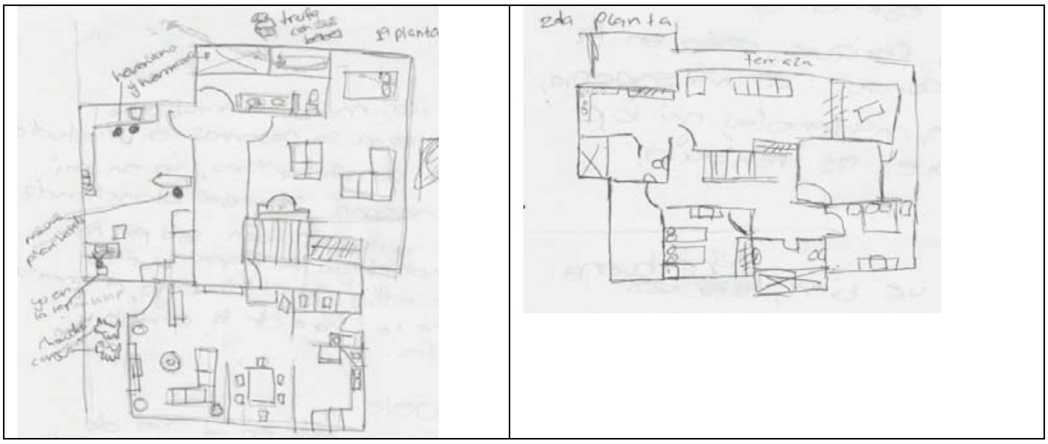

Fig. 3. Drawings of house. Facades Interpretation by So.

User testimony presented below:

So:

"I feel satisfied with house, I feel comfortable in it. See figure 3. *Have lounge, 2 bathrooms, 4 bedrooms, study, laundry room, dining room, kitchen, terrace, games room, and garden. My favorite places are the study and the living; there I spend time, doing homework or watching tv. They are large, comfortable spaces for me; yes I consider suitable for me. The objects I use most are the drawing board and laptop."* See figure 4.

Fig. 4. Favorite place drawing. Interior.
Interpretation by So.

"The less pleasant place is the kitchen. It is a large space, where they are a stove, a refrigerator, a microwave, a bar, a plaque, and shelves. But sometimes I can not reach things because the shelves are too high."

2.5. CONCLUSIONS.

The Personal Space (ESP) is a metric regulator, but do not a standard. However, if it's decided to take the ESP as a resource to standardize housing and/or their spatial components, is essential to consider the longitudinal differences in users' body structure. The possibility of metric adjustment gadgets in housing provides a challenge to designers.

A series of similar personal spaces have varied anthropometric data. The dimensions of furniture and space for activities not match the anthropometry of the user space.

The use of working environments or activity formed under standardized criteria is insufficient.

Standardization optimizes systematization but it is advisable to reconsider the design paradigm of living space, according to the anthropometric variability, for diversified design solutions.

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ANTHROPOMETRIC STUDY OF STUDENTS FROM NORTHWESTERN OF SINALOA AND SOUTHWESTERN OF SONORA

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RESUMEN: Los estados de Sinaloa y Sonora se encuentran en el noroeste de México, en donde Sinaloa cuenta con una población de 2´767,761 habitantes y Sonora con 2´662,480 habitantes, de los cuales 343 252 son estudiantes de licenciatura pertenecientes al estado de Sinaloa y 290 698 a Sonora. (INEGI, 2010).

El Instituto Tecnológico de Sonora es una Univerdidad pública y se encuentra ubicado en el municipio de Cajeme, en Ciudad Obregón, Sonora, donde se realizó un estudio antropométrico por los estudiantes de la carrera de Ingeniería Industrial y de Sistemas de la materia de Ergonomía, a los que se les facilitó una capacitación de seis horas. El objetivo principal de ese estudio es el de conocer las diferentes características antropométricas y la variabilidad de estas, que puedan existir en los estudiantes de las diferentes ciudades. En el estudio se tomaron medidas a 198 estudiantes pertenecientes al noroeste de Sinaloa (Los Mochis y Guasave) y suroeste de Sonora (Ciudad Obregón y Navojoa). La vestimenta de los participantes fue ropa ligera y sin calzado. Los resultados obtenidos muestran una diferencia significativa, por lo que se deben de considerar al momento de la compra del mobiliario y equipo para las instalaciones de la universidad, así como el diseño de espacios académicos.

Palabras clave: Antropometría, estudiantes

ABSTRACT: Sinaloa and Sonora states are found in the northwestern region of Mexico, in which Sinaloa has a population of 2´767,761 habitants from which 343,252 are undergraduate students, and Sonora has a population of 2´662,480 habitants with 290,698 undergraduate students. (INEGI 2010).

The Technological Institute of Sonora (ITSON) is located in Obregon City, Cajeme, Sonora, where an anthropometrical study was made by the students of the ergonomics subject of the Industrial and Systems Engineering program. The students were provided with 6 hours of training primarily in the measurement technique. The study's main purpose was to discover the different anthropometric characteristics and their variability that may exist in students of the different cities. One hundred ninety-eight students were measured in the study who belong to the northwestern region of Sinaloa(Los Mochis and Guasave) and the southwestern region of Sonora(Obregon

City and Navojoa). The participants' clothing was light and without wearing shoes. The obtained results show a significant difference that needs to be considered when purchasing furniture and equipment for university facilities as also academic facilities design.

Key words: Anthropometry, students.

Relevance to Ergonomics: Anthropometry gives a great contribution in order to prevent risks to students from universities relationated with the use of equipment and furniture, in this way they are able to prevent injuries musculoskeletal. The ergonomists have to considerate the anthropometric measures as a important factor when designing and purchasing furniture for university facilities.

1.- INTRODUCTION

Sinaloa and Sonora states are found in the northwestern region of Mexico, in which Sinaloa has a population of 2´767,761 habitants, and Sonora 2´662,480,Sinaloa counts with 18 universities and Sonora 27. Technological Institute of Sonora (ITSON) is located in Sonora and has campuses located in Navojoa(South and Center), Empalme, Guaymas, and Obregon City (Center and nainari). An anthropometric study was made in the ITSON campus nainari, where the students of industrial and systems engineering measured students from Los Mochis and Guasave Sinaloa, and Navojoa and Obregon City Sonora.

Anthropometry according (Roebuck, 1993), is the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body. The name is derived from *anthropos*, meaning human, and *metrikos*, meaning of or pertaining to measuring.

2.- OBJECTIVE

The study's main purpose was to discover the differences and similarities that may exist in students of different cities, through an antropometric study, to be considered when purchasing furniture and equipment for university facilities as also academic facilities desing.

3.-DELIMITATION

The study sampled ITSON students, men and women with an age between 18 and 25 years old, who belong to Los Mochis, Guasave, Navojoa and Obregon City.

4.- METHODOLOGY

Subject. The study’s participants were students from ITSON, within the student’s average age that live in Obregon City, but the native cities are one of the before mentioned. 198 students were measured(101 women and 97 men) inside the institute facilities.

Materials. The measurements were made using anthropometric instruments: 4 caliper verniers(three of them with 65 cm and one with 45 cm), a graduated cone, and a cabin of anthropometric and ergonomics studies. Data were collected in anthropometric sheets and were statistically processed with Excel 2007 software.

Procedure. The next steps were developed in order to perform the anthropometric study on the students.They are mentioned here:

- **a.** Select variables to measure
- b. Provide training to measurement team’s integrants
- c. Select the sample size
- d. Measure the sample of students
- e. Data organization
- f. Elaborate anthropometric sheets

5.- RESULTS

The analyzed data in the study, were classified in the next subjects: Gender, age, birthplace and parents' birthplaces. After studying in detail the obtained information, the next results were acquired:

Doing mention to the students' measured gender, as the Table 1 shows, female gender predominated in quantity, 101 women and 97 were measured. The aspects with a great relevance in the study that are very important for the anthropometry are the birthplaces of the students and their parents. Kroemer(2001) mentions that these characteristics have a great importance, being that depending the region of birthplace, would be the physic characteristics as height , length of arms and legs, etc.

For the study, northwestern region of Mexico was taken, this region is shape by 4 states(Baja California, Baja California Sur, Sonora and Sinaloa) where only were taken Sinaloa and Sonora, specifically northwestern of Sinaloa and southwestern of Sonora. The study’s results show that 25.75% of women sampled were born in Sinaloa State and 74.25% in Sonora state, and 21.65% of men were born in Sinaloa state and 78.35% in Sonora state.

The measures of the Table 2 were considered to make the study.

Table 1. Quantity of students per city

City	Female	Male
Guasave	9	11
Los Mochis	17	10
Navojoa	3	9
Ciudad Obregón	72	67
Total	**101**	**97**

Table 2. AnthropometricMeasures

Measures					
920	Weight	**230**	Chestcircumference	**856**	Thighheight
805	Height	**931**	Waistcircumference	**914**	Middle finger height with arms extended upward
328	Eyeheight	**178**	Hip circumference	**912**	Fist height with arms extended upward.
23	Shoulderheight	**430**	Head circumference	**2FGM**	Head heightsitting
309	Elbowheight	**144**	Distance between ears above the head	**4FGM**	Height since Floor to seat
949	Waisteheight	**165**	Width face at the height of sideburns	**200**	Front side knee length to the back of the shair
398	Glutealheight	**427**	Widht head	**194**	Lenght since knee to back of the seat
973	Wirstheight	**595**	Chin height to the top of the head	**678**	Height since floor to front side of the knee
265	Height to middle finger in natural position	**441**	Head length	**529**	Height since floor to knee
797	Width of extended arms to sideways	**420**	Hand length	**381**	Length since elbow to middle finger
798	Elbows width with hands to the center of the chest	**656**	Palm lenght	**507**	Back width with arms extended forward.
80	Arm length from a wall to the middle finger	**411**	Palm width	**459**	Hipswidth, sitting
752	Distance since a wall to the fist	**402**	Handgripdiameter	**859**	Thighs width with the knees thogether
122	Soulderswidth	**758**	Height since seat to head	**775**	Footlength
223	Chestwidth.	**330**	Height since seat to eyes	**777**	Footwidth
457	Hipswidth, standing up	**25**	Height since seat to shoulder	**776**	Instepheight
639	Neckcircumference	**312**	Elbow height in 90° position		

The tables 3 and 4 show some of the results obtained in the study, where the data of Weight (590), Height (805), Elbow height (309), Waist height (949) and Gluteal height (398) of men and women are shown.

Table 3. Results obtained of women

	MIN	MAX	"5%"	"50%"	"95%"
N920	41	89.5	45.7	60	83.5
N805	133.8	181	151	162.3	175
N328	134.8	169	141.9	151	164
N23	121.7	151	126.8	135.1	147.9
N309	10.3	132.4	97	103.1	112.8
N949	48.8	147	72	101	110.6
N398	64.2	101.3	66.3	74.1	84
N973	59.4	91	73.7	80	88
N265	36.2	167	58.4	63.5	76
N797	57	190	87.2	160	176.4
N798	42.5	158.3	60.5	82	93
N80	46.5	96	68.4	78.2	86.5
N752	36	731	59.9	69	80
N122	31	120	34	39.2	44.5
N223	22.5	53	25	28.5	46
N457	23.1	144	29.7	33.6	46
N639	26	45.3	28	32	37
N230	77.5	113	79	89	103.8
N931	17.3	161	62.3	73.5	93
N178	82	124	86	96	114
N430	32	87.6	39	55	58
N144	13.3	60	15	36	49
N165	10	28.5	12	13.5	16
N427	11.3	56.5	14	15.1	19.1
N595	16.4	27.3	18.38	20.95	24.325
N441	12	26	16	18.7	22.8
N420	10.7	20.3	15.5	17.2	19.5
N656	6	83	7.5	9.6	11
N411	5.5	9.8	6.3	7.4	9
N402	3.9	55	4	40.5	50
N758	64.5	93.3	78.5	84.6	90.2
N330	56.5	83.4	69	74	79.3
N25	39	71	52.9	58	63.1
N312	18.6	65.2	19.8	25	30
N856	10	121	10.9	14	18
N914	108	187	115.8	123.2	135.9
N912	11.6	177	57.9	114	128.9
N2FGM	38.2	150.5	41.8	125	138
N4FGM	32.9	54.2	38.6	41	52.5
N200	21	60.4	37	47	52.8

N194	28	65	37.7	55.6	63.1
N678	22	54.2	32.5	42.25	52.5
N529	30.1	58	36.1	50	54.9
N381	22.5	54.8	24.8	41.2	46.3
N507	21.1	120.7	30.5	39	102.4
N459	29.7	127.8	31.1	38.3	120
N859	18.6	45.1	22.2	32.8	41.1
N775	20	58.6	21.8	23.9	42.1
N777	3.2	105	5.5	8.6	10.2
N776	3.8	10	4.5	5.9	8

Table 4. Resultsobtained of men

	MIN	MAX	"5%"	"50%"	"95%"
N920	52	147.4	57.9	76	108.5
N805	1.83	194.5	79.38	174.5	186.06
N328	150	182.5	152.06	164.7	175.04
N23	132.6	166.2	134.66	146.5	162.02
N309	100.2	170	101.8	112	145.82
N949	11.5	170.6	94.6	107.7	118.6
N398	31	108.8	67.8	80.6	102.08
N973	71.1	95.2	77	84.8	92.16
N265	57.4	87.8	61.6	68	83.96
N797	65.7	203.1	70.36	176	194.2
N798	70.6	182	78.48	92	176.2
N80	44.6	101.5	77	86.7	94.26
N752	52.6	89.1	67.5	77	85.84
N122	34	94.6	40	44.5	72.22
N223	18.3	49.7	25.32	30.8	44.34
N457	24.1	42.6	28.46	33.1	40
N639	11.7	50.8	32.5	37.9	42.2
N230	37	138.2	40.08	95	116.02
N931	61.5	130.5	75.84	89	112
N178	76.5	134.6	83.9	99	114.92
N430	32.3	116	39.16	57.2	105.16
N144	14	5736	15.16	37	57
N165	11.9	153	12.5	14.6	136.8
N427	12.2	164	13.6	15.8	56.5
N595	12.02	28.1	15.28	22.6	25.92
N441	14.6	36.2	16.88	19.5	26.08
N420	10.5	22.3	16.4	19	21.32
N656	7	19.7	8.9	10.9	17.3
N411	0.08	92	7.24	8.5	11.6
N402	0.0053	55	4.3	42	53.2
N758	41.8	189	45.26	89	97.04
N330	60.1	117.3	71.82	77.5	89.68
N25	22.5	104.3	55.4	61	79.76

N312	15.8	64.5	19.9	24.8	59.12
N856	10.5	145	11.94	15.3	23.94
N914	13.6	189	17.66	135	148.74
N912	18.2	179	59.92	125	138.3
N2FGM	38.5	149	47.1	131	142.92
N4FGM	5.03	145	38.9	42	131.88
N200	30.5	61	38.48	48.9	55.06
N194	41	69.8	44.16	59.3	65.36
N678	33.1	65.4	38.98	46.2	59.44
N529	2.2	63	35.7	55	60.84
N381	24.4	59.4	28.46	46.1	56.14
N507	37.7	141.1	38.18	44.5	102.44
N459	27.8	137.1	29.96	36.8	126.34
N859	20.8	48.6	26.38	34	43.32
N775	22	48.8	23.86	27.1	46.44
N777	5.4	26.8	6.64	9.2	25.22
N776	4	11	4.4	6.3	9.14

6.-CONCLUSION

The study's main purpose has been achieved, since the information necessary to know the physical characteristics of the students that were measured in ITSON facilities were obtained. This information could work to guide similar studies that can be made in other universities, bennefitting the students with these kind of studies, since furniture and equipment would be given according to their dimensions. The Institute also received anthropometric information that could work to design the facilities of the university as laboratories, libraries, sport areas, and so on.

It's very important to mention that in Sonora don't exist official statistics of this kind of information about college students, making it impossible to ensure 100% reliability since the study wasn't carried out to the entire ITSON college community.

The main benefactor of this project will be ITSON students, since the changes that can be made will be appropriate for them.

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COTTON GLOVES' EFFECT IN MAXIMUM PINCH STRENGTH OF THE POPULATION OF HERMOSILLO, SONORA

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RESUMEN: Los Desórdenes Musculo esqueléticos de Mano debidos al trabajo son enfermedades que se presentan comúnmente en los trabajos del sector industrial y salud. Resultados de estudios realizados en otros países indican que el uso de guantes disminuye la máxima fuerza voluntaria del agarre de mano y de pellizco. A pesar de las estadísticas, existen pocos estudios relacionados con la máxima fuerza de agarre y el efecto del uso de guantes. El presente estudio tiene como objetivo analizar el efecto del uso de guantes de algodón (comúnmente utilizados en el sector industrial) en la fuerza máxima de agarre de pellizco. En el experimento participaron 487 estudiantes voluntarios (345 hombres y 142 mujeres) entre 17 y 26 años de edad. Los sujetos realizaron tres esfuerzos de agarre de pellizco, seguidos de un minuto de tiempo de recuperación por cada intento. Se registró la fuerza máxima promedio. Los resultados indican que el uso de guantes de tela tiene un mínimo efecto negativo en la máxima fuerza de agarre de pellizco, siendo las mujeres cuya mano dominante es la izquierda las más afectadas.

Palabras clave: Agarre de pellizco, máxima fuerza voluntaria, guantes de algodón

Abstract: Hand Work Musculoskeletal Disorders (WMSD) are common injuries in industrial and health related jobs. The results of some studies reported that wearing gloves reduces the maximum voluntary strength for the hand and pinch grip. Despite of the statistics, there are few studies related to the maximum pinch strength and the effect of wearing gloves on it. This study objective is to determine the effect of cotton gloves (commonly used in industrial work) on the maximum pinch strength. In the experiment participated of 487 volunteer students (345 male and 142 female) between 17 and 26 years. The subjects performed three pinch grip efforts with a one-minute recovery time between each trial. The maximum average strength was recorded. The results indicate that wearing cotton gloves has a small negative effect on the maximum pinch strength. The maximum strength reduction was found in left-handed women.

Key words: Pinch grip, maximum strength, cotton gloves

Relevance to Ergonomics: The data collected will serve as a basis for the design of industrial hand tools and the ergonomic design of workplaces

1. INTRODUCTION

Even though the automation and mechatronic advances in industrial processes, the human factor continues being the main resource in most of the companies. Important features of the manual work such as repetition, overexertion and awkward postures are considered the principal causes of Work Musculoskeletal Disorders (WMSD). In the last years, in Mexico, this kind of injuries has been increasing due to the factors commented before. Mexican Social Security Institute statistics reports a 5% increment in the occurrence, during the last years. (IMSS, 2010).

In most of manual activities, avoiding accidents and injuries requires the use of hand protection. There are several hand protection equipment types, gloves, are the most common in industrial activities. Despite of its benefits, gloves have been found to affect hand performance parameters such as dexterity, task time, grip strength and range of motion (Karwoski, 2003). It has been found that posture, gender, hand dominance and gloves as important factors in the study of the maximum grip strength (Armstrong et. al, 2012).

There have been conducted numerous studies around the world to determine the maximum hand grip strength and the gloves effect. In spite of the importance of finger strength standards, there are few studies on its effect on pinch strength. Pinch effort is defined as the exertion from the compressing actions between the thumb and the index finger or both index and middle fingers and the thumb (Ng, 2014). Pinching requires exertion by smaller muscles that control flexion of the digits individually, that means a significantly reduction in the contact area (3).

Kamal et. al. concluded that wearing gloves in lateral pinch strength does not affect the pinch capabilities (Karwoski 2005). Torrens and Newman (2000) reported a reduction of 13% in the maximum pinch strength while wearing CS95 and NBC gloves, compared with bare hands. Appendino et. al. (2011) analyzed the effect of Extra Vehicular Activity (EVA) gloves in different power and precision grips. They concluded there was a little or no effect at all on the performance of two-finger pinch grip (tip pinch).

2. OBJECTIVE

This study was carried out in order to determine the effect of cotton gloves in the maximum two fingers pinch strength.

3. METHODOLOGY

3.1 Subjects

Students of the Department of Industrial Engineering Department of the University of Sonora, Regional Center Unit, were considered in the experiment. A total of 487 volunteer students (345 male and 142 female) between 17 and 26 years old participated. All the subjects reported a good health and there was no evidence of an upper limb WMSD in the last two years.

3.2 Experimental Procedure

The subjects were instructed to perform three exertions at the maximum voluntary capability during three second each one. There was one-minute recovery time between each trial. The procedure was carried out with both hands, right and left. The subjects were instructed to wear cotton gloves and repeat the procedure after all postures performed.

3.3 Instruments

Baseline mechanical pinch gauges, 12-0200 with 30 lb. capacity and 12-0201 with 60 lb. capacity, were used to register the women and men measurements, respectively.

4. RESULTS

4.1 Descriptive statistics

Data obtained was rearranged by group aged, genre and hand dominance for a subsequent statistical analysis using software Minitab 16 for Windows. Percentiles (1, 5, 10, 25, 50, 75, 90, 95 and 99), mean, standard deviation (SD) and minimum and maximum values for each category were obtained (Tables 1 to 4). Figures 1 to 4 presents the data histograms and boxplots.

Table 1. Male Hand dominance statistics (lbs.)

Statistics	Bare hand				Wearing cotton gloves			
	Left Handed		Right Handed		Left Handed		Right Handed	
	LH	RH	LH	RH	LH	RH	LH	RH
Mean	13.40	14.04	13.05	14.13	12.98	13.38	12.32	13.42
SD	5.30	5.33	3.86	4.04	3.98	4.56	3.27	3.27
Minimum	5.33	7.67	2.00	4.50	6.67	6.67	1.00	1.50
Maximum	27.33	28.00	28.67	28.00	26.67	25.67	24.00	22.33
Range	22.00	20.33	26.67	23.50	20.00	19.00	23.00	20.83
Total (n)	31		359		31		359	

Table 2. Female Hand dominance statistics (lbs.)

Statistics	Bare hand				Wearing cotton gloves			
	Left Handed		Right Handed		Left Handed		Right Handed	
	LH	RH	LH	RH	LH	RH	LH	RH
Mean	9.98	9.38	8.24	9.42	9.19	8.07	7.82	9.11
SD	2.26	2.47	2.66	3.07	2.68	2.65	2.00	2.30
Minimum	6.67	6.00	2.00	3.00	6.00	4.67	2.67	3.33
Maximum	13.17	13.67	18.00	21.83	13.00	13.00	13.67	14.00
Range	6.50	7.67	16.00	18.83	7.00	8.33	11.00	10.67
Total (n)	7		139		7		139	

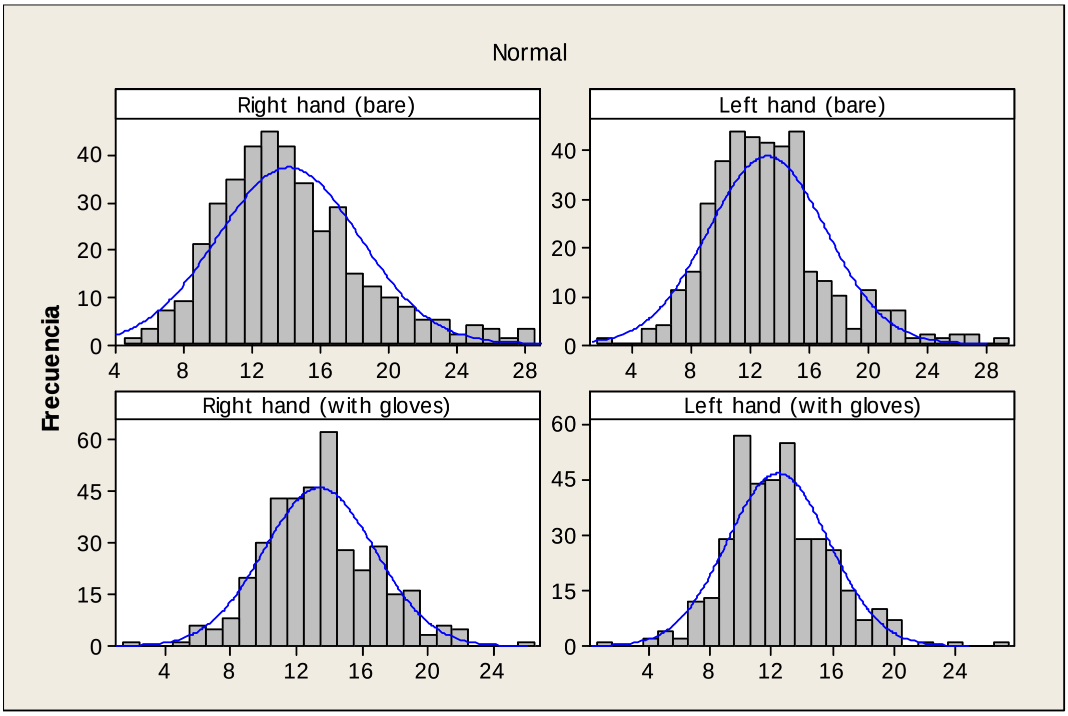

Figure 1. Male data histograms (lbs.)

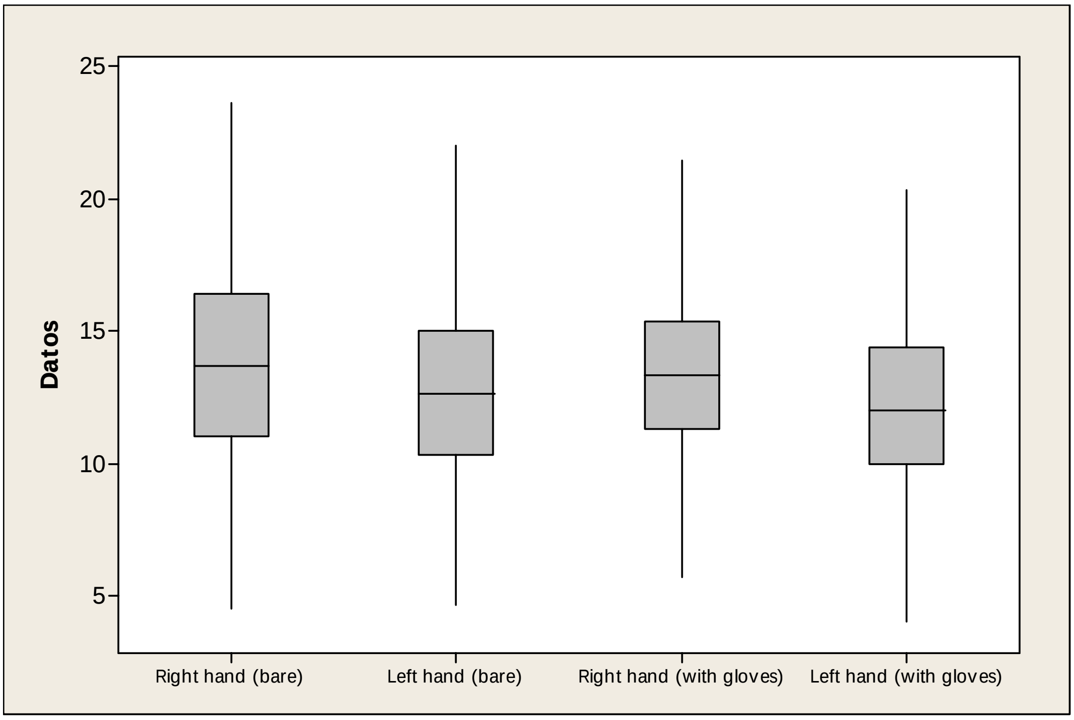

Figure 2. Male data boxplots (lbs.)

Table 3.Male aged descriptive statistics (lbs).

Age group	Hand Dominance	Hand	Bare hands					Wearing cotton gloves					N
			Mean	SD	Min	Max	Range	Mean	SD	Min	Max	Range	
15-19	Left Handed	LH	12.94	4.57	7.67	22.67	15.00	13.06	5.98	6.67	26.67	20.00	8
		RH	12.46	4.16	8.00	22.00	14.00	12.71	5.59	6.67	25.67	19.00	
	Right Handed	LH	12.74	3.07	6.67	20.50	13.83	12.26	3.04	5.00	20.33	15.33	87
		RH	13.62	3.65	7.00	25.67	18.67	13.45	3.21	7.33	21.67	14.33	
20-24	Left Handed	LH	13.57	5.62	5.33	27.33	22.00	12.95	3.20	8.00	19.33	11.33	23
		RH	14.59	5.66	7.67	28.00	20.33	13.61	4.26	6.67	22.33	15.67	
	Right Handed	LH	13.02	3.78	4.67	26.67	22.00	12.26	3.15	4.00	22.00	18.00	242
		RH	14.23	4.01	6.00	28.00	22.00	13.41	3.14	5.00	21.67	16.67	
25-29	Right Handed	LH	14.22	5.96	2.00	28.67	26.67	12.99	4.68	1.00	24.00	23.00	30
		RH	14.75	5.24	4.50	26.67	22.17	13.37	4.40	1.50	22.33	20.83	

Table 4.Female aged descriptive statistics (lbs).

Age group	Hand Dominance	Hand	Bare hands					Wearing cotton gloves					N
			Mean	SD	Min	Max	Range	Mean	SD	Min	Max	Range	
15-19	Right Handed	LH	7.85	2.37	5.00	16.83	11.83	7.62	1.88	5.00	13.33	8.33	42
		RH	9.54	2.69	5.33	18.83	13.50	8.98	1.78	5.33	13.00	7.67	
20-24	Left Handed	LH	9.98	2.26	6.67	13.17	6.50	9.19	2.68	6.00	13.00	7.00	7
		RH	9.38	2.47	6.00	13.67	7.67	8.07	2.65	4.67	13.00	8.33	
	Right Handed	LH	8.41	2.78	2.00	18.00	16.00	7.91	2.06	2.67	13.67	11.00	97
		RH	9.36	3.23	3.00	21.83	18.83	9.16	2.49	3.33	14.00	10.67	

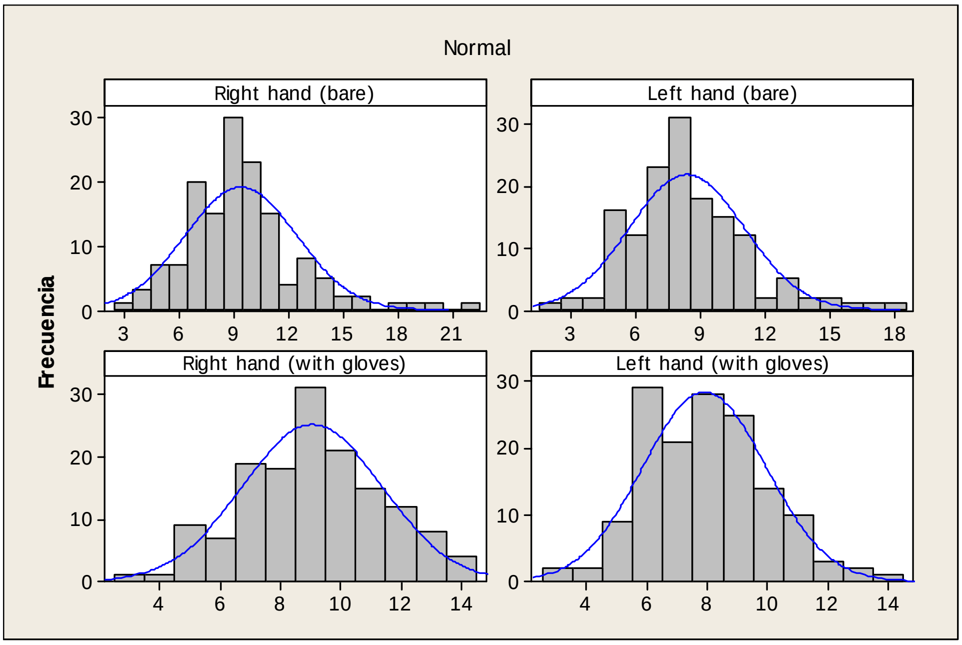

Figure 3. Female data histograms (lbs.)

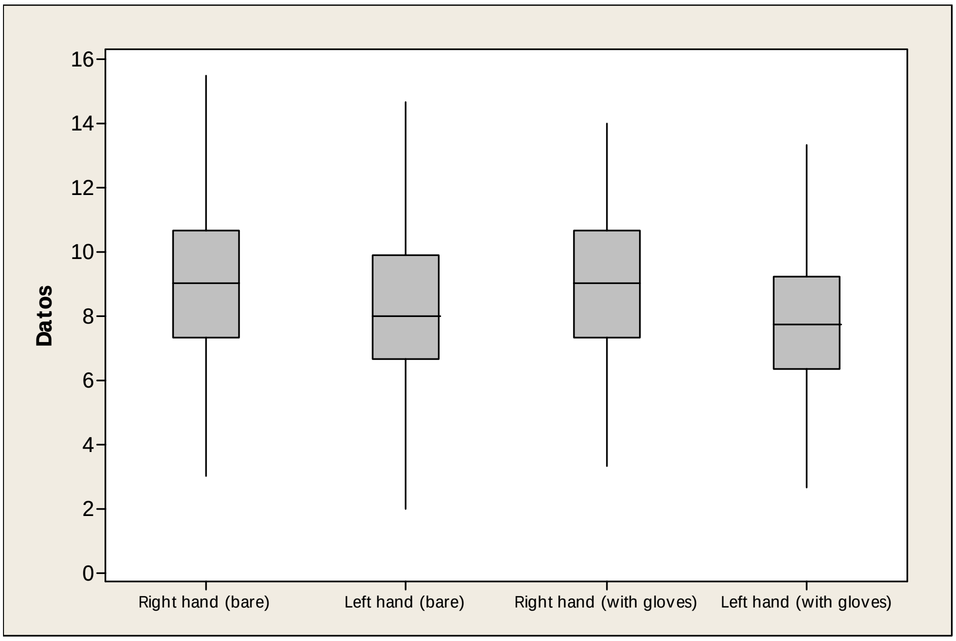

Figure 4. Female data boxplots (lbs.)

Pinch strength reduction percentage is presented in tables 5 to 7. Wearing gloves has a significant effect on left handed women pinch strength, while performing an effort with the dominant hand. Most of the efforts considered in the male experiment, pinch strength was reduced while wearing cotton gloves,

Table 5.Genre pinch strength reduction percentage (lbs.).

Genre	Hand Dominance	Hand	Bare hands	Wearing cotton gloves	Reduction percentage
Male	Left Handed	LH	13.40	12.98	3.13
		RH	14.04	13.38	4.70
	Right Handed	LH	13.05	12.32	5.69
		RH	14.13	13.42	5.03
Female	Left Handed	LH	9.98	9.19	7.92
		RH	9.38	8.07	13.97
	Right Handed	LH	8.24	7.82	5.1
		RH	9.42	9.11	3.29

Table 6. Male aged group pinch strength reduction percentage (lbs.).

Age group	Hand Dominance	Hand	Bare hands	Wearing cotton gloves	Reduction percentage
			Mean	Mean	
15-19	Left Handed	LH	12.94	13.06	+0.93
		RH	12.46	12.71	+2.01
	Right Handed	LH	12.74	12.26	3.77
		RH	13.62	13.45	1.25
20-24	Left Handed	LH	13.57	12.95	4.57
		RH	14.59	13.61	6.72
	Right Handed	LH	13.02	12.26	5.84
		RH	14.23	13.41	5.76
25-29	Right Handed	LH	14.22	12.99	8.65
		RH	14.75	13.37	9.36

Table 7. Female aged group pinch strength reduction percentage (lbs.).

Age group	Hand Dominance	Hand	Bare hands	Wearing cotton gloves	Reduction percentage
			Mean	Mean	
15-19	Right Handed	LH	7.85	7.62	2.93
		RH	9.54	8.98	5.87
20-24	Left Handed	LH	9.98	9.19	7.92
		RH	9.38	8.07	13.97
	Right Handed	LH	8.41	7.91	5.95
		RH	9.36	9.16	2.14

4.2 Comparison with other studies.

There was no statistical evidence to conclude there is no difference between the pinch strength in both conditions, as Appendino et. al. (2011) reported. Most of all categories reported a pinch strength reduction. Left-handed women pinch strength had a significant percentage reduction, as reported by Torrens and Newman (2000).

5. CONCLUSIONS

Wearing cotton gloves while performing pinch exertions has a little or no at all effect in the maximum voluntary strength, in both genres. It was found a pinch strength reduction when age increases, in both cases, male and female efforts.

The use of another countries population results should be avoided, in order to prevent injuries at work. This study results can be considered in the workstations ergonomic design.

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DETERMINATION OF MAXIMUM GRIP STRENGHT IN ADULT´S DOMINANT AND NO DOMINANT HAND

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Resumen: El objetivo de este estudio es determinar la fuerza máxima de agarre en Mano dominante y mano no dominante en hombres y mujeres universitarios con edad laboral, de ambos sexos, y determinarla en función del sexo y edad. La muestra estudiada se compuso por un total de 150 estudiantes entre los 17 y 24 años de edad. Se utilizó un dinamómetro Lafayette manual para la medición de la fuerza máxima. Los hombres presentaron de manera significativa más fuerza que las mujeres. Los derechos fueron más fuertes que los zurdos. La fuerza muscular siguió una tendencia de aumento a través de la edad en el caso de los hombres, esto no sucedió en las mujeres, el grupo de edad más fuerte fue el de rango 23-24 para hombres con 46.9 kg y en mujeres el grupo 19-20 con 26.5 kg, se concluye que son más fuertes los sujetos mayores de 20 años en hombres y más fuertes las mujeres menores de 20 años.

Palabras clave: Fuerza Máxima, Antropometría, Biomecánica

Abstract: The objective of this study is to determine the maximum grip strength in dominant hand and no dominant hand in college men and women of working age, of both sexes, and determine it according to sex and age. The study sample consisted of a total of 150 students between 17 and 24 years. Manual Lafayette dynamometer for measuring the maximum force was used. Men were significantly stronger than women. The rights were stronger than lefties. Muscle strength followed an increasing trend by age in the case of men, this did not happen in women, the strongest age group was the 23-24 range with 46.9 kg for men and women group 19-20 with 26.5 kg, it is concluded that they are stronger subjects over 20 years in men and stronger women under 20 years.

Relevance to Ergonomics: The grip strength can contribute both to the risks of work-related accidents and musculoskeletal injuries. Ergonomists should consider the gripping force as an important factor to consider an appropriate design.

Key Word: Maximum Force, Anthropometry, Biomechanics.

Relevance to Ergonomics: Grip strength can contribute both to the risks of work-related accidents and musculoskeletal injuries. Ergonomists should consider the gripping force as an important factor to consider appropriate workstation design.

1. INTRODUCTION

The International Labour Organization (ILO) shows that on average, rates of work-related deaths, accidents and diseases are declining in industrialized countries while in developing countries and newly industrialized countries, the number is stable or rises. ILO mentions that the reasons for this difference are complex, it is presumed that in industrialized countries this decrease is due to their prevention and emergency structures, so they have played an important role. However, it has also been the export of hazardous work. Indeed, most of the most dangerous jobs in the world are no longer performed in the traditional industrialized countries. (ILO, 2003).

It is frequent that many people ignore the relationship between discomfort and suffering caused by the repeated efforts made during a job. However, it is a clear relationship between certain musculoskeletal problems and activities involving awkward postures, repetitive work and excessive speed, handling heavy loads, use of tools, etc.

Musculoskeletal disorders are the major cause of absenteeism and represent a considerable cost to the public health system (WHO, 2004). A large number of injuries known as Musculoskeletal Disorders (MDS) are attributed to the use of hand tools in the occupational environment, resulting in needless suffering, loss of work days and expenses that could have been avoided, it´s prevention is the highest priority for the National Institute for Occupational Safety and Health (NIOSH) and the Administration of Occupational Safety and Health of California (Cal / OSHA).

By studying the physical requirements (posture, force, motion) of people, it is considered that when these exceed the responsiveness of the individual or there is a no adequate biological tissue recovery, the symptoms may be associated with the presence of MDS related work (Miroljub, 2002). Currently are, at least, four recognized principles that explain the mechanism of occurrence of MDS: multivariate interaction (genetic factors, morphological, psychosocial and biomechanical), differential fatigue (kinetic and kinematic imbalance), the cumulative load (repetition) and finally, excessive stress (force) (Kumar, 2001).

Castillo and Ramirez (2009) mention that a factor associated with the development of musculoskeletal injuries refers to the physical characteristics of the spaces and media work. The selections made by Infrastructure organizations are not, as in many other cases, the nature of work to be done, but are made in terms of economic and production lines, rather than efficiency and safety of individuals. Another factor that is not considered is the anthropometric characteristics of the population, which in many situations does not match the designed equipment and jobs parameters.

Heyward (2008) mentions that when good levels of muscular fitness remain the chance of other diseases such as osteoporosis fractures, musculoskeletal injuries and back problems are reduced.

Actually muscle strength is considered a benchmark of health and wellness in young adults and also being inversely related to mortality and positively with the guarantee of autonomy of a person (Padilla, 2010). Minimum levels of muscular strength are required to perform the activities of daily living, maintaining independence work over the years, and participate in active recreational tasks without tension or fatigue unconscionable (Heyward, 2008), this can be applied in performing work activities people, implementing a minimum of muscular strength for each job and also the employee does not feel excessive fatigue at the end of the day, or in the worst case suffer any illness or musculoskeletal injury.

Considering this, the purpose of this research project is to estimate the parameter of maximum grip force in dominant and no dominant hand in men and women, in order to have a standard of force that can be applied in manual operations.

1.1 Objetive

To determine the maximum grip strength in men and women in dominant and no dominant had.

1.2 Delimitation

This project presents only the grip strength parameter in one position (1 7/8 inch apart) in a population of working age.

2. METHODOLOGY

2.1 Materials

The measurements were performed with a Lafayette hand dynamometer (model 78010) shown in Figure 1. The dynamometer has adjustable handle to hand size and muscle strength measured between 0 and 100 kg in 0.1 kg. Before using the dynamometer was adapted distance from the handle to the end position to care for a standard 1 7/8 inch (4.7625 cm) inch for each subject, the experiment Muñoz De la Vega, Lopez, Ortiz and Duarte (2009) is considered as the ideal opening, where they obtained their maximum grip strength

Figure 1. Instrument used Lafayette hand dynamometer.

2.2 Sample

The population study was made subject of university students, aged between 17 and 23 years. Cases that meet the age requirements, without conditions prevent proper hand pressure, no disease or treatment with oral steroids or diuretics were selected, data from 150 students of both sexes, first through eighth semester were obtained. Data were taken from Monday to Friday, during the month of November and December 2013 and January 2014, at different times.

2.3 Procedure

An instrument for collecting data as age, sex, origin place, three items of maximum strength for dominant hand and non-dominant hand in kilograms (Kg), and determination of laterality (handedness) was developed see Table 1 .

Chart 1. Collecting data

					DH			NDH			
No.	Name	Origin place	Sex	Age	1	2	3	1	2	3	DH

The measurement technique was:

- A standing subject of study, abducted shoulders without rotation, 90 ° elbow, arm and wrist in neutral position. Se figure 2.
- Application of strength dominant hand (DH)
- Application of force non dominant hand (NDH)
- The maneuver is repeated three times for each hand leaving a recovery time between them and recording the data of each.

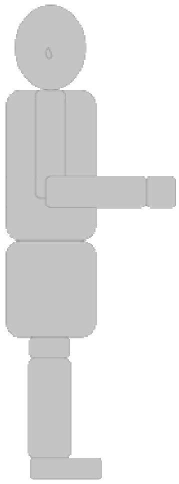

Figure 2. Position the subject of study

A database was prepared in Microsoft Excel software for data analysis, the information was treated with descriptive statistics. The maximum grip strength is presented as mean plus or minus one standard deviation for dominant and non-dominant hand. Percentiles 5, 10, 25, 50, 75, 90 and 95 for each sex were calculated and adjusted for age groups.

2. RESULTS PRESENTATION
3.

The measured sample (n = 150 individuals) was conformed with 59% of male and 41% female, 88% of the sample with right hand. The analysis of the information was generated by age groups follows: 17-18 years, 19-20 years, 21-22 years and 23-24 years (any cases of women were presented in this last group). Muscle strength followed an increasing trend by age in the case of men, this did not happen in women, the strongest age group was the 23-24 range with 46.9 kg for men and women group 19-20 with 26.5 kg, it is concluded that they are stronger subjects over 20 years in men and stronger women under 20 years.

Charts 2, 3, 4 and 5 show the information obtained, presenting the average number of subjects per group analyzed and calculated percentiles, followed by Figure 2 and 3 where the maximum grip strength in dominant hand was comparing between women and men.

Chart 2. Strength in women dominant hand (DH)

Age	Cases	Ave.	p 5	p 10	p 25	p 50	p 75	p 90	p 95
17-18	17	25.4	20.9	21.8	23.5	25.4	27.2	28.9	29.9
19-20	24	26.5	20.0	21.5	23.9	26.5	29.2	31.6	33.0
21-22	20	24.7	15.1	17.2	20.7	24.7	28.6	32.1	34.2

Chart 3. Strength in women no dominant hand (NDH)

Age	Cases	Ave.	p 5	p 10	p 25	p 50	p 75	p 90	p 95
17-18	17	22.7	17.0	18.2	20.4	22.7	25.0	27.2	28.5
19-20	24	25.1	17.4	19.1	22.0	25.1	28.2	31.0	32.7
21-22	20	23.3	12.6	15.0	18.9	23.3	27.6	31.5	33.9

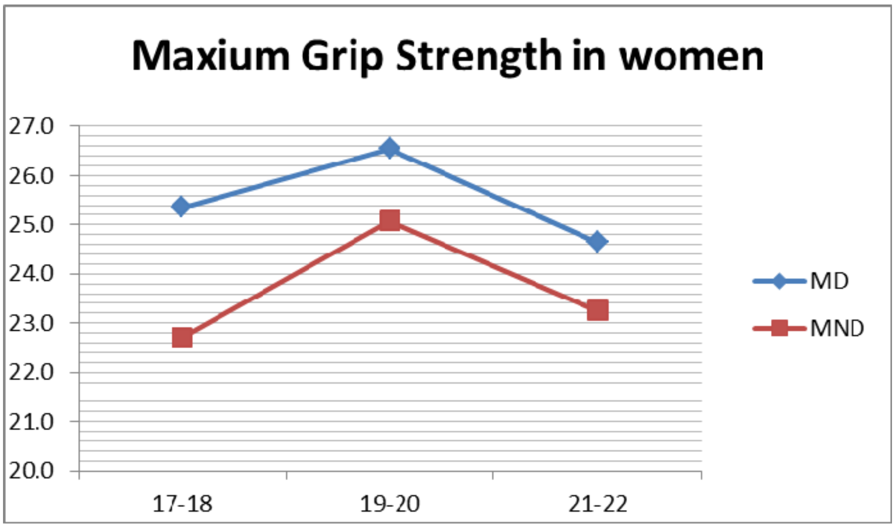

Figure 3. Comparison of Maximum Grip Strength in Dominant Hand (DH) and Non Dominant Hand (NDH) in women.

Chart 4. Strength in men dominant hand (DH)

Age	Cases	Ave.	p 5	p 10	p 25	p 50	p 75	p 90	p 95
17-18	17	45.0	34.4	36.8	40.7	45.0	49.3	53.2	55.6
19-20	28	46.9	34.4	37.2	41.8	46.9	52.0	56.6	59.4
21-22	30	48.2	31.6	35.3	41.5	48.2	55.0	61.2	64.8
23-24	14	48.9	32.3	36.0	42.1	48.9	55.6	61.7	65.4

Chart 5. Chart 4. Strength in men non dominant hand (NDH)

Age	Cases	Ave.	p 5	p 10	p 25	p 50	p 75	p 90	p 95
17-18	17	43.8	32.6	35.1	39.3	43.8	48.4	52.6	55.0
19-20	28	45.4	34.8	37.2	41.1	45.4	49.6	53.6	55.9

21-22	30	45.5	29.7	33.2	39.0	45.5	51.9	57.8	61.3
23-24	14	46.9	29.0	33.0	39.6	46.9	54.1	60.7	64.7

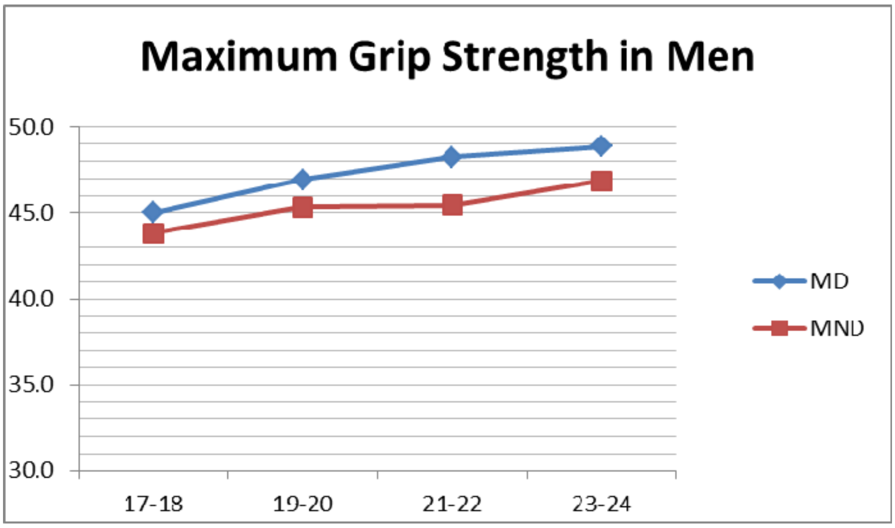

Figure 3. Comparison of Maximum Grip Strength in Dominant Hand (DH) and Non Dominant Hand (NDH) in men.

Subsequently the data were grouped into two segments: men younger and equal to 20 years, and men over 20 years, and women younger and equal to 20 years, and women over 20 years. The Maximum Grip Strength on dominant hand was compared and the data is presented in Chart 6.

Chart 6. Comparison of maximum grip strength (MGF) average by age groups +-20 years.

	> 20 años			<= 20 años		
Sex	Cases	MGF Ave.	sd	n.o casos	MGF Ave.	sd
Hombres	68.0	48.4	9.1	21.0	43.9	6.4
Mujeres	27.0	24.9	5.5	34.0	26.2	3.3

4. CONCLUSIONS

Information presented allows to work with own standards and begin design work for the characteristics of the study population, this will allowed to have appropriate tools for the task-operator and may reduce the risk of injury. We believe it is necessary to conduct a study that includes a larger sample size and to investigate which factors influence the anthropometric exert maximum force. According Heyward (2008), one of several attributes that determine fitness is muscular strength, strength is a variable that is partly determined by genetic endowment of the individual but some lifestyle habits such as diet or training have great influence on the force. Furthermore, the force is specific muscle group, the type of muscle contraction (static or dynamic), the speed of muscle contraction (slow or fast) and evaluated joint angle (static contraction).

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APPLICATION OF A MULTIVARIATE MODEL OF REPEATED MEASURES FOR MANUAL EFFORT ANALYSIS WITH A SPLIT-PLOT NESTED DESING.

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Resumen: Las actividades donde se desarrollan esfuerzos manuales son habituales en la industria manufacturera. El desempeño realizado por estos esfuerzos puede ser representado por un modelo multivariado donde se consideran la edad, peso, estatura, ancho de la muñeca y ancho de la mano, como factores determinantes en el ejercicio laboral. Con el apoyo de un diseño anidado de parcelas divididas, se puede hacer una representación mediante un modelo de dichos esfuerzos manuales considerando los factores antes expuestos.

Palabras claves: Modelo multivariado; Medidas repetidas; Parcelas divididas.

Abstract: Activities which are developing manual efforts are common in the manufacturing industry. The performance made by these efforts can be represented by a multivariate model where the age, weight, height, wrist width and width of the hand, as determining factors in the employment office are considered. With the support of a nested split-plot design, a representation using a model of such efforts manual whereas before exposed factors can be.

Keywords: Multivariate model, repeated measures, split plots.

Relevance to ergonomics: An ergonomic objective is one that provides user convenience, efficiency and high level of productivity. It is required to seek a better life quality in the workplace. The application of this research can be used as support for the development of studies related to the reduction of injuries caused by overuse or hand fatigue and thereby provide a better quality of living for a worker.

1. INTRODUCTION.

Repetitive movements is a group of continuous movements, involving the same musculoskeletal set causing pain in this, overload, and muscle fatigue accumulated sufficient to cause injury. It is considered that a movement is repetitive when its frequency is greater than 4 times per minute. The repetitive tasks are common in manufacturing, assembly line work, repair, administrative work, making crafts, etc. leading to musculoskeletal injuries especially in the upper limbs.

This type of repetitive activities over time is stressors. The concept of stress is based on that proposed by Richard Lazarus theory, which defines stress as a sustained process in time, where regularly an individual perceived imbalance between the demands of a situation and the resources he has to deal to that situation (Lazarus, 1999).

In the above definition, the author raises three elements that are part of a stress process: the situation, the resources of the person and the person's perception of the situation and resources. However, the key to stress is the relationship that eventually established between these elements. From the perspective of Richard Lazarus (1999), stress is a process where a transaction between individual environmental variables and the history of this relationship occurs. Thus, the assessment that the individual makes of the elements involved, the emotions that arise in the relationship and how the situation facing the individual are defining the stress process.

The neglect of this process of increasing stress on workers, brings consequences injury or accidents. In Mexico, according to data provided by the Mexican Social Security Institute (IMSS, 2013), employees of services production support are those with more cases of injury accidents, with 64.558 cases in 2012. The anatomical region most often work injury is the hand and wrist, with cases such as wounds, superficial injuries, fractures, dislocations, sprains and strains of joints and ligaments.

A case study because workers who daily perform such repetitive activities described above, can contribute to the reduction of injuries and accidents.

2. OBJECTIVES.

General: Conduct a study on the behavior of the grip strength of manufacturing workers by applying a multivariate model supported by a nested split plot design.

Specifics:

- Get a multivariate model, which represents the gripping force that can carry out manufacturing workers based on factors such as your weight, height, age, hand width and wrist width.
- Get a multivariate model based on a nested split plot design.
- Determine the expected grip force workers according to a certain time.
- Use statistical tools for data processing.

The study considers only the female working age who perform manufacturing activities with high repetition rate in the city of Hermosillo and will focus on the anatomy of the hand.

3. METHODOLOGY.

A group of 35 workers with work experience and performing daily activities in manufacturing, in the community of Hermosillo was selected randomly. 5 factors were considered for the performed study: age, weight, height, wrist width and hand width. Each of these factors was categorized into 4 levels. The 4 categories of age (years) factor are: 19-24, 25-29, 30-34. The 4 categories of weight factor (kgs) are: 46-58, 59-71, 72-84 and 85-97. The 4 categories of factor height (cms) are: 150-156, 157-162, 163-169 and 170-176. The 4 categories of wrist width factor (cms) are 4.9-5.3, 5.4-5.8, 5.9-6.3 and 6.4-6.8. The 4 categories of hand width factor (cms) are 6.8-7.2, 7.3-7.8, 7.9-8.4 and 8.5-9.0.

3.1 Data collection.

Dynamometers were prepared to measure the strength of hand grip. Test subjects were instructed to stand in front of a structure holding the dynamometer at heights that form a right angle with your elbow. The wrist was maintained in a neutral position with the hand resting on the dynamometer. Test subjects were instructed to perform a force on the hand grip dynamometer. 3 shots hand grip strength were performed at the beginning, middle and end of the working day, for five weeks. Test subjects were instructed to apply their maximum acceptable force, assuming that the level of grip which can be selected repeatedly sustained.

3.2 Data processing.

Data were recorded in a spreadsheet for easier handling. The peak force was recorded for each insert with dynamometers.

The data were nested according to the factors and corresponding categories. The arrangement of the variables by categories was carried out as shown in Figure 1.

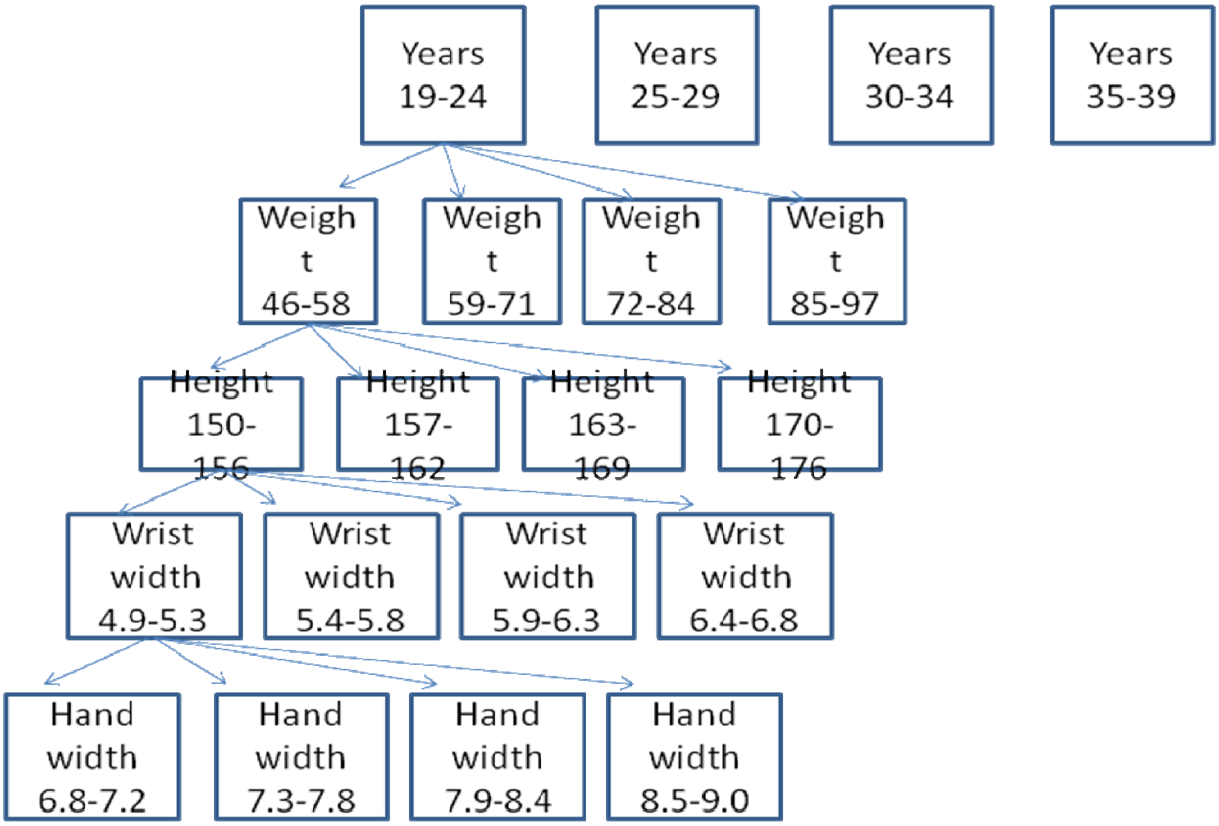

Figure 1. Arrangement of variables by category.

Based on the arrangement shown in Figure 1, a split plot design for what are considered the three samples at the beginning, middle and end of the working day that took 5 weeks for each test subject is made and nest according to the category of each factor. The general model, considering the proposed design will be:

$$y_{ijklm} = \mu + \tau_i + \beta_j + \square_k + \kappa_l + \nu_m + (\tau\beta)_{ij} + (\tau\square)_{ik} + (\tau\kappa)_{il} + (\tau\nu)_{im} + (\beta\square)_{jk} + (\beta\kappa)_{jl} + (\beta\nu)_{jm} + (\square\kappa)_{kl} + (\square\nu)_{km} + (\kappa\nu)_{lm} + (\tau\beta\square)_{ijk} + (\tau\beta\kappa)_{ijl} + (\tau\beta\nu)_{ijm} + (\tau\square\kappa)_{ikl} + (\tau\square\nu)_{ikm} + (\tau\kappa\nu)_{ilm} + (\beta\square\kappa)_{jkl} + (\beta\square\nu)_{jkm} + (\square\kappa\nu)_{klm} + (\tau\beta\square\kappa)_{ijkl} + (\tau\beta\square\nu)_{ijkm} + (\tau\beta\kappa\nu)_{ijlm} + (\tau\square\kappa\nu)_{iklm} + (\beta\square\kappa\nu)_{jklm} + (\tau\beta\square\kappa\nu)_{ijklm} + \square_{ijklm} \quad (1)$$

$i = 1, 2, 3, 4$	τ = age
$j = 1, 2, 3, 4$	β = weight
$k = 1, 2, 3, 4$	$\square$ = height
$l = 1, 2, 3, 4$	κ = wrist width
$m = 1, 2, 3, 4$	ν = hand width

3.3 Statistical analysis.

Using Minitab 16 software was made to analyze the main effects of the data and make comparisons on their behavior and fitness for a multivariate model using a nested split plot design.

4. RESULTS.

With the captured data processing and analysis with nesting proposal using the software Minitab 16, the estimates for each factor and the combination of these effects are obtained. This leads us to Table 1 where p values obtained are shown below:

Table 1. P values for the relationship of the variables.

VARIABLE(S)	**p Values**	**Coefficient**
One factor		53
Age	0.117 No significant	- 16
Weight	0.013	- 50
Height	0.013	- 131
Wrist width	0.002	64
Hand width	0.004	- 44
Two factors		
Age* Weight	0.005	- 313
Age* Height	0.015	- 248
Age* Wrist width	0.001	206
Age* Hand width	0.000	- 249
Weight* Height	0.008	- 101
Weight* Wrist width	0.004	- 240
Weight * Hand width	0.015	- 183
Height * Wrist width	0.002	- 271
Height * Hand width	0.848 No significant	- 5
Wrist width * Hand width	0.006	112
Three factors		
Age * Weight * Height	0.462 No significant	45
Age * Weight * Wrist width	0.001	- 479
Age * Height * Wrist width	0.006	- 746
Age * Weight * Hand width	0.121 No significant	- 178
Age * Height * Hand width	0.159 No significant	108
Age * Wrist width * Hand width	0.005	183
Weight * Height * Wrist width	0.012	- 611
Weight * Height * Hand width	0.018	846
Weight * Wrist width * Hand width	0.050	- 395
Height * Wrist width * Hand width	0.000	81
Four factors		

Age * Weight * Height * Wrist width	0.007	- 2027
Age * Weight * Height * Hand width	0.005	1974
Age * Weight * Wrist width * Hand width	0.564 No significant	105
Age * Height * Wrist width * Hand width	0.128 No significant	58
Weight * Height * Wrist width * Hand width	0.000	598
Five factors		
Age* Weight * Height * Wrist width * Hand width	0.025	- 629

According to equation (1), substituting the values of the coefficients obtained in Table 1, and eliminating the variable or combination of no-significant variables, we obtain the following polynomial which is the multivariate model with a split plot design:

$$y = 53 - 50\beta - 131\square + 64\kappa - 44\nu - 313(\tau\beta) - 248(\tau\square) + 206(\tau\kappa) - 249(\tau\nu) - 101(\beta\square) - 240(\beta\kappa) - 183(\beta\nu) - 271(\square\kappa) + 112(\kappa\nu) - 479(\tau\beta\kappa) - 746(\tau\square\kappa) + 183(\tau\kappa\nu) - 611(\beta\square\kappa) + 846(\beta\square\nu) - 395(\beta\kappa\nu) + 81(\square\kappa\nu) - 2027(\tau\beta\square\kappa) + 1974(\tau\beta\square\nu) + 598(\beta\square\kappa\nu) - 629(\tau\beta\square\kappa\nu) \quad (2)$$

5. CONCLUSIONS.

This multivariate model based on a nested split plot design, we represent the behavior of the manual force may exercise the person in the course of a given time, considering the 5 factors described above.

The combination of the factors and levels were successful. It is noted that the age is not significant factor.

The height–hand width, age–weight–height, age–weight–hand width, age–height–hand width, age–weight–width wrist–hand width–height and age–height–wrist width–hand width combinations, were considered to be no significant in the model.

This model can be found in a very successful way, the manual force to exercise the person based on the factors age, height, weight, wrist width and hand width at a given time. This information can help us to determine the level of stress or fatigue that this person has accumulated and thereby contribute to the prevention of workplace injury or accident.

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GRIP AND PINCH STRENGHTS EVALUATION ON MEXICAN POPULATION

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RESUMEN: El conocimiento de las capacidades y limitaciones físicas de trabajadores y usuarios es imprescindible para el análisis y optimización ergonómica de productos de consumo, máquinas, herramientas y puestos de trabajo. Entre éstas, los esfuerzos musculares de las manos resultan muy importantes pues con ellos se desarrolla un alto porcentaje de tareas y actividades que podrían resultar en el desarrollo de molestias y lesiones musculo-esqueléticas. En este estudio se evaluaron 100 sujetos de ambos sexos, de los cuáles el 48 % corresponde al sexo femenino y el 52% al masculino, con una edad promedio de 24.6 años (d.e. ±7.9). El 79.8% del total eran estudiantes y el restante 20.2% eran trabajadores. Se tomaron medidas antropométricas de las manos, así como estatura y peso. Se evaluó a cada sujeto su esfuerzo máximo muscular voluntario de agarre y de pinza en tres intentos espaciados, en ambas manos, tomando el mayor como dato definitivo. Los resultados muestran diferencias significativas entre sexos, y entre trabajadores y estudiantes hombres no así entre trabajadores y estudiantes femeninas. Se encontraron correlaciones positivas altas entre peso y fuerza de agarre y entre las dimensiones de las manos y los esfuerzos de agarre y pinza, tanto en hombres como en mujeres. Al comparar la fuerza de agarre con poblaciones de EUA y de Brasil, se encontraron diferencias estadísticamente significativas siendo mayor la de los mexicanos en ambos sexos,.

Palabras Clave: Fuerza de agarre, Fuerza de pellizco, Ergonomía

ABSTRACT: The knowledge of capabilities and physical limitations of workers and users is essential for the analysis and ergonomic optimization of consumer products, work stations, tools and machinery. Among them, the muscular effort of the hands is very important because with them a high percentage of tasks and activities are developed, these activities can lead to muskuloskeletal discomfort and injuries. In this study 100 subjects of both sexes, of which 48% were female and 52% male were evaluated, with a mean age of 24.6 years (s.d. ± 7.9). The 79.8% of the total were students and the remaining 20.2% were workers. Anthropometrical measurements of the hands were taken, as well as height and weight. The maximum voluntary muscular effort of both hands was measured in three separated attempts for each subject, taking the higher value as final data. The results shows significant differences between male workers and students but not between female workers and students High and positive correlations were found among weight and grip strength and also between hand size and grip and pinch effort in both, men and women. The obtained data of the grip

strength was compared with the correspondent information for USA and Brazilian population. Statistically significant differences were found, being the greater Mexicans in both sexes.

Keywords: Grip Strengt, Pinch Strength, Ergonomics

Relevance to ergonomics: Knowledge of the physical characteristics of Mexican users and workers for better ergonomic fits of products and jobs

1.- INTRODUCTION

The application of muscle over-strains is one of the most ergonomic risk factors associated with the development of musculoskeletal injuries (Silverstein, Fine, & Armstrong, 1986; Moore &Garg, 1994). According to ergonomic principles based on biomechanical and physiological studies of the musculoskeletal system the recommended strength for frequent and highly durable activities (more than 2 hours) must not exceed the limit of 30% of the Maximum Voluntary Muscular Effort (MVME) in men and 15% in women, due to this it is necessary to know the variability of the MVME in the different age groups of our population in order to locate the work efforts within these limits avoiding unnecessary fatigues as well as long and medium term injuries, the muscular efforts can be evaluated through several methods like electromyography or subjective scales like Borg, however the most precise method is the dynamometry for which there are several precise and reliable equipment. Since the arms and hands are the most active parts of the human body with witch the majority of task and actions are performed it is important to have information about the more often muscular efforts made with them in order to make appropriate adjustments to the use of consumer products, machines, tools, jobs and workstations. In more developed countries the information about muscular efforts in several population sectors is already available, however in developing countries like Mexico these kinds of evaluations are not very common and it is hard to find published studies about it.

2.- METHOD

2.1. Subjects

The sample comprises 100 healthy adult subjects without pre-existing arms or hands injuries, of which 48% were female and 52% male having an average age of 24.6 years (s.d.+- 7.9). The 79.8% of the total were students and the remaining 20.2% were workers. Anthropometric measurements of the hands as well as weight and height were taken, the obtained data is shown in the next table.(Table 1).

Table 1. Anthropometric dimensions of the sample

Dimensions *	Female					Male				
* Weight in kg;. Remaining dimensions in mm.	Average	S.D.	Percentile			Average	S.D.	Percentile		
			5	50	95			5	50	95
Weight	61.43	14.98	42.20	60.00	91.53	74.75	11.26	52.50	73.65	97.16

Height	1603	82	1447	1616	1736	1715	66	1600	1714	1860
Length of hand	171	9	151	172	185	183	11	160	183	208
Length of Palm	100	5	92	100	109	108	7	93	108	116
Hand width	87	5	79	87	95	99	5	87	101	105
Palm width	74	5	66	76	81	83	4	75	83	89

All the subjects received a verbal explanation about the purpose and procedure to follow during the test; they were also asked for their voluntary consent to participate in the study.

2.2.-Instruments

A hydraulic hand dynamometer mark BASELINE, 90kg of capacity and an adjustment of grip 1.35 -. 3.35 in. it is similar to the model Jamar (Hidraulic Hand Dynamometer) it was also used a hydraulic dynamometer clip of the same brand, 22.5 kgs. (Hidraulic Pinch Gauge).

For the anthropometrical measurements of the hands it were used a vertical Martin type anthropometer and a 400 mm special design short branches compass manufactured in the Universidad de Guadalajara.Weight was taken with a mechanical sliding scale brand Torino, Mod Express, up to 140 kg, and an accuracy of 100 g.

2.2.- Subjects posture for effort evaluations

The grip effort evaluation was made in a standing position with both feet slightly apart in a natural way, with both arm-forearm in a 90° angle, the wrist in a straight position and the dynamometer opening in the second position (55mm).

The pinch effort was made in the same standing position, taking the dynamometer between the thumb and the index finger in a lateral pinch way (Willard &Spakman, 2005)

1.- How to properly hold the dynamometer for the grip effort

2.-How to property hold the dynamometer for the pinch effort

2.3.- Anthropometric measurements taking to the subjects

1.-WEIGHT: Is the total mass of the subject measured in kilograms and using a clinical swing to within 100 grams.
2.-TOTAL HEIGHT: Maximum vertical distance from the vertex to the ground, the subject standing with his head being oriented to the Frankfort plane.
3.- HAND LENGHT: length is limited by the crease nearest the wrist carpus, and the apex of the middle finger (dactilión III) the subject standing upright.
4.- LENGTH OF THE PALM: Distance from the crease nearest the wrist, to the crease of the metacarpophalangeal joint of the middle finger wrist.
5.- HAND WIDHT : Distance between the outer part of the carpal region on the side of the little finger and the outermost point of the thumb, when flexed against the palm of the hand.
6.- PALM WIDHT: Distance between the outer part of the carpal region on the side of the little finger and carpal outermost point in the region of the thumb.

2.4. Procedure

Before the effort evaluation was made, the subjects were verbally advised about the objective of the study and the accurate way to perform the effort then, also verbally they were asked for their consent, right away anthropometic measurement were taken and registered in an electronic format created for such activity.

Then the body and hand-wrist posture to adopt for realizing the grip and pinch effort were taught to them. They were allowed to use the dynamometers with their free hand while they were performing the effort with the other one.They were told to hold the manual dynamometer and to perform their maximum effort and hold it for 3 seconds.

By the same way they were told how to hold the pinch dynamometer and how to put their thumb and their index finger so they could realize their maximum effort which they had to hold on for 3seconds.They were asked to perform three times each kind of effort, they were taken with a one minute break between each one.

3.-RESULTS

Pinchand grip strenght

Pinch and grip strengths were compared between both sexes, statistically significant differences were found in both groups being greater in both cases for the male sex. It was observed that in the 95 percentile the grip strength is bigger 55% in males than in women and the pinch strength is bigger in a 77% and in a 65.5% and 70% respectively within percentile 5. Equally the results of workers and students were compared finding significant differences only in the pinch strength in which male workers data happened to be 25% bigger than the results for male students; in other hand the comparison of the female data did not show any significant difference. Tables 2 and 3 present the obtained statistics.

Table 2. Comparison of maximum pinch and grip strength between both sexes

Force(kg.)	Female					Male					Test t
	Average	S.D.	Percentile			Average	S.D.	Percentile			
			5	50	95			5	50	95	
Grip	31.9	5.2	24.9	31.5	40.6	56.5	10.7	38.0	58.0	74.0	14.43 (p=.001)
Pinch	7.3	1.3	5.5	7.5	10.1	10.9	1.8	7.8	10.9	13.0	11.48 (p=.001)

Table3. Comparison of maximum pinch and grip strength between sex and occupation

Gender	Female										Test t
Occupation	Student					Worker					
Fuerza (kg.)	Average	S.D.	Percentiles			Average	S.D.	Percentiles			
			5	50	95			5	50	95	
Grip	31.6	4.5	26	31	40	33.1	6.9	20	33	44	---
Pinch	7.1	1	5.5	7.5	9.5	7.9	1.8	5.5	7.5	10.9	---

At being realizing the analysis of the effort relations with the anthropometric dimensions among the sex groups it was found that the ones that affect grip and pinch strength appears to be different depending on the sex of the subject . For women (table 4) the grip strength was related to weight, the long of the hand and the pinch strength was related with the long of the palm.

Table 4. Correlations of pinch and grip strength with body dimensions

	Gender			
	Female		Male	
	Grip	Pinch	Grip	Pinch
Weight	.602***	.612***	.359**	.284*
Height	.366**		.461***	
Length of hand	.286*		.489***	.306*
Length of Palm	.342*		.375**	
Hand width	.365*			
Palm width	.387**		.442***	
Grip		.537***		.536***

*** < 0.001 ** < 0.01 * < 0.05

For men, as is shown in table 5 the maximum grip strength is related with the long of hand and palm as well as with the width of it while the pinch maximum strength is related with occupation, age and also the width of the hand (table 5).

Table 5. Correlations between grip and pinch strengths and anthropometric dimensions in sex and occupation

	Gender							
Occupation	Female				Male			
	Student		Worker		Student		Worker	
	Grip	Pinch	Grip	Pinch	Grip	Pinch	Grip	Pinch
Weigth	0.858***	0.549***			0.349*			
Heigth	0.475**				0.458*		0.872**	
Length of hand	0.406**				0.523***	0.385**		
Length of Palm					0.365*			
Hand width	0.475**						0.809*	
Palm width	0.479**				0.444**			
Grip		0.472**				0.531***		

*** < 0.001 ** < 0.01 * < 0.05

A high correlation resulted between the weight and the female sex students; the height and the width of the hand are relevant for the male workers.

The age groups were divided in subjects under 22 years old and subjects older than 23, that because of the sample size. Strong correlations were found between the weight and the hold capacity in the under 22 years old female group and correlations between the hold capacity and the width of the hand on the older than 23 male group. in the same group correlations were found between the weight and the pinch. Also a high correlation between the weight and the pinch hold on the female subjects older than 23 years old (Table 6).

When the information obtained in this investigation were compared with the existing data about Brazil and USA it was found that at the moment of comparing the grip strength mean of the females there was a significant statistic difference ($t= 10.41$ $p<0.001$) between the data collected in this study and the one that were used by Budziareck, Pureza Duarte & Barbosa-Silva, (2008). Talking about the men strength data, the grip strength of the subjects evaluated in this study was bigger that the results showed in the other ones being this difference statistically significant regarding to the data reported by Hanten, Chen, Austin, Brooks, Carter, Law, et al. (1999); Tvalue= 13.9 ($p<0.001$) and with a Budziareck et al, (2008), in which the significant difference had a tvalue= 8.3 ($p<0.001$).

Table 6. Correlations between pinch and grip strength with anthropometric dimensions in sex and age group.

*<0.05 **<0.01 ***<0.001

	Gender							
	Female				Male			
Grupo etareo	≤22		≥23		≤22		≥23	
	Grip	Pinch	Grip	Pinch	Grip	Pinch	Grip	Pinch
Weigth	0.836***	0.398*		0.707**	0.368*			
Heigth	0.38*			0.5*	0.508**			
Length of hand					0.565***	0.388*		
Length of Palm		-0.445*			0.371*			
Hand width	0.547**						0.748*	
Palm width	0.366*				0.437**			
Grip				0.657**		0.545***		0.648*

4.- CONCLUSIONS

The results indicate that the significant differences between the maximum grip and pinch effort that are related with the strength are different for each gender. This has to be notices at the activities designing stage.Although the result may seem obvious because it is known that strength is bigger in men than in women in almost every population the knowledge of the variability of both strengths has barely begun to be known among Mexico population groups. However exploring the correlations between anthropometrical variables and strength data is important because it can help as a starting indicator of expected results. It was interesting to observe that in women the weight is positive and highly related with the grip strength and that in men this strength is related with height.

Regarding to the relations given by the occupation, is amazing that significant differences in the female sample were not advised, college students and workers are capable of similar effort capacities. Otherwise, between men a significant difference was observed regarding with the pinch strength, this happened to be 82% higher in workers than it is in students.

It was also surprising that strength in Mexican is significant higher than in Americans and Brazilians of both sexes.

Given by the fact that the sample used in this study was a very little one, this data couldn't have a representativeness that allowed its generalization but they can be used as a reference for discrete application and also for grew the sample up among other regions of the country as well as within age groups with the purpose of conforming a national data base that will be useful for evaluating applications and in the ergonomic optimization of consumer products, machinery, tools, jobs and work stations.

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MAXIMUM PINCH STRENGTH: STANDARS FOR THE HERMOSILLO, SONORA POPULATION

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Resumen: En la actualidad, las lesiones de trabajo representan un alto costo a las compañías, principalmente a aquellas que involucran trabajo manual en sus actividades. El análisis de la fuerza de mano y dedos en este tipo de tareas es esencial en la disminución de las lesiones de miembro superior. En países como Estados Unidos y Singapur se han llevado a cabo estudios para determinar la fuerza de pellizco, sin embargo no existe evidencia de investigaciones similares en México. El objetivo principal de la presente investigación es determinar la fuerza máxima de agarre de pellizco recomendada para la población de Hermosillo, Sonora, con la finalidad de establecer estándares de fuerza categorizados por edad y género. Se llevó a cabo un experimento en el que participaron 536 estudiantes voluntarios (390 hombres y 146 mujeres) entre 17 y 26 años de edad. La edad fue categorizada en tres grupos: 15-19, 20-24 y 25-29 años, para el análisis posterior de su efecto en la fuerza de agarre. Se solicitó a los sujetos de investigación realizaran tres esfuerzos de agarre de pellizco sostenidos durante tres segundos cada uno, teniendo un minuto como tiempo de recuperación entre esfuerzos. Los resultados indicaron que la fuerza máxima de agarre determinada para poblaciones de otros países difiere significativamente de los resultados obtenidos para la población mexicana, por lo que no se recomienda su uso en el diseño de estaciones de trabajo.

Palabras clave: Agarre de pellizco, fuerza máxima, biomecánica.

Abstract: Injuries at work represent a high cost for the companies, mainly the ones that include manual work. Analyzing the finger exertion during this kind of activities is essential, in order to minimize the upper limb lesions. To determine the pinch strength capabilities, several researchers in countries such as USA have conducted some studies and Singapore; nonetheless there is not scientific evidence about these studies conducted for Mexicans. The main objective of this study is to determine the maximum recommended pinch strength for the population of Hermosillo, Sonora, in order to establish gender and age strength standards. A total of 536 volunteer students (390 men and 146 woman) between 17 and 26 years old participated in the study. The age was reorganized into three groups 15-19, 20-24 and 25-29 years old for a subsequent analysis of age effect. The subjects were instructed to perform three pinch efforts during three seconds each one and a one-minute rest between efforts. The results indicate that

the maximum pinch strength data obtained in other country studies differs significantly from the data obtained for the Mexican population, so it is not recommended its application in the work stations design.

Key words: Pinch grip, maximum strength, biomechanics

Relevance to Ergonomics: The data collected constitutes an essential element for the ergonomic industrial hand tools and workplaces design.

1. INTRODUCTION

Injuries at work represent a high cost for the companies, mainly the ones that include manual work. Analyzing the finger exertion during this kind of activities is essential, in order to minimize the upper limb lesions.

Forceful exertions, awkward postures, repetition, and some other environmental conditions such as vibration are the aspects of a job or task that impose a biomechanical stress on the worker, exposure to ergonomic risk factors in the workplace can cause or contribute to the risk of developing an MSD.

The Work Related Musculoskeletal Disorders has increased significantly in recent years. According to the 2010 Mexican Social Security Institute statistics, the 6.25 % of the total cases of work related lesions corresponds to synovitis, tenosynovitis and bursitis, that's means an increment of 5.15 % in the last five years (IMSS, 2010).

Swanson et. al. (1970) established the clinical norms for the tip pinch strength, based on the average of three successive trials and one-minute rest between trials. They found that there was a minimal difference between the mean scores of the right hand dominant and left hand dominant for men. In the case of women, the right-handed mean scores were larger than de left handed scores.

Mathiowetz et. al. (1985) studied the hand and finger grip strength. The study included 628 volunteers (310 men and 318 women) aged 20 to 94 years. During the experiment, both hands, three successive trials hand and finger strength were measure. The researchers concluded the average scores were relative stable from 20 to 59 years, with gradual declines from 60 to 79 years.

Incel et. al. (2002) studied the effect of hand dominance in the pinch strength. A group of 149 (121 right handed and 21 left handed) volunteers participated in the study. The three maximum attempts average was recorded. Researchers did not report evidence of a significant difference in the stronger no dominant hand strength percentage (28.12 and 28.57 % for the right and left handed subjects respectively).

In Mexico, there is no evidence of studies about the maximum recommendable sustained pinch strength for the assembly activities that involved pinch grip, mainly in the industrial work.

2. OBJECTIVES

The main objective of this study is to determine the maximum recommended pinch strength for the population of Hermosillo, Sonora, in order to establish gender and age strength standards.

3. METHODOLOGY

3.1 Subjects

A total of 536 (390 men and 146 woman) volunteer students of the Department of Industrial Engineering of the University of Sonora, participated in this study. The subjects aged between 17 and 26 years old. Age was reorganized into three groups 15-19, 20-24 and 25-29 years old for a subsequent analysis of age effect. Dominant hand was define as Incel et. al. (2002). All the subjects reported a good health and there was no evidence of an upper limb WMSD in the last two years.

3.2 Experimental procedure

The subjects were instructed to perform three pinch efforts, sustained during three seconds. A one-minute recovery time was taken between trials. During the experiment the subjects were seated and the upper and lower arm were positioned at 45º flexion and the wrist adducted between 20-45º. A table always supported the elbow. Both hands measures were recorded and the average was taken in consideration for the data analysis.

During the experiment environmental conditions such as illumination and temperature were controlled according to the Mexican normativity.

3.3 Instruments

Baseline mechanical pinch gauges, 12-0200 with 30 lb. capacity and 12-0201 with 60 lb. capacity, were used to register the women and men measurements, respectively.

3.4 Statistical analysis

Minitab 16 software was used for statistical analysis. “t” and two variances tests were used in the comparisons with other studies results.

4. RESULTS

4.1 Standard data.

Tables 1 to 8 presents the standards obtained from de data collected during the experiment. The data histograms and boxplots are shown in figures 1 and 2. Inferential analysis, demonstrates that age is an important factor in the pinch strength, as it decreases when age increases for 4 and 5 aged groups women (right handed), while using dominant hand, and the opposite when using the no dominant hand. Men strength increases as age increases for the right-handed subjects. Statistical analysis demonstrates that left handed women are stronger than right handed, when they use the dominant and no dominant hand. It was also proved that left-handed women are stronger when they performed an exertion with the no dominant hand.

Table 1. Right and left hand maximum pinch strength (lbs.).

Percentile	Male		Female	
	Right hand	Left hand	Right hand	Left hand
0.01	6.00	5.33	3.31	2.47
0.05	8.33	7.52	5.33	4.67
0.10	9.33	8.67	6.00	5.33
0.25	11.00	10.33	7.33	6.67
0.50	13.67	12.67	9.00	8.00
0.75	16.42	15.00	10.67	9.88
0.90	19.67	18.15	13.33	11.48
0.95	22.15	20.67	15.10	13.38
0.99	26.76	26.06	20.74	17.45

Table 2.Maximum pinch strength. Descriptive Statistics (lbs.)

Statistics	Male		Female	
	Right hand	Left hand	Right hand	Left hand
Mean	14.12	13.08	9.41	8.32
Standard Deviation	4.15	3.99	3.04	2.67
Minimum	4.50	2.00	3.00	2.00
Maximum	28.00	28.67	21.83	18.00
Range	23.50	26.67	18.83	16.00
Total (n)	390		146	

Table 3. Maximum pinch strength. Hand dominance percentile (lbs.)

Percentile	Male		Female	
	Dominant hand	Nondominant hand	Dominant hand	Nondominant hand
0.01	6.00	5.64	3.31	2.47
0.05	8.33	7.85	5.33	4.67
0.10	9.33	8.67	6.00	5.33
0.25	11.00	10.33	7.33	6.67
0.50	13.67	12.67	9.00	8.00
0.75	16.33	15.00	10.71	9.67
0.90	19.67	18.67	13.22	11.33
0.95	22.48	20.67	15.10	13.61
0.99	26.73	26.06	20.74	17.45

Table 4. Maximum pinch strength. Hand dominance descriptive statistics (lbs.)

Statistics	Male		Female	
	Dominant	Nondominant	Dominant	Nondominant
Mean	14.07	13.13	9.44	8.29

Standard Deviation	4.15	3.99	3.03	2.65
Minimum	4.50	2.00	3.00	2.00
Maximum	28.00	28.67	21.83	18.00
Range	23.50	26.67	18.83	16.00
Total (n)	390		146	

Table 5. Male Aged percentile (lbs.)

Percentile	Right handed						Left handed			
	Dominant hand			Nondominant hand			Dominant hand		Nondominant hand	
	15-19	20-24	25-29	15-19	20-24	25-29	15-19	20-24	15-19	20-24
1	7.00	6.00	4.50	6.67	5.48	2.00	7.67	5.33	8.00	7.67
5	8.67	8.67	6.79	8.13	7.05	4.93	7.67	5.87	8.00	7.73
10	9.60	10.00	9.40	8.93	8.67	7.40	7.67	8.13	8.00	8.00
25	11.00	11.67	10.58	10.67	10.33	10.17	9.83	9.33	10.25	9.00
50	13.00	14.00	14.50	12.33	12.67	13.17	11.92	12.67	11.67	13.33
75	16.00	16.67	17.13	14.67	15.00	18.63	14.83	16.67	12.83	18.67
90	19.07	19.23	24.60	16.40	17.67	22.27	22.67	23.67	22.00	22.47
95	20.80	22.28	25.93	19.93	20.64	27.20	22.67	26.87	22.00	27.13
99	25.67	27.09	26.67	20.50	25.00	28.67	22.67	27.33	22.00	28.00

Table 6.Male aged descriptive statistics (lbs.)

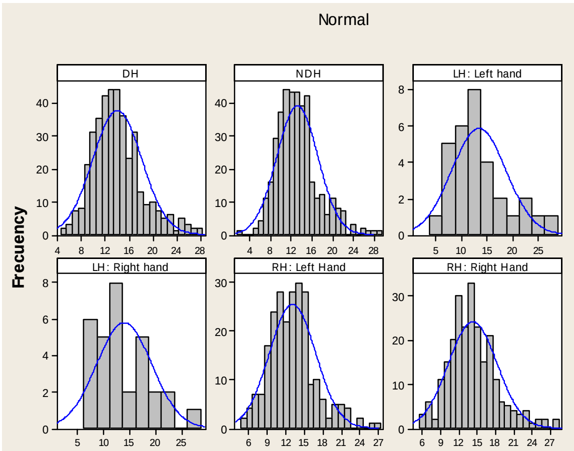
Statistics	Right handed						Left handed			
	Dominant hand			Nondominant hand			Dominant hand		Nondominant hand	
	15-19	20-24	25-29	15-19	20-24	25-29	15-19	20-24	15-19	20-24
Mean	13.62	14.23	14.75	12.74	13.02	14.22	12.94	12.24	12.46	12.46
SD	3.65	4.01	5.24	3.07	3.78	5.96	4.57	3.70	4.16	4.16
Minimum	7.00	6.00	4.50	6.67	4.67	2.00	7.67	5.33	8.00	8.00
Maximum	25.67	28.00	26.67	20.50	26.67	28.67	22.67	19.66	22.00	22.00
Range	18.67	22.00	22.17	13.83	22	26.67	15	14.33	14.00	14.00
Total (n)	87	242	30	87	242	30	8	23	8	23

Table 7. Female Aged percentile (lbs.)

Percentile	Right handed				Left handed	
	Dominant		Nondominant		Dominant hand	Nondominant
	15-19	20-24	15-19	20-24	20-24	20-24
1	5.33	3.00	5.00	2.00	6.67	6.00
5	6.10	4.63	5.00	3.97	6.67	6.00
10	6.77	5.33	5.33	4.97	6.67	6.00
25	7.67	7.00	6.00	6.67	8.00	8.00
50	9.05	9.00	7.67	8.00	10.17	8.83
75	10.33	11.00	8.67	10.00	11.83	11.33
90	13.93	13.33	10.37	11.47	13.17	13.67
95	15.38	15.40	13.43	14.20	13.17	13.67
99	18.83	21.83	16.83	18.00	13.17	13.67

Table 8. .Female aged descriptive statistics (lbs.).

Statistic	Right handed				Left handed	
	Dominant hand		Nondominant hand		Dominant hand	Nondominant hand
	15-19	20-24	15-19	20-24	20-24	20-24
Mean	9.54	9.15	7.85	8.41	9.98	9.38
SD	2.69	3.23	2.37	2.78	2.26	2.47
Minimum	5.33	3.00	5.00	2.00	6.67	6.00
Maximum	18.83	21.83	16.83	18.00	13.17	13.67
Range	13.50	18.83	11.83	16.00	6.50	7.67
Total (n)	42	97	42	97	7	7



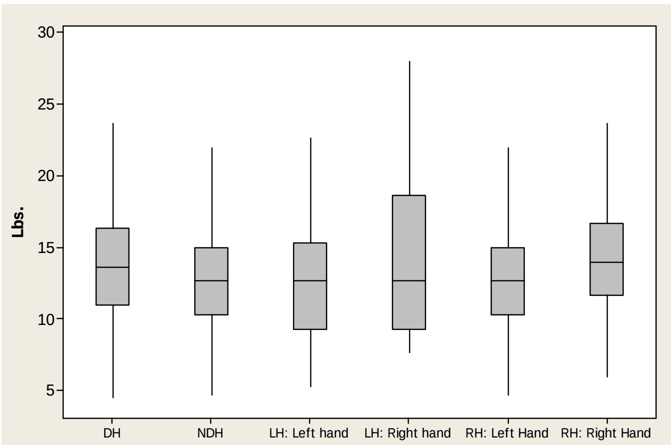


Figure 1. Male data histograms and boxplots.

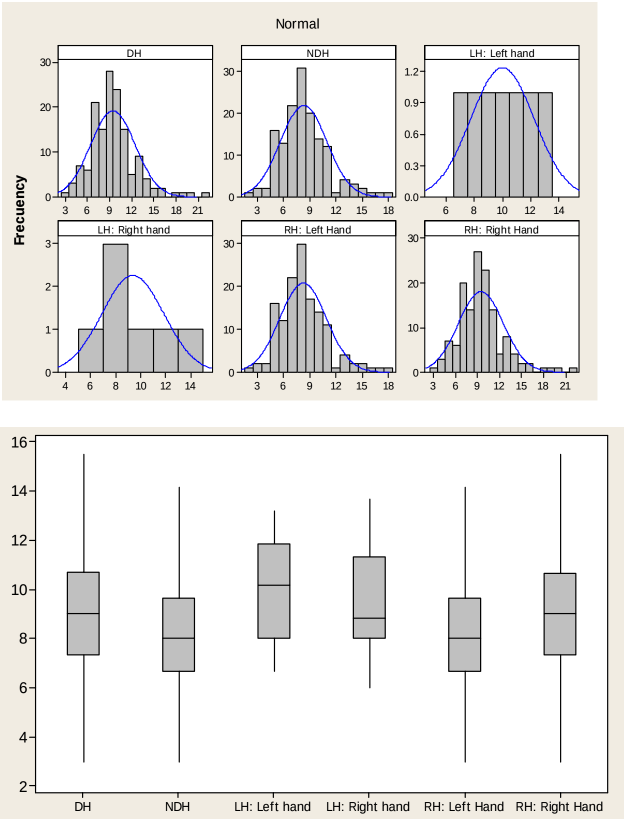


Figure 2. Female data histograms and boxplots.

4.2 Other studies comparisons.

Other studies statistical data are presented in tables 9 to 12. Mean comparisons were performed in statistical software Minitab 16, using two samples “t” test with a significance level of 5 percent. The results reported lower values for the Mexican population in all cases.

Table 9. Comparative data. Angst et. al.

Age group	Angst et al						This study					
	Male			Female			Male			Female		
	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
18-19	20.9	3.96	496	15.18	2.64	482	13.56	3.71	95	9.54	2.69	42
20-24	21.56	3.08	496	14.3	2.86	482	14.12	3.96	265	9.40	3.17	104
25-29	22.22	3.08	496	14.96	2.91	482	13.37	4.40	30	-	-	-

Table 10. Comparative data. Incel et. al.

Statistics	Incel et. al.		This study	
	Dominant hand	No dominant hand	Dominant hand	No dominant hand
Mean	17.2	15.55	12.81	11.81
SD	4.62	4.07	4.39	4.26
n	149		536	

Table 11. Comparative data. Mathiowetz et. al. (aged groups)

Age	Hand	Mathiowetz et. al.				This study			
		Male		Female		Male		Female	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
20-24	Right	18.0	3.0	11.1	2.1	14.25	4.02	9.36	3.18
	Left	17.0	2.3	10.5	1.7	13.05	3.80	8.51	2.76
25-29	Right	18.3	4.4	11.9	1.8	14.75	5.24	-	-
	Left	17.5	5.2	11.3	1.8	14.22	5.96	-	-

Table 12. Comparative data. Mathiowetz et. al.

Genre	Statistics	Mathiowetz et. al.				This study			
		Right handed		Left handed		Right handed		Left handed	
		LH	RH	LH	RH	LH	RH	LH	RH
Male	Mean	16.3	17	16.8	17.1	13.05	14.13	13.40	14.03
	SD	4.0	4.1	3.9	3.3	3.86	4.04	5.29	5.32
	n	-	-	-	-	359		31	
Female	Mean	10.7	11.4	11.7	11.2	8.23	9.43	9.98	9.38
	SD	2.5	2.6	1.9	2.5	2.64	3.05	2.26	2.47
	n	-	-	-	-	139		7	

5. CONCLUSIONS

A significant difference with another countries population standards was found during the study. Mexican ergonomists should be careful while using international data in the workstations and hand tools design. Standards obtained in this study can be considered in the ergonomic in the workstations design for the Mexican population.

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ERGONOMICS APPLIED TO INDUSTRIAL DESIGN WITH A SOCIAL APPROACH

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RESUMEN: Proyecto multidisciplinario de investigación e intervención tecnológica en el que destaca la ergonomía aplicada con un enfoque social. Está dirigido al sector artesanal del bambú de los estados de Puebla y Veracruz. Tiene como objetivos vincular la investigación con la docencia y con los sectores productivos artesanal e industrial; generar un espacio de participación de profesores y alumnos en la solución de problemas reales. Se diseñaron los equipos de preservación y secado de bambú, con el enfoque de diseño centrado en el usuario. Se construyeron modelos y prototipos de pruebas en los laboratorios de la FES Aragón.

Palabras clave: Diseño, ergonomía, social.

ABSTRACT: This multidisciplinary research and technological intervention project emphasizes the importance of ergonomics, user centered design with a social approach, and it is aimed to work with bamboo artisans of the states of Puebla and Veracruz. This study has the following educational objectives: apply expertise to external organizations as artisans and industrial groups; engage teachers and students to work together in real problems, and encourage students' participation in social programs. Bamboo preservation and drying bamboo poles equipment was designed with the user in mind. Testing models and prototypes were made and installed in laboratories of FES Aragón.

Keywords: Ergonomics, Design, social.

Relevance to Ergonomics: Basic anthropometric data of some artisans were obtained in workshops of Puebla and Veracruz. Image sequences were recorded to study them carefully to help define and solve the ergonomic requirements.

When designing with the user in mind, two proposals are achieved that improve ergonomic working conditions, one intended for preserving bamboo poles and another to dry them. With this equipment, awkward postures, overexertion and repetitive movements are avoided.

Ergonomic assessments take place in laboratories of FES Aragon and later on in the artisans' workshops, in both circumstances relevant ergonomic data will be obtained.

1. INTRODUCTION

The Universidad Nacional Autónoma de México (National Autonomous University of Mexico) "organizes and conducts outstanding research about social needs and favor nations development”. In the Facultad de Estudios Superiores Aragón (FES Aragón) two major areas are considered: research carried out to support teaching and research that contributes to the solution of national and nearby problems.

Under these guidelines teachers of Industrial Design Department together wrote the following educational objectives:

- Apply expertise to external organizations as artisans and industrial groups.
- Involve teachers and students to work together in real problems.
- Generate students’ participation in social programs, a semester-long paid work in business or industry and achievement of their degree.

Two teachers have studied for several years the growing and processing of bamboo used in building, as well as in furniture and numerous objects in the handicraft sector in the states of Puebla and Veracruz. Also studied problems that artisans overcome to achieve quality products to be offered domestically and internationally.

In this background a team worked in the multidisciplinary research and technological intervention project called *Equipment for Bamboo Craft Workshops*, leaded by two professors, M.I.D. Carlos Chávez Aguilera specialized in Technology of Materials and Processes and DI Ma. Fernanda Gutiérrez Torres in the field of Ergonomics, with other teachers and students of Industrial Design Program.

2. OBJECTIVES

Improve working conditions of artisans of workshops in that zone; speed manufacturing and increase quality of bamboo products, considering user centered design, environmentally and social responsible design.

Significant learning experience is created in design courses since the students are engaged in research projects with social approach.

3. DELIMITATION

This paper is part of a research and technological intervention project aimed to work with bamboo handicraft sector, which includes primary processes as presevation treatment on green bamboos, by the Boucherie modified technique and drying with solar energy.

Figure 1.
Preservation of bamboo poles by modified Boucherie technique.

Figure 2
Fixing the clamps embracing the culm end.

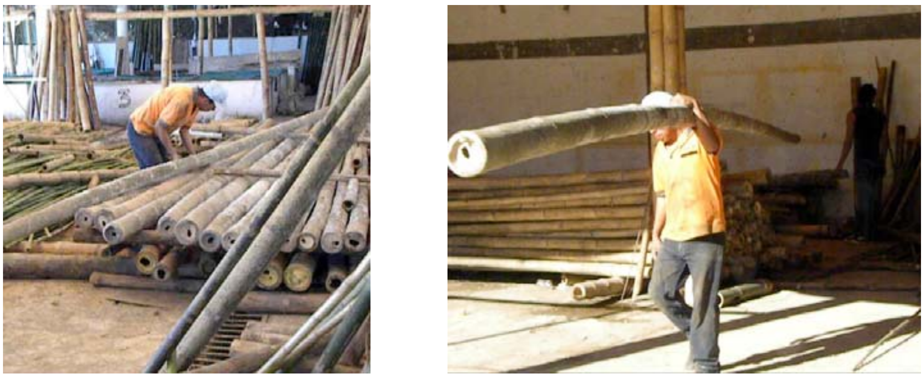


Figure 3.
Handling bamboo poles in the shed.

Figure 4.
Handling bamboo poles to dry in the sun.

4. METHODOLOGY

- Documentary and field research to understand the background of craft workshops in the area.
- Ergonomic analysis of activities led by artisans, using still photography and video recording.
- User-Centered Design. Problem identification, definition of technical and ergonomic requirements: safe and comfortable work for the user, possibility of construction at the site with local workforce and affordable costs to small workshops. Use of biodegradable, recyclable and recycled local materials is desirable.
- Development of the proposition listening to users' needs.
- Assessment with testing prototypes at Laboratories of FES Aragón.

5. RESULTS

Bamboo preservation and drying bamboo poles equipment was designed with the user in mind. Testing models and prototypes were made and installed in laboratories of FES Aragón. One student won the award "Gustavo Baz Prada" for best social service aimed to the community and other student received honorable mention for the project called "Drying Solar Kiln for Bamboo Poles".

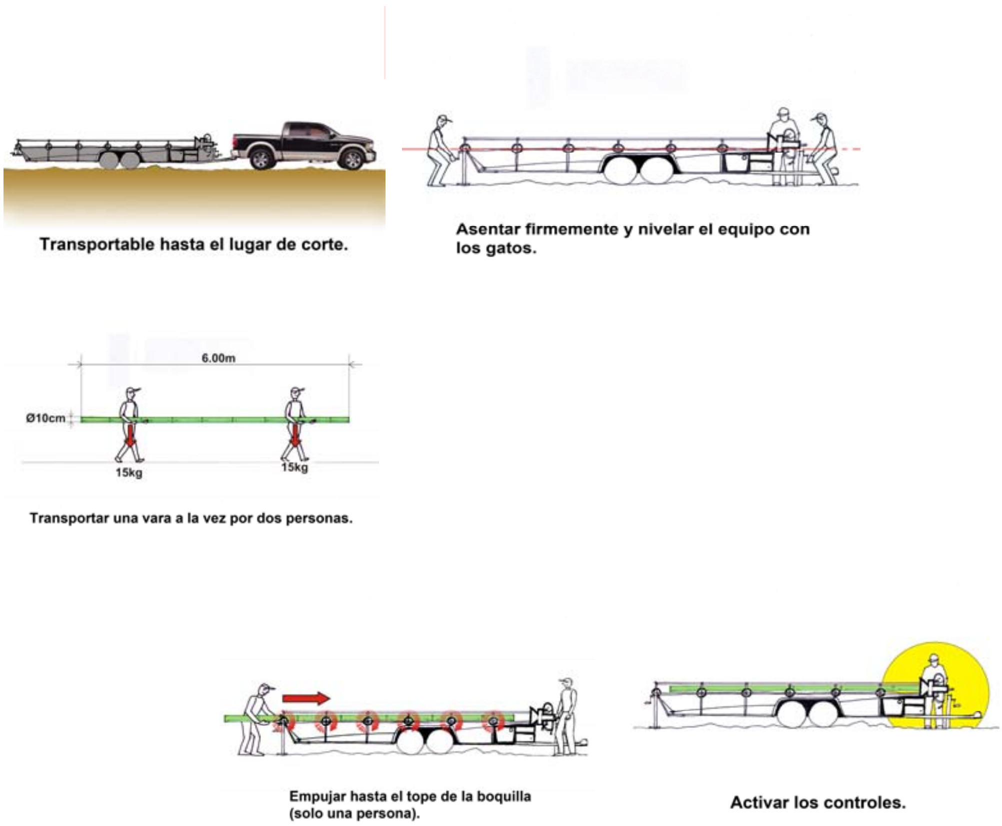
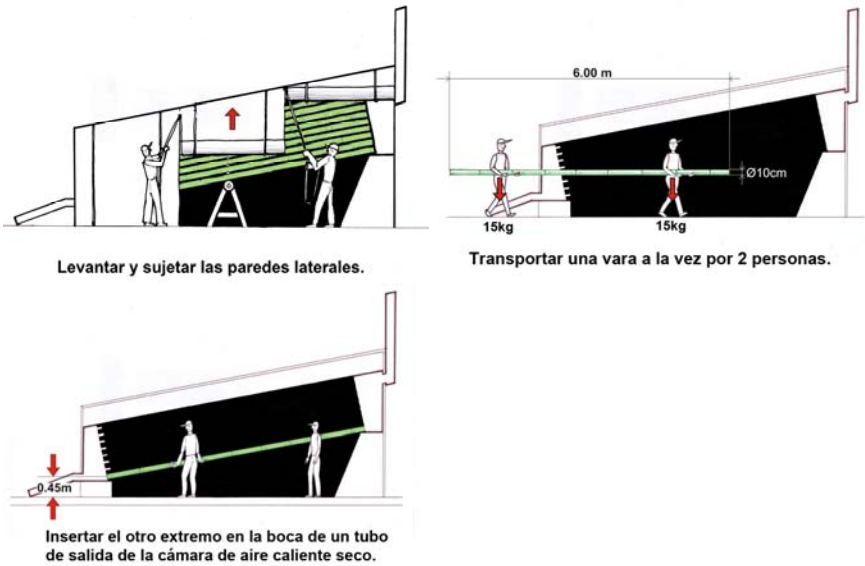


Figure 5.
Different activities to work on equipment designed for bamboo preservation by sBoucherie modified technique.



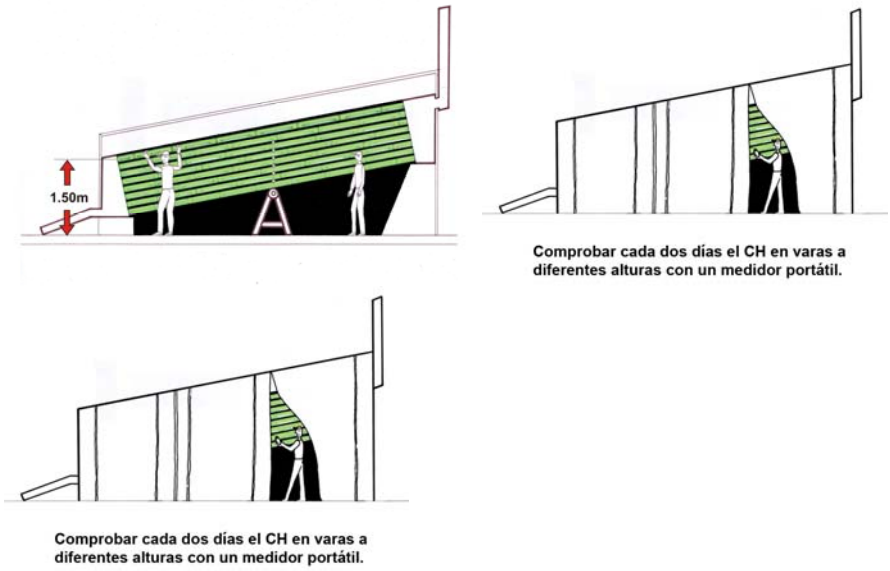


Figure 6.
Handling bamboo poles to be placed inside solar dryer.

6. CONCLUSIONS

We underline the importance of having applied ergonomics with a social emphasis on both design projects and linking academic goals with the technical and social needs of some artisan groups that work with bamboo.

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A STRATEGY FOR THE EVALUATION OF WEB SITES BASED ON USABILITY THEORY PRINCIPLES

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RESUMEN: En el estudio de la interacción humano-computadora, la usabilidad se refiere a un atributo de calidad que mideque tan fácil es utilizar una interfaz de usuario. La palabra "usabilidad" también se refiere a métodos para mejorar la facilidad de uso durante el proceso de diseño(Nielsen, 2003).

La evaluación de la usabilidad es el proceso mediante el cual se determina que tan usable es una interfaz de usuario, de esta forma es recomendable que dicha evaluación se lleve al cabo al menos una vez cuando un sistema es implementado o cuando este ha sufrido alguna modificación en su interfaz de usuario.

La implementación de sistemas usables tiene un impacto positivo dentro y fuera de la organización. Dentro de la organización contribuyen a mejorar los procesos internos (Matera, Rizzo & Carughi, 2006) y a incrementar la productividad organizacional (Dubey & Rana, 2011). Fuera de la organización ayuda a fomentar una percepción positiva de los clientes hacia la organización (Bolchini, Garzotto & Sorce, 2009).

En este trabajo de investigación se presenta una propuesta estratégica que a partir del uso y del aprovechamiento de las ventajas que ofrecen los métodos de cuestionarios y evaluación heurística permite llevar a cabola evaluación de la usabilidad de un determinado sitio Web obteniendo como resultado un reporte con un mayor índice de descubrimiento de problemas de usabilidad que el que se obtendría al utilizar alguno de los métodos ya existentes por separado.

Las secciones que conforman este artículo son: Introducción, Objetivo, Metodología, Resultados, Conclusiones y Referencias.

Palabras claves: Usabilidad Web, Pruebas de Usabilidad, Interacción Humano-Computadora

ABSTRACT: In human-computer interaction, usability is a quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process(Nielsen, 2003).

The evaluation of usability is the process in which it is determined, how usable a user interface is, and is recommended that said evaluation takes place at least once when a system is implemented for the first time or when its user interface has undergone a modification.

The implementation of usable systems has a positive impact in and out of the organization. Inside the organization they contribute to internal process improvement (Matera, Rizzo &Carughi, 2006) and to increase organizational productivity (Dubey&Rana, 2011). Out of the organization, they help foster a positive perception towards the organization's clients (Bolchini, Garzotto&Sorce, 2009).

In this investigation a strategic proposal is presented, in which the user can realize the advantages of using questionnaires and heuristic evaluation while evaluating the usability of a determined Web site. A report with a higher quantity of usability problems is the result of using the proposed methodinstead of using other existing methods.

The sections that conform this article are: Introduction, Objective, Methodology, Results, Conclusions and References.

Keywords: Web Usability, Usability Testing, Human-Computer Interaction

Relevanceto ergonomics: Evaluation of the usability of a system is the starting point when you want to improve the human-computer interaction. Currently, there are some methods that allow to carry out the evaluation of usability; however, most of these methods are focused on very specific problems of usability.
The strategic proposal presented in this research makes use of two of the main usability methods in order to obtain a more detailed and complete report of the usability problems in the evaluated web site.

1. INTRODUCTION

The WWW is one of the technologies that managed to advance and penetrate the most into daily life of people. According to INEGI (2012) data, at the end of 2012, Mexico had little more than 45 million internet users, a number that represents a growth of almost 900% since year 2000. Unfortunately, due to the diversity of methodologies employed for Web design, many of them are not created according to user's needs. As a result of this, some Web pages make difficult to obtain useful information from them (Thomas & Fischer, 1997). Franzoni and Gervasi(2009)say that in most cases, when a Web site does not comply quickly with user's expectations, visitors end up leaving the site in a term not greater than 35 seconds.

In the past 20 years, various research carried out in the field of human-computer interaction has focused on making interactive systems more user-friendly (Bridger, 2003), opening the door to the deployment of Web usability as a field of study.

Initially, references to usability were associated with the term "easy to use", however, since some user interface designers have considered that by definition, the term "easy to use" is inappropriate, this term has been replaced by the usability concept (Nielsen, 1993).

A definition widely accepted for this concept is provided by the ISO-9241-11 (1998) standard, which defines usability is as "the degree in which a product can be used by a specific user group to achieve certain specific objectives with effectiveness, efficiency and satisfaction in a context of specific use". On the other hand, Nielsen (2003) defines usability as "an attribute of quality that measures how much user interfaces are easy to use.

The importance of the study of Web usability is related to ever changing users, therefore, it is necessary to understand how people use web sites, because some of them have more visitors than others, and if the use experience of users is satisfactory [8]. For this reasons, this document presents a strategy to assess the usability of a web site based on a set of principles derived from two of the most commonly used usability methodologies (Baravalle, 2003).

Some of the best documented benefits involving the implementation of a usable Web site are lower costs, an increase in sales and income, a significant improvement in organizational processes and lower costs and time required for the development and maintenance of the site (Matera, Carughi & Rizzo , 2006).

In addition to the above, the correct application of Web usability has proven to be an efficient strategy to improve organizational productivity by reducing the time required to train a web administrator and to document processes (Dubey & Rana, 2011).

Bolchini, Garzotto & Sorce (2009) emphasize that the usability of a website is linked to the perception that users have of the organization that owns the site. For example, if a user has a bad impression of a web site, he unconsciously associates that bad impression with the image of the organization.As a result of this, it is important to develop or redesign a organizational Web site assessing its usability prior to implementing the changes.

At present, there are a lot of methods, techniques and tools to address Web usability issues. Although several taxonomies have been proposed to classify the different methods of usability evaluation, they can be classified broadly into two types: empirical or testing and inspection methods (Fernandez , Insfran , & Abrahão , 2011).

The main difference between empirical methods and inspection methods is that while the former require user participation to be carried out, inspection methods are performed by experts and not require user´s participation to be executed. Table 1 shows a brief summary of some of the most used usability evaluation methods.

Each of the methods listed in Table 1 have their advantages and disadvantages, however, the proposal in this research is based on the use of two of the methods used globally to assess the usability, obtaining as a result the rate of discovery of usability problems superior to that obtained using either method separately, as a result of the analysis obtained from implementing the proposal. The proposal used are the heuristic evaluation and the questionnaire method.

Fichter (2004)states that the two different existing approaches to Web usability assessment do not contradict each other, they complement each other when used together and allow a more accurate and detailed report of a site´s usability problems.

2. OBJECTIVE

To deploy a strategy that will allow the assessment of a particular web site using principles of usability in order to identify clear and timely the existence of usability problems.

Table 1 . Usability evaluation methods comparison (Holzinger, 2005)

	Métodos de inspección			Métodos de pruebas		
	Evaluación heurística	Recorrido cognitivo	Análisis de acciones	Pensando en voz alta	Observaciones de campo	Cuestionarios
Se aplica en la fase:	Todas	Todas	Diseño	Diseño	Pruebas finales	Todas
Tiempo requerido	Bajo	Medio	Alto	Alto	Medio	Bajo
Usuarios requeridos	Ninguno	Ninguno	Ninguno	3+	20+	30+
Evaluadores requeridos	3+	3+	1-2	1	1+	1
Equipo requerido	Bajo	Bajo	Bajo	Alto	Medio	Bajo
Experiencia requerida	Medio	Alto	Alto	Medio	Alto	Bajo
Intrusivo	No	No	No	Si	Si	No
COMPARACIÓN DE LOS MÉTODOS DE EVALUACIÓN DE USABILIDAD						

3. METHODOLOGY

In most cases, when evaluating the usability of a Web site researchers do not use more than one method, due to the amount of human and financial resources required; however, the methodological proposal below focuses on the optimization of available resources. The methodology is divided into two phases to be deployed simultaneously using questionnaires and heuristic evaluation.

3.1. Questionnaire method

If someone wants to know what a person thinks of a website, there is no better way to find out than simply questioning. Young and Stanton (2004) state that the two main advantages of the use of questionnaire method are the high degree of validity of the results obtained and the flexibility of the method to be adapted according to the situation and context of use.

Several researchers have developed questionnaires to measure the usability of a Web site (Tullis & Stetson, 2004), however, derived from its highly technical language and the presence of some extremely difficult items to understand and / or evaluate users, it is not feasible to use one of these previous questionnaires.For this reason, and as a result of a literature review, a new questionnaire was developed (Table 2), using eight reactives that must be evaluated by the user using a Likert seven-point scale (Lewis, Polson, Wharton, & Rieman, 1990). Table 2 is divided into two columns. The left column shows the statement that the user must assess and the right column the component of usability that this statement evaluates.

Table 2. Questionnaire applied to evaluate usability.

Reactive	Usability Component
It's easy to learn to use this website	Learning easyness
Use of this website is easy.	Learning easyness
I can find the information I need quickly	Efficiency
Information in this Web site is well organized	Efficiency
Overall, I am satisfied with this website	Satisfaction
I would like to use this website more frequently	Satisfaction
It's easy to remember how to search for information within the “apoyos” section of this website	Memorability
The website signals me when an error has occurred and the information provided is useful enough	Errors

In order to have a better use of time, questionnaires were applied using a Web survey. This method allowed to involve actual users of the site. The final design of the questionnaire is shown in Figure 1.

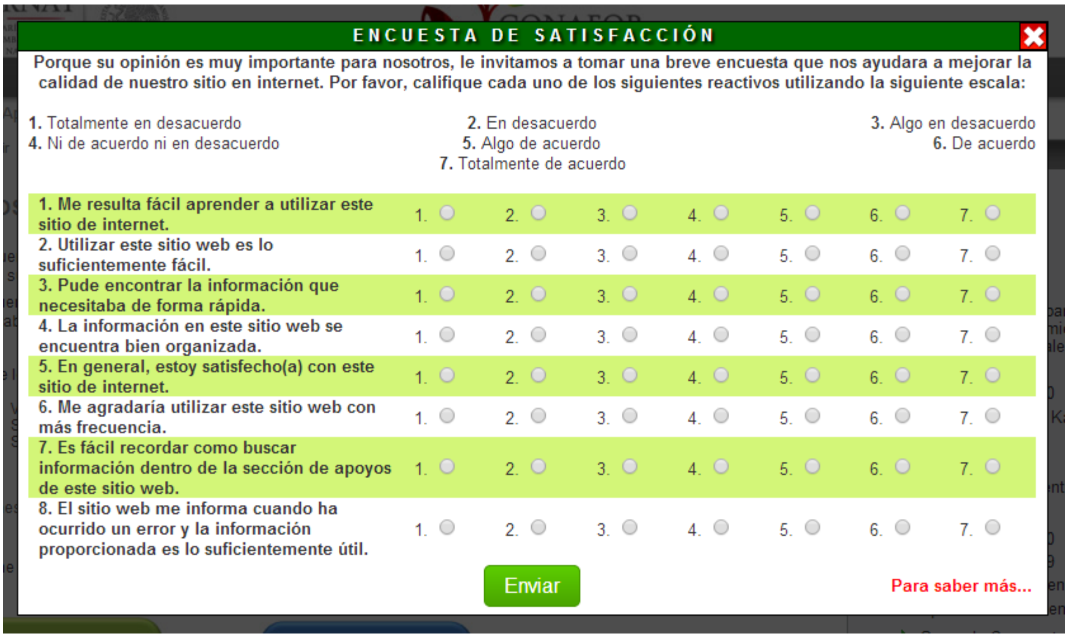

Figure 1. Web questionnaire used on the research.

Some of the advantages of modal windows in Web surveys are a that the user does not have to make great effort to answer the questionnaire, it is a non-intrusive method, also by requesting participation using a modal window which overlaps with the content on the site, user has the feeling that participation in the study is an option and not an obligation, and thus, users involved answering the questionnaire do it voluntarily and consciously.

Studies carried out by Law and Hvannberg (2004) and Schmettow (2012)point out that the results obtained by applying questionnaires to be valid there must be at least 56 participants. According to these authors, conducting a study with 56 or more participants will result in discovery of a rate of discovery in usability problems higher than 0.8.

3.2. Heuristic evaluation.

One of the strengths of the proposal presented in this research is that while data collection is done through the Web survey, heuristic evaluation can be made simultaneously, resulting in a better use of time.

Heuristic evaluation assesses whether the elements of the user interface of a Web site correspond to established usability principles from a checklist. Andreu- Vall and Mark (2012) explain that this technique is the best in terms of cost-benefit because it can detect a large number of usability problems on Web sites at a lower cost.

To perform heuristic evaluation, the tool developed by Andreu- Vall and Mark (2012) and usability principles of Nielsen (1995) were used. Nielsen´s usability principles are still valid and their acceptance within the scientific community is very high.

The instrument created by Andreu- Vall and Mark (2012) is shown in Table 3. Essentially it is a list of indicators drawn in question form, a second column indicate the frequency of the error, the impact associated to each indicator, and a fourth column indicating the severity of the error.

Table 3. Heuristic evaluation tool.(Andreu-Vall & Marcos, 2012)

Web site indicator	Error frequency	Error impact	Severity
Does the system keeps the user informed about what is happening?Does the system provides feedback of what is happening in a reasonable time?	0	1	0 = No error
Is there a relationship between the system and the real world? Does the information appear in a natural and logical order? Does the system uses a language familiar to users ?	1	1	1 = very slight error
Does the system provide a clear and easy to undo or redo function?	2	1	2 = slight error
Does the system follows established conventions?	0	2	0 = No error
Does the system have a design that prevents the occurrence of errors?	1	2	2 = slight error
Does the system have always visible objects, actions and options? Does the user remember the information provided? Does the system have visible on how to use instructions?	2	2	4 = Prioritary
Does the system can be adapted by the user to frequent use?	0	3	0 = No error
Do dialogue boxes display information which is irrelevant or rarely used by users?	1	3	3 = Medium error
Does the system allow users to diagnose and recover from errors? Do error messages provided by the system presented in clear and simple language? The problem is stated precisely?	2	3	6 = Urgent

The system has a documentation system? Is the system documentation well organized and well developed?	0	1	0 = No error

In this case, the list of indicators in the form of written questions was taken from Nielsen´s (1995) 10 usability principles.The frequency of an error can be 0 (never), 1 (sometimes) and 2 (often or always). The impact associated with each indicator can have values from 1 (low), 2 (medium) or 3 (high). Calculation of the error´s rate severity is performed by multiplying the frequency value by the value of the impact indicator. Finally, the source of the indicator is used to point the usability principle origin. However, since the application of this method accounts only for Nielsen usability principles (1995), the last column has been deleted.

When all the questions have been answered in Table 3 , the " Severity " column indicates a numeric value between 0 and 6 which evaluate the worst usability rated indicators and therefore requiring immediate attention. In the "Severity" column of Table 3 is shown the meaning of each value that might arise in this column at the end of the evaluation.

4. RESULTS

The results obtained from the implementation of this strategic proposal on a web site are presented. The results are divided into two parts, firstly the survey results and then results obtained from heuristic evaluation.

4.1 Results of the questionnaire method

The data obtained from the Web application questionnaires were retrieved from the database in which is stored and were interpreted using descriptive statistics.

A total of 85 participants completed the Web questionnaire assessing each of the elements that were presented (Figure 1). Table 4 shows the average score for each of the reactives shown in Figure 1. It is important to remember that the minimum value that a reactive could receive was 1 and the maximum value of 7, where 1 meant strongly disagree and 7 strongly agree, on a Likert scale.

Table 4. Mean ratings per reactive.

R1	R2	R3	R4	R5	R6	R7	R8
4.8	5.1	3.7	3.0	5.2	5.5	2.9	5.8

Taking as a starting point tables 2 and 4 , it can be said that the element of Web usability worst valued by users on the Web site is studied followed memorability efficiency . In general, users said they somewhat disagree when asked about the performance of Web usability element which measures how easy a website and its operation can be remembered when spending time without interacting with the system. The same was true when asked about the efficiency with which can perform tasks on the site since the first time I interacted with this.

In contrast, the highest rated item by users who participated in the surveys was that which indicates how many mistakes are made in the interaction with the Web site and how easy it is to recover from such errors once they have committed.
Table 5 shows the mean scores each of the 85 users gave the Web site is. One aspect to consider in this table is that the minimum value assigned by a user score was 2.9 and the highest score 5.5. The overall site taking into account all shares was 4.5 , a very low value considering that the maximum possible score was 7.

Table 5. Medias de calificaciones por participante

Num.	Mean	Num.	Mean	Num.	Mean	Num.	Mean	Num.	Mean
1	4.4	**18**	4.6	**35**	4.1	**52**	4.6	**69**	5.0
2	4.3	**19**	5.5	**36**	4.1	**53**	3.3	**70**	4.4
3	5.3	**20**	4.4	**37**	4.3	**54**	4.1	**71**	5.4
4	4.4	**21**	4.3	**38**	3.9	**55**	4.6	**72**	4.9
5	5.1	**22**	5.0	**39**	4.1	**56**	4.4	**73**	4.5
6	4.4	**23**	4.9	**40**	4.4	**57**	4.5	**74**	3.8
7	4.0	**24**	4.5	**41**	4.1	**58**	4.5	**75**	4.0
8	4.8	**25**	4.0	**42**	4.5	**59**	4.1	**76**	4.6
9	4.9	**26**	5.3	**43**	4.9	**60**	4.3	**77**	4.9
10	5.1	**27**	4.8	**44**	3.8	**61**	4.8	**78**	4.3
11	4.8	**28**	2.9	**45**	4.8	**62**	4.9	**79**	5.0
12	5.5	**29**	4.0	**46**	5.0	**63**	4.9	**80**	4.5
13	4.5	**30**	4.5	**47**	4.1	**64**	3.8	**81**	5.0
14	4.6	**31**	4.3	**48**	4.4	**65**	3.8	**82**	4.8
15	5.0	**32**	3.8	**49**	3.9	**66**	4.3	**83**	4.4
16	4.9	**33**	4.9	**50**	4.5	**67**	4.0	**84**	5.5
17	3.8	**34**	3.9	**51**	5.0	**68**	5.0	**85**	5.3

4.2 Heuristic evaluation results

Unlike the method of questionnaires, the results of heuristic evaluation do not need data processingt for interpretation, because usability principles not present are clearly seen. In the "error impact" column of Table 6 an equal weight was assigned to each of the usability principles, then the "error rate" column with the corresponding value according to its compliance with the principle stated in the "indicators" column.

Table 6. Results obtained from the heuristic evaluation.

Web site usability indicator	Error frequency	Error impact	Severity
Does the system keeps the user informed about what is happening? Does the system provides feedback of what is happening in a reasonable time?	0	2	0
Is there a relationship between the system and the real world? Does the information appear in a natural and logical order ? Does the system uses a language familiar to users ?	0	2	0
¿El sistema ofrece de forma clara y de fácil acceso funciones de deshacer o rehacer? Does the system provide a clear and easy function to undo or redo actions?	1	2	2
Does the system respect conventional forms?	2	2	4
Does the system have a design that prevents the occurrence of errors ?	0	2	0
Does the system have always visible objects, actions and options? Does the user need to remember the information that is given on a part of the process to move forward? Does the system have visible instructions on how to use ?	2	2	4
Is the system adaptable by the user for frequent use?	2	2	4
Do the dialogues display information irrelevant or rarely used by users?	2	2	4
Does the system allow users to diagnose and recover from errors? Do error messages provided by the system are given in clear and simple language? The problem is stated precisely ?	0	2	0
¿EL Is the system documentation is well organized and well developed ?	2	2	4

According to the results of applying this method, the 10 principles of usability assessed in the Web site under study, five of them need to be addressed with priority. The principles not well implemented are:

1. Consistency and standards. Users have to assess whether different words, situations or actions mean the same thing. No standard conventions are followed.
2. Recognition rather than recall. The Web site does not minimize the user's memory load by making objects, actions and options visible. The system keeps no visible instructions nor these can be retrieved when required.
3. Flexibility and efficiency of use. The site does not let users customize frequent actions.
4. Aesthetic and minimalist design. The dialogue boxes and texts contain irrelevant or rarely needed information.
5. Help and documentation. The system has no documentation or help function for users.

4.3 Results Contrastation

The results of questionnaires reveal the existence of two major usability problems on the website, however, the method of heuristic evaluation found five problems of Web usability in the same site; the same problems that were not detected totally by the first method.
Both methods detected that the Web site blocked users from performing tasks efficiently, however, only the method of questionnaires signaled that the memorability attribute is not well implemented on the site. On the other hand, heuristic evaluation pointed four problems different to those detected by the questionnaire method.

5. CONCLUSIONS

Organizations that are concerned about maintaining a usable Web site there are a variety of methods to detect usability problems and thus be able to correct those problems. The methodological proposal combines the use of heuristic evaluation and questionnaires to measure the usability of a particular website and obtain results with a detection rate higher thanthose obtained by using any of the evaluation methods separately.

In a general form, the questionnaire method detected the absence of usable Web sites characteristics, while the heuristic evaluation method focuses on identifying problems caused by the absence of elements that every website should have (such as menus, help topics, information, symbols, buttons, etcetera). Nevertheless, the results of the two methods do not contradict each other but are complementary and used together they identify a greater number of usability problems.

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ANALYSIS OF A MANUFACTURING SYSTEM WHERE WORKS HANDICAPPED PEOPLE

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RESUMEN: El presente trabajo presenta un análisis de un sistema de manufactura donde se emplean personas con diferentes tipos de discapacidad. El propósito es el detectar áreas de oportunidad de mejora en elementos del sistema como el flujo de materiales, el manejo de los inventarios y la seguridad y ergonomía. Se presentan estudios de tiempos y la descripción de los materiales utilizados por una línea de productos. Las conclusiones se centran en las acciones de mejora que permitan una mejor integración de este personal a un sistema de manufactura con diseño para personas con necesidades especiales.

Palabras clave: Sistema de manufactura, discapacidad, discapacidad visual y motriz

Abstract: This paper presents an analysis of a manufacturing system where people with different types of disabilities are employed. The purpose is to identify areas of opportunity for improvement in system elements such as material flow, inventory management and safety and ergonomics. Time study and description of the materials used in a product line are presented. The conclusions focus on the improvement actions that allow a better integration of this peoplein a manufacturing system design for people with special needs.

Keywords: Manufacturing system, disabilities, visual and motor impairment.

Relevance to ergonomics. One of the pure concepts of ergonomics comes from one of the definitions; fitting the task to the people. For this project, the purpose is analyze what kind of improvements need to be done to fit mostly of tasks to people with some disability, for instance, tactile design for inventory management and redesign workstations for a better work posture.

1.- Introduction

Handicapped people has been, in certain way, ignored when a system for manufacturing goods is designed, especially in countries in development. Mostly oh the initiatives deals with integration and acceptance to social duties.Momm and Geicker (1998 in the ILO Encyclopedia of occupational health and safety) refers about how recently there has been some efforts to describe disability as the difficult in perform some types of function, thus a disabled person could be defined as a people which performing a task could be affected by the disability. It´s no easy to design for handicapped people due the diversity of cases and characteristics that this people deal with.

Integrating handicapped people to work systems has been treated from anthropometrics, Lucero et al (2012) shows anthropometric data from Mexican population for adult wheelchairs users with the expectance of a possible use of data on the workstation design on a future. On the same way, Sandoval and De la Vega (2003), refers to an integration using concepts from the facilities design and anthropometrics considering some ergonomics concepts and the requirements for people on interiors work spaces.

Closer to analyze a work system, Venkatakrishna-Bhatt(2003), proposes a method to classify what kind of tasks can realize a disabled person according to the skills required. The methods present a matrix form crossing the nature of work and the production efficiency and assign people to certain task that could be performed. People participating on the study were handicapped as follows;

- Visually handicapped
- Hearing and speech handicapped
- Mentally retarded
- Orthopaedicallyhandicapped

Dimensioning the problem. According to results of surveys conducted in the 2010 census by the National Institute of Statistics, Geography and Informatics (INEGI), show that there are about 5 million 739 thousand 270 people with disabilities in Mexico, which corresponds to 5.1% of the total population. Regarding the city of Hermosillo Sonora, 5000 355 people living with these features, according to records of the State Council for the Social Integration of Persons with Disabilities. With this information we have realized that the current offer of employment for people with disabilities is relatively low, the actual access to them is a small segment of the population, are hampered because their requirements, policies, discrimination etc.

Most people seem to know what a disabled person and is sure she could recognize an individual as disabled, it is known that certain health lends itself to be referred to disability. However, it is not so easy to establish what exactly does the term disability. A common view is that, "having a disability determines that an individual is less able to perform a number of activities" which is wrong because there are different ways to do one activity, the problem is in order to properly adapt to each type of disabilities, Momm and Geicker (1998).

Thus in the exhaustive search for engineering applications in manufacturing processes for people with a physical or visual disability, we note that most of the offer, with respect to this product is about, but not processes or jobs within the industry for them. Manufacturing is seriously inadequate for these people, hence the motivation arises to carry out this project.

In recent years, public policies for people with disabilities have led to their integration into the production area. To this end, who are responsible for implementing training and selective placement takes into account the most appropriate work activities, based on the skills, attitudes and abilities of individuals with disabilities. Open the labor market to the disabled population presents a challenge that must be assumed in all sectors of society.

During the launch of the Internet portal "DISCAPACINET" mentioned that unfortunately people with disabilities have been marginalized since ancient times, the same company for a long time has made the world believe that people with disabilities are people without value, and unable to develop a critical consciousness. Ibarra (2005).

Nowak (1994), stated that global statistics show a significant increase, as the number of people with disabilities are concerned, which will lead to great disturbance in the demographic distribution and serious problems in many countries. That is why in 1984, the World Health Organization, working with the Global Programme of Activities for the Benefit of Persons with Disabilities thought in solving problems related to disability, and made a special emphasis on prevention, rehabilitation and equal opportunities for these people. This program has involved different fields of study, including human, medical, biological and technical disciplines related to disability.

In recent years, public policies for people with disabilities have led to their integration into the production environment. To achieve this, those who are responsible for implementing training programs and selective placement takes into account the most appropriate work activities , based on the skills, attitudes and abilities of individuals with disabilities.

Open the labor market to the disabled population represents a challenge that must be assumed in all sectors of society, as there are few jobs that meet the specific requirements in its processes to suit the special characteristics of these people, because depending on the type of disability depend on the activities that they can perform within a workstation in the labor sector.

Hence the need to design a manufacturing system that is suitable for people with physical or visual disabilities to serve as a watershed for improved job security for these people.

2. Method

For this project, the analysis were in a workshop that manufactures some cleaning products such diverse types of mops and brooms and commercialize some cleaning chemical products. People employed presents some of the follow disabilities;

- Motor impairment: The difficulty of a person in the management and control of your body and which by its nature requires the implementation of various adjustments so you can function in the various contexts in which it participates. A person with Motor Disability is considered when for various reasons (physical-muscular, motor nerves and brain) affected his ability to control and manage the movement, balance, coordination and posture of the various parts of the body. (INEGI, 2010)
- Visual Impairment: The total absence of visual perception to achieve or perceive light without defining what is or where it comes from. There is talk of visual impairment when there is a significant decrease in visual acuity even with the use of glasses or a significant decrease in the visual field. (INEGI, 2010).

First at all, is necessary to define a manufacturing system for all possible articles being manufactured there. Basically they produce mops, so, the system will be focused on it, but, also produces brooms, and other sell other products.
There are a coincidence on almost all the process for all the mops, differentiates itself only by the weight and by the type of thread. The table 2.1 shows the lineup of basic products.

Once materials has been classified,the next step is describe all the tasks for assembly the mop and check if a time study does exist. In negative answer, will be necessary made it. Time study allows to make a comparative about the physical capacities from motor impaired people. They are the operators assigned to manufacturing the mops. A safety and ergonomics studies will be necessary too due to the characteristics of the materials, some are very flammables, and due to the workstation design, sometasks could be improve with some ergonomic principles. Also the inventories for raw material and for finished goodswill be reviewed. In a first look, there some chances for improve, especially due to that person selling direct to public is visual impairment and he walk to the racks of finished goods.

Table 2.1. Bill of materials for the mop lineup.

Thread	Weight	Code	Materials	% Production
Candlewick	1 Kg	P1K	Mota 65 cm, bastón 1.2m, forro blanco	3%
	750 gr	P7G	Mota 60 cm, bastón 1.2m, forro blanco	4%
	500 gr	P5G	Mota 55 cm, bastón 1.2m, forro blanco	18%
	350 gr	P3G	Mota 50 cm, bastón 1.2m, forro blanco	9%
Softthread	1 Kg	S1K	Mota 65 cm, bastón 1.2m, forro blanco	3%
	750 gr	S7G	Mota 60 cm, bastón 1.2m, forro blanco	4%
	500 gr	S5G	Mota 55 cm, bastón 1.2m, forro verde	14%

	350 gr	S3G	Mota 50 cm, bastón 1.2m, forro verde	5%
Yarn	500 gr	H5G	Mota 55 cm, bastón 1.2m, forro verde	8%
	350 gr	H3G	Mota 50 cm, bastón 1.2m, forro verde	5%
Black thread	750 gr	N7G	Mota 55 cm, bastón 1.2m, forro blanco	12%
	350 gr	N3G	Mota 50 cm, bastón 1.2m, forro blanco	2%
Magitel	500 gr	M5G	Mota 50 cm, bastón 1.2m, forro blanco	9%
	220 gr	M2G	Mota 40 cm, bastón 1.2m, forro blanco	4%
% Total				100%

Next, a description of the process and normalized times with stopwatch and predetermined timesis condensed are shown on tables 2.2 and 2.3 respectively.

Table 2.2 Process description.

Station	Description	Products
1	Cover the handle cane	All
2	Measure, cut, weigh and store.	All
3	Assemble mop	All
4	Styling, labeling, packaging and cutting	ALL

The normalized time were obtained from two methods just to compare if disability could be related to achieve a production standard. There is not enough data to compare results statistically, but it seems to be very similar. Predetermined time was made just for the candlewick product, but it could be assumed the same trend for the other products.

Table 2.3 Normalized times

Thread	Weight	Code	Time study (sec)	Predetermined (sec)
Candlewick	1 Kg	P1K	500.17	512.25
	750 gr	P7G	499.33	511.60
	500 gr	P5G	466.77	471.49
	350 gr	P3G	484.01	470.98
Softthread	1 Kg	S1K	513.46	
	750 gr	S7G	499.33	
	500 gr	S5G	466.77	
	350 gr	S3G	484.01	
Yarn	500 gr	H5G	466.77	
	350 gr	H3G	484.01	
Black thread	750 gr	N7G	577.62	
Magitel	500 gr	M5G	484.01	

Essentially all products shares all process, so, time study is shown in generalized terms.

All materials are storage in tree warehouses, almost without racks, just lying in the floor or in boxes or improvised containers. Each warehouse has been determined for certain materials or finished goods.

There is so much to improve, on this first stage just is the analysis the purpose, the advance has been in understanding the design, the process and the system. Now, it is necessary to be focused in redesign the manufacturing system. Once the time study show the time for all the tasks and demand a production mix has been calculated, next step could be stabilize material flow and from here redesign warehouses, containers and racks. The flow will begin in every workstation, according to the production mix, the proposal is to implement a pull system, balancing production from the weekly demand to a daily demand. The pull system will provide the needs for the number and size of containers. The containers flowing to the production area will determinate how much raw material needs to be storage and will allow to establish an acquisition policy, even when supplies could not be standardized.

Next is redesign the final good storage, especially considering the impairment of the salesperson and manager. One alternative is adopting concepts from haptic design and redesign containers with an specific geographic location inside de warehouse room and labeled in certain way that allows be detected on a tactile way in what container is located determined product. The flows to the final storage should be according to the production mix trying to minimize the number of containers. A good strategy will be not allow any material in the floor, instead any material will be placed on a designed container or rack.

Safety is a major concern, inside the producing place is a boiling water device used to set the cover to the cane. Water is heating using gas and there is a lot of flammable materials everywhere, so there is an urgent need to improve safety, more than ergonomics, even when there some workstations practically virtual. A five “S” program could be very welcoming.

There are some tasks requiring cutting the threads, by now it is being done by hand, using a knife and without a pattern. In particular, this workstation is just a chair, materials are placed on knees, no table no cutting device. Furthermore, the operator is visual impairment, so all the task is made in a tactile way.

The part of process where is coiling a wire to tie the threads to the cane is a rustically machine. The operator is motor impairment, part of the process could be mechanized and operation control could be arranged in a better way.

There is a lot of needs for sure and perhaps there is not enough budget to redesign the manufacturing and safety systems, so, one of the purposes of the project should be document every proposal, every part of the process and support the management on searching of financing, targeting government founds, noticing the relevance that, this production system is generating some jobs and integrating disabled people into a productive environment.

3. Conclusions.

Partially advance on this project has been useful in many ways, first at all getting conciseness about needs of disabled people and how they needs to be integrated into productive systems improving morale and self-value. The time study lead to conclude that, for the mop manufacturing process, there is not a noticeable difference between stopwatch times, normalized, and the predetermined times, assuming that there is not necessary change production rates. Improving the system come from the materials and inventory management, there is a major chance here, materials has a direct cost affecting productivity and profits.

Safety is a big issue, there is a latent risk due to the nature of the materials, all are flammable and one operation requires of fire. Ergonomics is a chance too, providing the elements to redesign workstations.

Final project results will show how engineering can be humanized, providing knowledge in order to redesign a manufacturing system considering that impaired people generate special needs, and manufacturing systems designers can solve it. It is a great cause. Hope to help to get the funds.

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CRUTCHES AXILLARY... A REAL PROBLEM

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Resumen: Las muletas son unas de las herramientas más utilizadas para rehabilitación en miembros pélvicos. Generalmente, se ajustan a la altura de la cadera, sirven como soporte del cuerpo y reducen la carga en una sola pierna. Ahora bien, el uso y dependencia de un par de muletas estará en todo momento relacionada con la gravedad en las extremidades pélvicas debido a luxaciones, fracturas, o daños físicos permanentes, resultado de enfermedades congénitas o accidentes. Aunado a ello se tiene que, aún y cuando el uso de muletas axilares puede ser por un corto tiempo, las personas suelen desarrollar problemas como son: dolor en los ligamentos de la muñeca ocasionado por los impactos o malas posturas que fuerzan la posición natural de la articulación; así como la disfunción del nervio axial, daño que lleva a la pérdida del movimiento o de la sensibilidad del hombro. Por tanto, se hace necesario abordar la problemática y con ello, establecer las bases para llevar a cabo el diseño de unas muletas ergonómicas.

Palabras clave: Diseño, Muletas, Lesión.

Summary: Crutches are one of the most used tools for lower limb rehabilitation. Generally conform to hip height, serve as support the body and reduce the load on one leg. However, the use and dependence on a pair of crutches at all times be related to the severity in the pelvic limbs due to dislocations, fractures, or permanent physical damage resulting from congenital diseases or accidents. Added to this must be, even if the use of axillary crutches may be for a short time, people often develop problems such as pain in the ligaments of the wrist caused by impacts or poor posture that force the natural position of the articulation, as well as axial dysfunction nerve damage leading to loss of movement or sensation of the shoulder. Therefore, it is necessary to tackle the problem and thereby lay the foundation for carrying out the design with ergonomic crutches.

Keywords: Design, Crutches, Injured.

Relevance to Ergonomics.- Throughout time, man has managed to give each product created rationality, a value and a certain way... spread the excitement of who conceptualized. In relation to this work, the industrial designer contributes in two ways, one, in the art of the artificial environment on the other, in this environment is fully habitable. And that's where lies with the relevance of ergonomics as a science that studies the relationship between man and his environment, can fully adapt to each other, making it currently one of the fundamental bases without fear of error, the most important in the design stage.

1.- INTRODUCTION

The issue of using crutches is controversial. On the one hand, is identified as necessary for the movement of people who are in rehabilitation element due to injury in their lower limbs and is a basic tool for people with a permanent atrophy. On the other side is an element that can be seen as a hindrance to the time of use because of its rigidity and size. However, in the final analysis, it can be considered as a basic tool for rehabilitation necessary to improve the quality of life of a disabled person.

According to the provisions of the World Health Organization, an injury is "any alteration of the biopsychosocial balance" and to our study, a lesion is an abnormal change in the morphology or structure of a body part (pelvic region), produced by an external or internal injury, where the cells undergo a deterioration that can cause two situations: a) the cell death b) cellular adaptation.

One way to support the rehabilitation treatment when the victim of trauma as it is mentioned above, is through the use of tools or aids, being the most helpful crutches by function, as these represent the best means to prevent atrophy and death of the affected cells, that is, when the skeletal muscle system loses its functionality due to the deterioration in mobility.

Now, say the Royal Spanish Language (2007) is understood as crutches to cane metal, wood or other material with the upper end adapted to place the underarm or forearm and hand, and which is used to support the people go when they have difficulty doing so.

In connection with this tool, its use dates back to prehistoric times, information known through drawings exist from ancient Egypt, where paintings, murals and hieroglyphs show that the ancient Egyptians suffered from the same ailments that we suffer today, also teaching some orthopedic practices of that time. It is important to note for the time that have been found in mummies splints, made of bamboo, cane, wood or bark and padded canvas. There is also evidence of the use of crutches, being the oldest witness an engraving in the year 2,830 BC at the entrance of the tomb of Hirkouf.

Figure 1. Image recorded on grave Hirkouf (2,830 BC)
http://www.ujaen.es/investiga/cts380/historia/civilizaciones_antiguas.htm

Similarly, they have been found evidence in several medical papyri of ancient Egypt, Ramesseum (1900 BC), Kahoum (1850 BC) and in the papyri found by Ebers, Hearts and Edwin Smith dating from 1600 BC, where coexist quotes about related skeletal muscle injury practices. Evidenced in such wise that these documents provide several case reports detailing fractures of limbs and poisonous bites. Being crutches or supports for the operation, the devices used by the pharaohs of ancient Egypt to help relocate. (Crutches, 2013).

It is noteworthy that since ancient times the basic design has not changed much crutches. The truth is that man has always used in one form or another to help move when an injury or illness makes walking difficult. Elaborating, it is possible that the original design departed from the moment that the man required external support after suffering an injury, and in such a situation, should it decide to employ cut tree branches, or use scrap wood whose dimension coincide with the bottom of his shoulder.

In the twentieth century, specifically in 1915 was I. M. & C. Briscoe who obtained *U.S. Patent 1156747 A*, of what might be called the first crutch, which introduced the ability to fit the dimensions of people. Then come various designs as can be seen in the following table.

Patent Crutches

No. Patent	Date of Presentation	Date of publication	Requestor	Title
US2453632	October 15, 1945	November 9, 1948	Lofstrand Jr Anders R	Crutch
US2516852	September 8, 1947	1950	Burry William C	Crutch
US2575681	March 23, 1948	November 20, 1951	Peters Jerry M	Crutch
US2788793	Apr 1 1955	April 16, 1957	Abbott Charles E	Crutch
US3272210	September 24, 1964	September 13, 1966	Otto Boruvka	Folding Telescopic Crutch
US3635233	March 19, 1970	January 18, 1972	Robertson Charles H	Cane and Crutch Foldable Construction
US3710807	November 18, 1971	January 16, 1973	Ferry C	Crutches
US4869280	July 1, 1988	September 26, 1989	Joseph Ewing	Folding Crutch

No. Patent	Date of Presentation	Date of publication	Requestor	Title
US6085766	September 25, 1998	July 11, 2000	Geary, John A.	Geary Convertible System Crutch
US7104271	October 10, 2003	September 12, 2006	Millennial Medical Equipment, LLC	Ergonomic Folding Crutch
US7222633	June 23, 2005	May 29, 2007	Werner Iii Philip Henry	Apparatus Ergonomic Support Staff
US7347215	September 14, 2006	March 25, 2008	Bernardo Birnbaum	Ergonomic Crutches
US7383848	May 15, 2006	June 10, 2008	Erwin Kowsky Gmbh & Co. Kg	Forearm Crutches to Walk
US7434592	October 7, 2004	October 14, 2008	Millennial Medical Equipment, LLC	Ergonomic Folding Crutch
US7712478	7 Apr 2008	May 11, 2010	Cowboylogic, Llc	Ergonomic Crutch
US7712479	October 15, 2007	May 11, 2010	University of South Florida	Folding Crutch
USH2138	September 7, 2001	January 3, 2006	The United States of America as represented by the Secretary of the Air Force	Forearm Crutch Custom Fit Composite Carbon Fiber
WO2011048028A1	October 15, 2010	April 28, 2011	Conall Stokes	Ergonomic Crutch "A Walking Aid"

Font: IFI Claims Services Patentes, U.S. (2013)

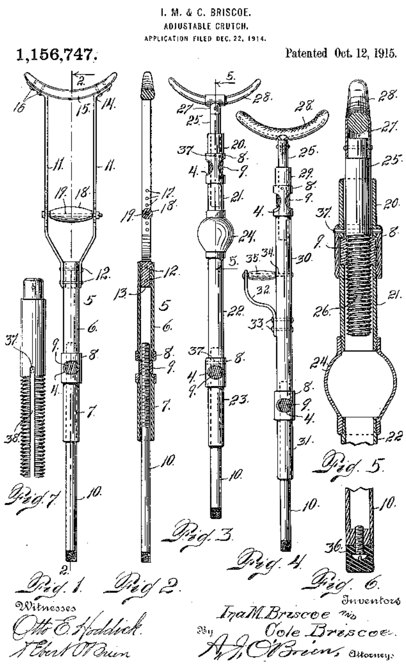

Figure 2. First recorded mapping crutch,
Patent U.S. 1156747 A

Despite the existence of a large number of axillary crutches, the commercial or recommended in the area of orthopedics appeared on the market around 1988 model, and it is the work of Thomas Fetterman, who contracted polio in the 1950´s when he was only 8 years old. It Fetterman noting the dangers associated with continued use of crutches under his arm, as slips, falls and possible damage to the nerves in the armpit area, dedicated his efforts to design crutches that could be used safely, using criteria that crutches require greater support area on the ground. (Ujuaen, 2013)

However, even if the models are varied, and that the design has endured for being "functional" is not quite ergonomic, since the use of axillary crutches despite being for some cases for a short time, has identified that the vast majority of people problems often develop as are pain in the ligaments of the wrist caused by impacts or poor posture that force the natural position of the joint, as well as dysfunction of the axial nerve damage leading a loss of movement or sensation of the shoulder. Which is why it is important to address this issue, looking slow postural complications and increase efficiency, especially considering that every person with a disability wants to be autonomous, and to that end, you must have the necessary tools to improve their lives without limiting or that they are uncomfortable.

2.- OBJECTIVE

Contents in a first step a documentary research on the problems caused by the use of axillary crutches, which will establish at a later stage, alternative solutions with a view to designing a ergonomic crutches to facilitate the progress of people with disabilities in lower limbs whose ages range between 10 and 50.

3.- METHODOLOGY

For this research project has been based on the design method of Bernd Löbach, which comprises the following six steps:

- Target.
- Phase 1 training: where most problematic analysis, human needs / products, history, market (function, structure, aesthetics and distribution) is developed.
- Phase 2 preparation: problem definition, requirements.
- Phase 3 Incubation sketches, drawings, models and tests.
- Phase 4 Lighting: functional model.
- Phase 5 verification: building plans, costs, lay out.

Moving on, usually using crutches is necessary after having suffered an injury or surgery at all or partiality of one or both lower extremities, specifically when it is necessary to have some help with balance and stability to walk.

Elaborating, various are the situations that make essential use of these devices, as in the case of a ligament injury in the knee or the presence of an amputation, which speaks of the separation of an individual or part thereof, a body extremity by trauma, also called avulsion or surgery. It is worth mentioning that amputation is a type of procedure performed for centuries with the goal of reducing disability, remove useless limbs and save lives, and that lower limb amputations are 7 or 8 times more frequent than those of a member superior, likewise due to immobility syndrome, which is the decreased ability to perform activities of daily living impairment of motor functions, or getting osteoarthritis, degenerative disease that causes erosion of cartilage in the joints. (The University of Chicago Medicine, 2013)

However, once it has been diagnosed using crutches, has been identified that being such a stranger to the body object it generates a reaction, both positive and negative, with the possibility to appear after a short interaction time permanent damage. At first you have an injury or dorsal spine, shoulder problems due to excessive use or wear of the muscles and joints and torn muscles surrounding the head of the shoulder joint (ROTATOR CUFFS), not to mention problems in the wrists and elbows by repetitive stress and muscle during the seizure of those items.

An injury is more pain that is located on the wrist, which usually tends to be associated with a hamstring injury, whose origin is in shock from impact or awkward postures which force the natural position of the joint, eventually causing a sprain.

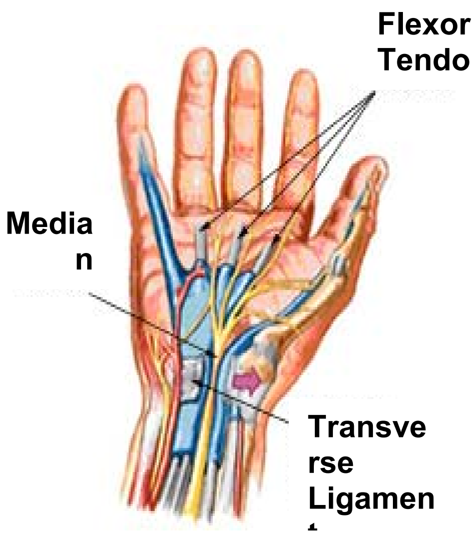

Figure 3. Ligaments of the wrist

http://ortopediaplus.blogspot.mx/2013/05/ortopedia-la-importancia-de-adquirir.html

Furthermore, a recurrent injury is dysfunction axial nerve injury leading to loss of movement or sensation of the shoulder, where the axillary nerve dysfunction is a form of peripheral neuropathy that occurs when there is damage to axillary nerve which supplies the deltoid shoulder muscle and the skin around it, a problem which is called as mono neuropathy. It is noteworthy that the damage may destroy the myelin sheath that covers the nerve or part of the neuron. (LARSSON, 2012)

As for the shape, while there have been changes in the configuration of the crutches, most have been based on a structure that has certain basic elements. In this regard, the Biomechanics Institute of Valencia (2009) has established that the essential elements that must be at least a crutch are:

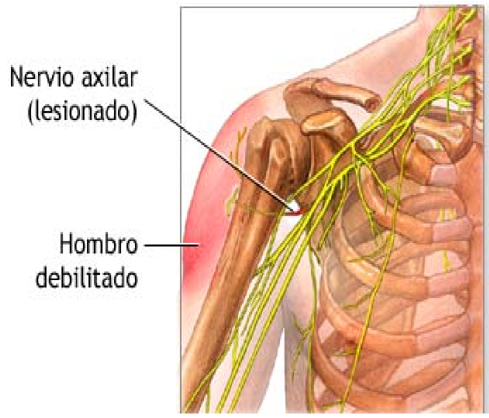

Figure 4. Axial nerve injury
http://www.clinicadam.com/imagenes-de-salud/8729.html

1. The crutch, which seeks to stabilize the trunk of the user. Ideally should be held between the inner arm and the anterior lateral aspect of the thorax. Typically, it is formed by the same material as the structure and is lined with a soft material such as foam, to avoid damage to the bearing region.
2. The arm element is usually composed of two bars passing through both ends of the handle. In some models is adjustable in length.
3. The handle, which should allow a comfortable and secure grip of the hand. The shape of the handle may be straight or anatomic. On some models the clamp arm and handle are a single integral piece.
4. The cane, whose aim is to transmit the load to the floor. Normally it is metal and adjustable length, allowing the adaptation of the crutch to the user's height.
5. The ferrule, responsible for cushioning the impact of the crutch with the ground and also serves as anti-skid system. Usually made of rubber.

So far the problem seems to be tiny, however, according to statistics from 2010, it was estimated that over one billion people living with disabilities, nearly 15% of the world population, a figure that far exceeded to estimates by the World Health Organization made in the early seventies of the last century. Providing a vision of the spirit, the National Institute of Statistics and Geography reported through the census in the year 2010 that exist in Mexico 5 million 739 thousand 270 people with disabilities, which speaks of a 5.1 % of the total population. Of these, 58.8 % have a physical disability, a situation that one way or another refers to the loss or limitation of a person to move, walk, keep a few positions around the body or a part thereof. And where is the total population, 49 % are male and 51% female. (INEGI, 2013), so a large number of people at national or international level in a given time need the support of crutches to resume its movement autonomously.

Finally, it should mention that, although generated design proposals relating to crutches, which at first seem to be the best solution to the problems that develops in an individual after use, has neglected the economic factor, given that the majority of the population does not have the ability to access models created in Madrid as Spain in 2011, a proposal was developed using carbon fiber and plastic, which to be the lightest with only 430 grams per unit and whose cost reached € 500. Or the Millennial

Junior crutches, which have a shock absorption system and assistant walking, or crutches Mobilegs calls, which give the option to be personalized and presented two variants, the universal ergonomic design and extra ultra estate, both with a comfortable arm support and pivot that rotates according to the movements of the body.

4.- RESULTS

After a review of both domestic and foreign existing products, we have identified that axillary crutches are used or recommended that forearm crutches and platform, so that the same type of crutches have in common the advantage of being adjusted according to the height of the user, be lightweight and provide a certain comfort in those parts that have direct contact with the human body. However, the disadvantages are found to be higher, as in the case of its low efficiency in traveling on public transport, direct or indirect discomfort generated by reducing the living space, instability or stairs to access to a wet surface, the cost, appearance and most importantly, damage to the bone structure.

Therefore, it was determined that for the second stage of this research, the new design of axillary crutches should at all times seek to avoid injury develop in parts of the human body that have direct contact or serve to provide support in pursuit of greater stability, use materials that make use of experience comfort, they can be customized easily by the user in turn, the possibility of being acquired by people of limited economic resources and enable the transfer comfortably in any type of transportation.

5.- CONCLUSIONS

Within the work of the industrial design is extremely important to conduct research through which they are identified social problems, problems that even when there are objects or systems of objects destined to play a role, they turn out to be not entirely efficient or that instead of benefit, are generating more problems. As you see the left anterior axillary crutches information regarding products conceptualized as support for the march.

In relation to this problem, its importance lies in the centrality rating on par physical and cognitive aspects of the person using crutches, since at the time to use them in one way or another requires attention span, memory and adaptation. And where on many occasions who design a product, forget or lose sight of the march after an accident or being unable carries an increased risk or even a risk to others.

It is a fact that the crutches are used to facilitate the ongoing increasing stability by broadening the base of support and reduce the load on one or both lower limbs, but it is also a fact that needs to be done in order to give the society a crutches that only provide support and where possible, reduce time of incapacity.

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http://www.ujaen.es/investiga/cts380/historia/civilizaciones_antiguas.htm#top

ALTERNATIVE DESIGN, BUILDING AND AUTOMATIZATION OF A GLOBE THERMOMETER

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Resumen. En este trabajo se diseñó y construyó un termómetro de globo, el cual fue automatizado a partir de una tarjeta de adquisición de datos tipo GPIB-usb y un software diseñado en Labview 2012. El prototipo se construyó de aluminio a partir del método de fundición, moldeo y soldadura, de tal manera que se obtuviera una geometría lo mas parecida a una esfera y la cual fue recubierta con una capa de negro de humo. Nuestro diseño se comparó con un termómetro comercial obteniendo una mayor precisión en la medición de la temperatura de globo, aunque por el tamaño de nuestro diseño se requiere un tiempo de estabilización mayor para iniciar el monitoreo de la temperatura.

Palabras clave: termómetro de globo, negro de humo, automatización

Abstract. In this paper we designed and built a globe thermometer, which was automatized by mean of data acquisition card of the type GPIB-usb and software developed in Labview 2012. The prototype was built of aluminum from the method of melting, molding and welding, to obtain the most similar geometry to a sphere, which was coated with a layer of carbon black. Our design was compared with a commercial thermometer and we obtaining a better accuracy in the measurement of globe temperature. However, by the size of our prototype, this requires a longer stabilization time to start monitoring the temperature.

Keywords: globe thermometer, carbon black,automatization.

1. INTRODUCTION

Use of hot or cold floors or roofs as heating and cooling system are getting increasingly popular. In these systems moreover, the radiative heat flux and radiant temperature gain greater importance that traditional systems. By this reason, is important to the proper implementation of measurement and control techniquesof these physical properties.

Globe thermometer is the most common radiant temperature measurement instrument. The methodologies so far suggested to quantifying the mean radiant temperature from de globe temperature, stand on the assumption that the temperature at the center of the globe is equal to the average temperature of the globe surface.

This project is focus in the design, build and automatize a prototype that is capable of measure the globe temperature. The globe temperature is necessary parameter to obtain the mean radiant temperature, with which it is possible quantify the thermal comfort in the room.

The idea for this project arose from the need to have a device to measure the mean radiant temperature by mean of globe temperature, with better accuracy and with an automatized system.

This work is divided in three parts: first, an analysis of the design of thermometer was made. This analysis includes the materials selection, study and research of different prototypes. The second part was the choice the methodology of manufactured of the prototype, and finally the design of data acquisition system by mean of GPIB-usb interface and software mad in Labview 2012.

2. OBJECTIVE

Design and build a prototype of a globe thermometer. The design include the materials choice, the electronics necessary and a software to obtain of automatized way, the globe temperature.

3. METHODOLOGY

In this section, the materials choice, the manufactured process and the data acquisition system were discussed. The data acquisition system includesfriendly software for the user. The prototype was calibrated from measurements in real time of the globe temperature in a room.

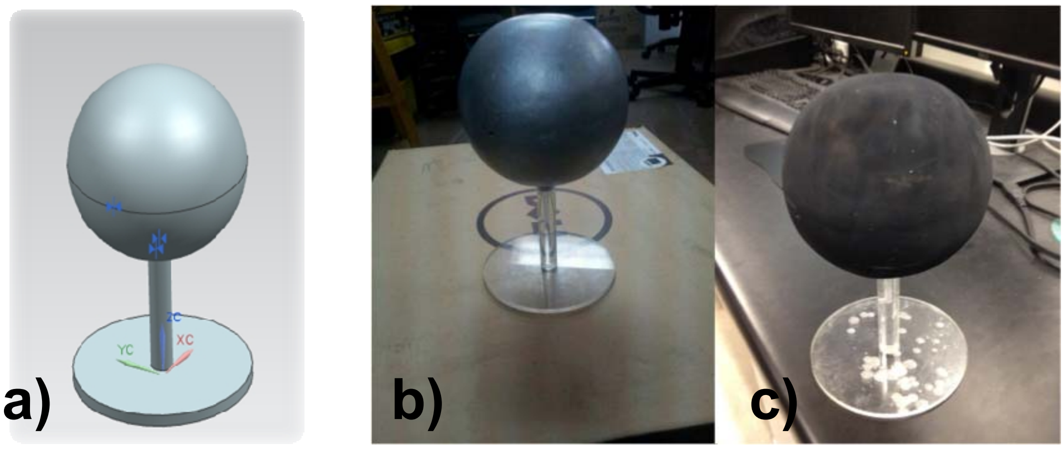

Figura 1. Globe thermometer prototype, a) 3D design in a CAD software, b) coated sphere with

mate black paint and c) coated sphere with carbon black.

To the build of thermometer, is very important know the materials properties. To our prototype, we use aluminum as main material and we obtained quasi-sphere geometry by the method of melting, molding and welding. The surface of the sphere was painted with black paint and then a coat of carbon black was applied. The sphere´s dimensions are: outside diameter of 15.24cm, inside diameter of 14.60 cm and the hole, into which is screwed the acrylic base, have a diameter of 1.17 cm. The figure 1 show a sketch of our prototype.

The data acquisition software (homemade design with LabView 2012) of the globe thermometer acquires data with a sampling rate of one data per second. To measure the temperature a K type thermocouple and a data acquisition card was used. The data acquisition card is the GPIB-usb type, which is connected to PC.In the figure 2, we show a block diagram (programming code) and front panel (control panel) of the data acquisition software.

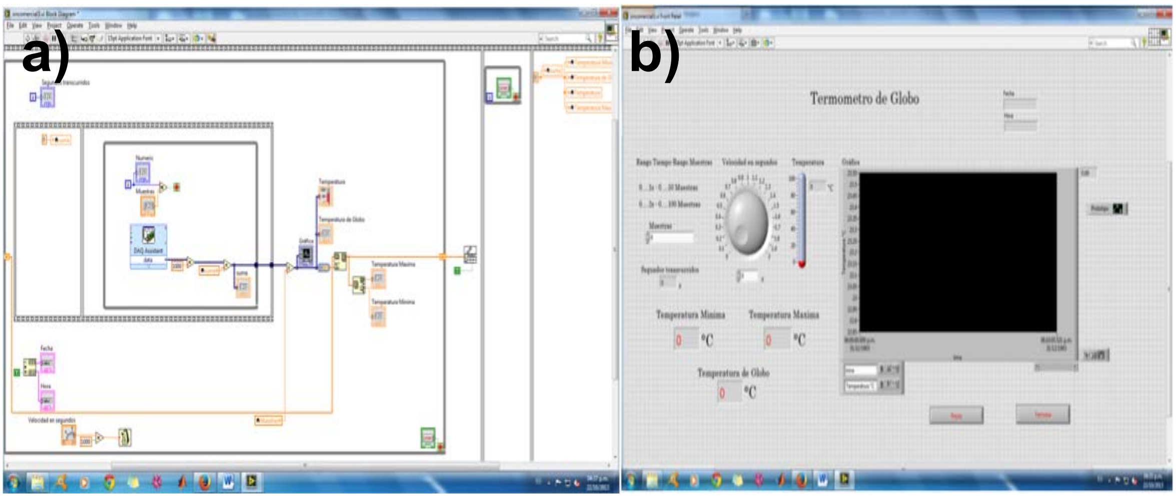

Figure 2. a) Block diagram and b) control panel, of the data acquisition software of the globe thermometer.

4. RESULTS

In this section, we show the calibrations plot of our prototype. The thermometer was calibrated in a rectangular room with two persons inside, under conditions of forced convection (air conditioning).The figure 3, show the behavior of the temperature (ºC) with the time (s) of the globe without the coated of carbon black.

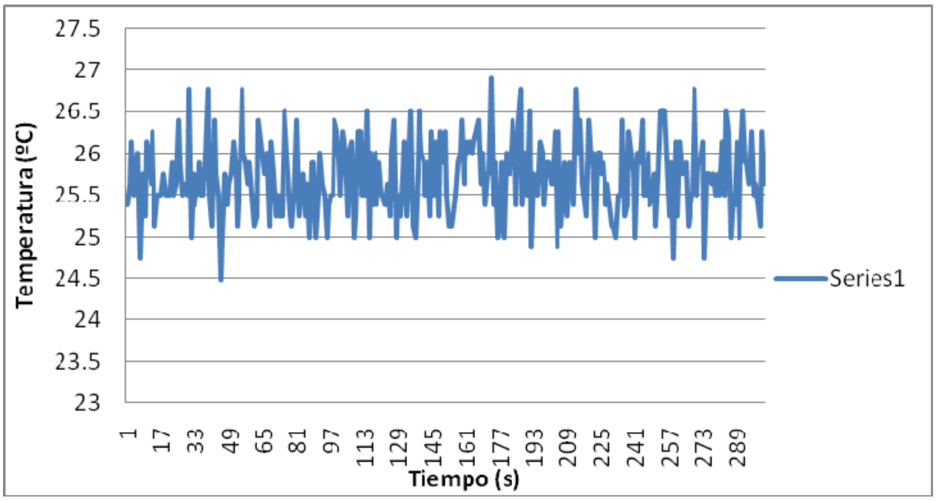

Figure 3. Behavior of the temperature data with the time. These data correspond to globe without coated of carbon black.

In figure 3, we can see that temperature ranged at 1.5 ºC, this result say us that there is a significative error in the measurement. This effect could be attributed to low emissivity of black paint.

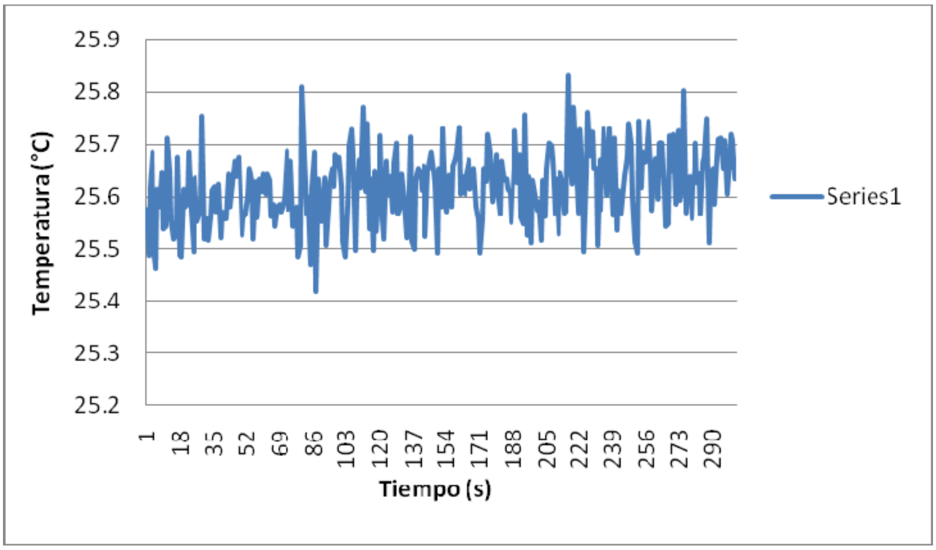

Figure 4.Behaviour of the temperature with the time. Globe with coated of carbon black.

When the globe is coated with carbon black we can see that the ranged in the temperature is the 0.3 ºC, see figure 4. We can say that the coated improvement the measurement, which could be attributed to high emissivity of coat carbon black.

Our prototype was compared with a commercial thermometer. Our globe thermometer have better resolution than the commercial, also can measure of automatized way and at real time the globe temperature, however our prototype requires a longer stabilization time, this effect can be produced by the bigger size of the sphere than ellipsoidal geometry of the commercial thermometer.

In figure 5, we show the experimental setup and the comparison in the measure reads of both thermometers.

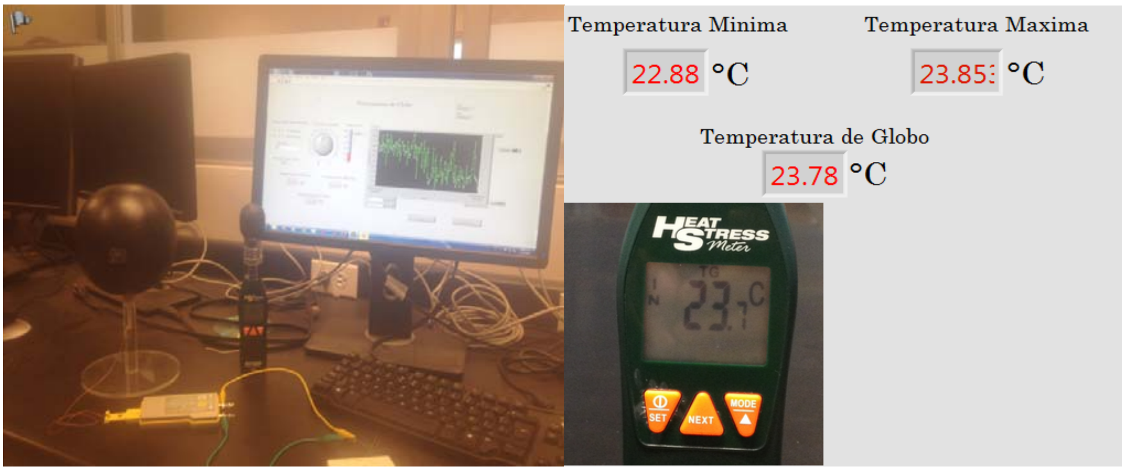

Figure 5. Comparison between the commercial and prototype thermometer.

5. CONCLUSIONS.

We propose an alternative design of globe thermometer. Our prototype was built of aluminum and was coated with carbon black. Our experimental results of calibration process was compared with a commercial thermometer and our prototype has a better resolution that the commercial, although requires a longer stabilization time as a result of the sphere´s size.

This project served as thesis work to Christian Nuñez to obtain the degree of engineer in mechatronics engineer of Anáhuac University Mayab.

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DESIGNING A CLASSROOM IN HIGHER EDUCATION LEVEL CONSIDERING SAFETY AND ERGONOMIC BASIC PRINCIPLES

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RESUMEN: Esta investigación fue realizada en el Instituto Tecnológico Superior de Ciudad Constitución, con el objetivo de diseñar un aula tipo para el Nivel Educativo Superior basada en principios ergonómicos y de seguridad. Considera específicamente: Las características del modelo educativo para el siglo XXI Formación y Desarrollo de Competencias Profesionales de la Dirección General de Educación Superior Tecnológica, las características físicas de los alumnos, las condiciones físicas del ambiente y los factores sociales presentes en un lugar de trabajo, buscando implementarla para alcanzar el nivel de aprendizaje adecuado de los alumnos en los contenidos de los diferentes planes y programas de estudio que cursan y contribuir al desarrollo productivo de las empresas y organizaciones del municipio de Comondú y en general del estado de Baja California Sur y del País. Esta investigación incluyó la medición antropométrica de una muestra de estudiantes del Instituto Tecnológico Superior de Ciudad Constitución, la medición de condiciones ambientales como iluminación, ruido y temperatura en las aulas y la aplicación de un cuestionario para conocer la opinión de los estudiantes sobre el nivel de comodidad de las aulas en cuanto a mobiliario y condiciones ambientales. A partir de esta información se hacen recomendaciones para el diseño de un pupitre y del Aula tipo para el Nivel Educativo Superior, basado en principios ergonómicos y de seguridad básicos tomando como referencia diferentes investigadores del campo de la ergonomía.

Palabras clave: Ergonomía en Educación Superior,

ABSTRACT: This research was carried out in the Instituto Tecnologico Superior de Ciudad Constitution, in order to design a classroom type for Higher Education Level based on ergonomic and safety principles. Specifically considers: The characteristics of the educational model for the XXI Century, Education and Professional Skills Development of Direccion General de Educacion Superior Tecnologica, the physical characteristics of the students, the physical conditions of the environment and social factors in a workplace, looking for implementing to achieve the appropriate level of student learning of content in the different plans and curricula that present and contribute to the productive development of enterprises and organizations of the municipality of Comondú and Baja California Sur state and the country. This work included the anthropometric measurement of a sample of students from the Instituto Tecnologico Superior de Ciudad Constitution, the measurement of environmental conditions such as lighting, noise and temperature in the classroom and the application of a questionnaire to know the opinion of students on the level of comfort of the classrooms in furniture and environmental conditions. From this information recommendations were made for the design of a classroom desk and classroom type for Higher Education Level, based on ergonomic principles and basic safety with reference to different researchers in the field of ergonomics.

Keywords: Higher education, Ergonomics

Relevance to Ergonomics: The significance of the research project in relation to ergonomics is that from the results, a classroom for the higher education level with environmental, physical and media adequate in relation to the physical and psychological student characteristics was designed, allowing better development of activities under teaching-learning process, reflected in better results in their academic and personal performance. This represents better training for students of the educational program, impacting positively in sectors where their work will be developed.
Keywords: Ergonomics in Higher Education

1. INTRODUCTION

Among challenges that an institution of higher education is facing, we found enhancement and preservation of quality in teaching and learning, forcing it to take further actions to enable the fulfillment of this demand (UNESCO, 1998). The quality of the teaching- learning process is established regularly from the programs scop, planning teaching and learning strategies, and the use of information technology without considering a more holistic overview of the learning environment. As a holistic overview including issues related to student comfort as furniture, lighting, space, temperature, noise, humidity, and ventilation, and audiovisual media functionality is estimated. In this sense, the ISO 9001:2008 states that you must manage the work environment needed to achieve conformity to product requirements. In the case of higher education the product is the prepared practitioner and the environment where the teaching-learning process develops, considering those conditions where the work is performed.

Including things like furniture and comfortable environment for the student in the classroom supposes a better performance from them, derived from less fatigue and stress generated by a classroom design without considering basic ergonomic elements. Some research has been conducted to determine the characteristics of primary school children in order to develop an appropriate desk thereby improving sitting postures and comfort(Gastelum, 2004) and design desks for senior students from an anthropometric database (Gianikellis , et al; sf). Other research evaluating the adequacy of a classroom building to the comfort needs of students, detected several discrepancies to the conformity of ergonomics elements is conducive environment to develop the teaching-learning process (Plascencia, 2004). Considering the characteristics of students according to educative level, physical condition, in addition to climatic and infrastructure conditions, it is important to adequate the physical space to the needs of students for better performance, which requires having the appropriate information.

Although the Instituto Tecnologico Superior de Ciudad Constitucion, over time, has received suggestions and comments from the student population about the size of desks and the discomfort about taking classes there is no information to make necessary adjustments and improve physical comfort. Because of it was decided to conduct a study to design and implement a classroom considering basic ergonomic elements, creating an enabling environment for the optimum development of the teaching-learning process, looking for some advantages as decreased fatigue and lumbar strain on the ischial bones, greater educational attainment, increased teacher-student care and improving the learning environment.

2. OBJECTIVES

2.1 General Objective

Designing a Classroom in Higher Education Level considering basic ergonomic elements for an enabling environment that develops an optimum teaching learning process.

2.2 Specific Objectives

1. To determine spacing, lighting, temperature, noise level and ventilation in the classroom.

2. Designing and manufacturing a prototype desk under the Anthropometric characteristics of the students of the Institute, based on the design principles established by ergonomics.

3. Proposing a classroom according to results of previous phases.

3. METHODOLOGY

3.1 Delimitation

The research was conducted in the period June 2013 to January 2014, in the Instituto Tecnologico Superior de Ciudad Constitucion particularly during the teaching-learning process within a permanent use and representative classroom.

The classroom current layout is showed in Figure 1. It shows dimensions and desk layout considering dimensions in meters.

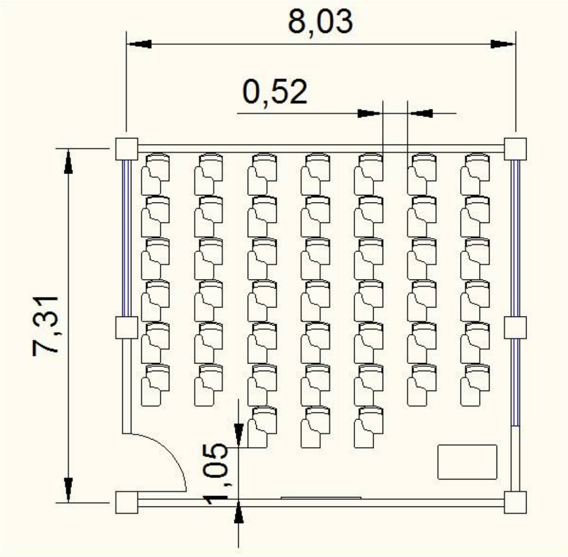

Figure 1. Current Plane of Classroom in the ITSCC. (Meters)

Current environmental features such as lighting, temperature and noise in the classroom are presented in Table 1. The averages are derived from measurements taken at different points of the classroom.

Table 1. Shows the Environmental Conditions of Lighting, Temperature and Noise Average in the Classroom.

Classroom Environmental Condition	**Mean ± Standard deviation**
Lighting	386.63 ± 204.22 lux
Temperature	27.89 ± 0.028 °C
Noise	64.59 ± 1.922 dB

3.2 Anthropometric Measurement

Anthropometric measurements of a representative sample of pupils of different groups of ITSCC, were selected using systematic sampling.

The anthropometric measurements followed the next recommendations:

1. Broad and temperature controlled for the comfort of the individual study room.
2. Guy barefoot with little clothing as possible
3. Measuring instruments calibrated before the measurement.
4. All measurements were taken on the right side of the body.
5. Participants are advised to remain in the position indicated in each of the measurements.

The measuring instruments used for anthropometric study were:

- Height rod-. Accuracy 1 mm. It was used to measure the height and sitting size of the individual.

- SCALE - . Scale weighs-people accuracy 100 grams. Used to obtain the weight of the study.
- Anthropometer - . Metric scale with two branches, one fixed and one moving. Branches can be straight and curves with olives. Accuracy 1 mm. Body segments, large diameters and heights are measured.
- ANTHROPOMETRIC TAPE - . Flexible, non-elastic , metal , less than 7 mm wide, with a space before zero ungraded and easy to read scale graduated in centimeters. Accuracy 1 mm.
- Pachymeter SMALL DIAMETER OR COMPASS - . Compass graduated slide deep in its branches 5th mm, capable of measuring 0 to 250 mm, and accuracy of 1 mm. To measure small diameters.

3.2.1 Auxiliary Material
- Wooden bench known height to measure sitting height and facilitate anthropometrist taking different measures.
- Dermographic pencil to mark the anatomical points and benchmarks.
- Metric weights and scale to calibrate the apparatus.

3.3 Physical Measurement In The Classroom.

Using a thermometer, a digital sound level meter and light meter factors such as temperature, noise and lighting were measured seeking to know the current status and propose improvements to these conditions for the proper performance of students in their learning process. Measures in different points of classroom were made.

3.4 Students Opinion

To know students opinion a seventeen questions survey was designed. The students were asked about comfort characteristics both classroom and desk and its easiness to allow learning and attention activities.

3.5 Statistical Analysis

Mean, standard deviation, maximum and minimum value and range were estimated using SPSS 15.0 for Windows©.

3.6 Design Of Furniture.

With ergonomic principles and considering anthropometric data, bank or appropriate desk was designed.

4. RESULTS

From the anthropometric measurements the ITSCC student population table was established (Table 2). Using this information the classroom desk dimensions were recommended, the measures includes age, standing and sitting height and other body measurements. The maximum and minimum values were used mainly.

The students opinion about comfort characteristics both classroom and desk and its easiness to allow learning and attention activities, can be found in Table 3 and Figure 2. The level of grading is not low at all, but we can see there is an improvement opportunity to achieve a hundred percent of satisfaction.

Table 2. Anthropometric Table of the ITSCC Student Population.

	Mean	Standard Deviation	Variance	Maximum	Minimum	Range
AGE	20.66	2.47	6.08	35.00	18.00	17.00
WEIGHT	72.12	17.28	298.49	132.70	38.70	94.00
STANDING HEIGHT	165.84	9.19	84.53	186.00	146.50	39.50
STANDING EYES HEIGHT	154.41	8.80	77.46	179.50	135.00	44.50
STANDING SHOULDERS HEIGHT	138.50	8.28	68.49	155.50	120.50	35.00
STANDING ELBOW HEIGHT	102.83	6.97	48.57	116.00	57.50	58.50
STANDING CERVICAL HEIGHT	146.67	8.47	71.66	165.00	128.50	36.50
SITTING HEIGHT	129.50	6.31	39.81	149.50	112.60	36.90
SITTING EYES HEIGHT	117.71	6.70	44.85	140.00	100.20	39.80
SITTING SHOULDERS HEIGHT	101.83	5.64	31.83	119.50	87.00	32.50
SITTING ELBOW HEIGHT	66.75	4.46	19.93	94.00	57.00	37.00
GLUTEAL TO KNEE DISTANCE	57.62	4.33	18.78	69.00	40.00	29.00
SHOULDER TO ELBOW DISTANCE	34.47	2.61	6.84	44.00	29.00	15.00
ELBOW TO WRIST DISTANCE	27.50	2.18	4.77	33.00	22.00	11.00
SITTING LOW BODY PART HEIGHT	45.26	3.00	9.02	55.00	39.00	16.00
SITTING KNEE HEIGHT	49.12	3.70	13.65	59.00	40.50	18.50
SHOULDER WIDE	43.49	4.71	22.17	55.00	16.50	38.50
HIP WIDE	35.22	4.32	18.67	47.30	17.30	30.00
BODY DEPTH	19.82	3.79	14.38	36.50	13.40	23.10
ABDOMINAL DEPTH	23.08	3.89	15.16	36.00	15.50	20.50

Table 3. Opinion of Students on Classroom Ergonomic Satisfaction Level.

Item	Initial Scale	Final Scale	Mean ± Standard Deviation
Extent to which desk allows correct posture	0 Very Uncomfortable	100 Very Comfortable	76.78 ± 21.20
Degree to which desk lets appropriate care and activities	0 Very Uncomfortable	100 Very Comfortable	77. 80 ± 20.56
Comfort Degree of the seat to attend and perform activities	0 Very Uncomfortable	100 Very Comfortable	81.05 ± 18.68
Comfort Degree of paddle desk to attend and perform activities	0 Very Uncomfortable	100 Very Comfortable	78.26 ± 21.44
Comfort level of the desk to get out and sit on it	0 Very Uncomfortable	100 Very Comfortable	81.92 ± 19.49
Comfort that allows the space between desks to move around	0 Very Uncomfortable	100 Very Comfortable	72.17 ± 24.69
Extent to which can make movements to reach objects near the desk while sitting on it	0 Very Uncomfortable	100 Very Comfortable	78.73 ± 19.90
Degree of adequacy of space where desk for the effective development of activities is located	0 Very Uncomfortable	100 Very Comfortable	79.42 ± 16.84
Rate of level of physical activity performed in classroom	0 Very Low	100 Very High	52.71 ± 28.07
Proper time maintaining their positions in their efforts to perform comfortably	0 Very Uncomfortable	100 Very Comfortable	67.51 ± 21.17
Level to desk space allow the movement of attention and work	0 Very Uncomfortable	100 Very Comfortable	75.46 ± 18.90
Degree conditions your space allows you to keep 1 hour of attention	0 Very Uncomfortable	100 Very Comfortable	78.71 ± 18.38
Comfort that allows you the appropriate of lighting to meet and perform activities	0 Very Uncomfortable	100 Very Comfortable	84.07 ± 18.23
Comfort of adequate of room temperature for attending and performing activities	0 Very Uncomfortable	100 Very Comfortable	78.25 ± 23.42
Comfort of adequate of noise level to attend and perform activities	0 Very Uncomfortable	100 Very Comfortable	72.38 ± 24.30

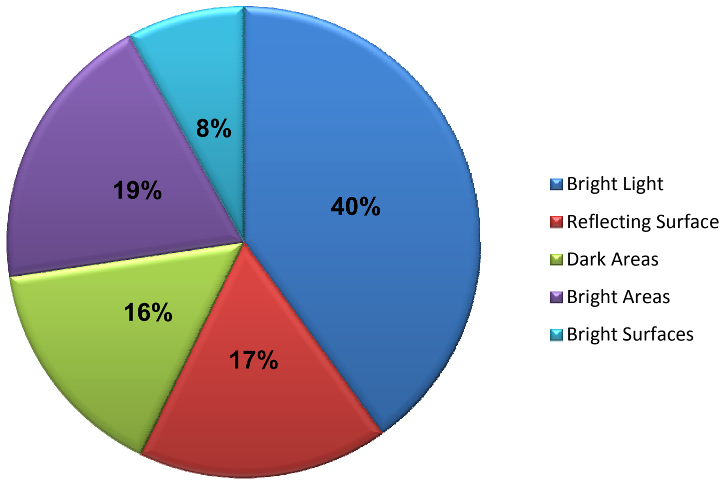

Figure 2. Situations presented in the classroom that students perceive are shown.

Based on anthropometric table presented above, the measures for the desk (Figure 3) were determined. The values used were the height to the bottom of the highest student sitting (55 cm) and lower (39 cm) to define the height of the seat and footrest base, below the knee and buttock hip width served to the width dimensions of the seat and backrest. The highest sitting shoulder height allowed younger set back height and seated elbow height (54 cm) allowed to define the height of the table to complement the desk dimensions one seat-back 115 ° angle was established and generally used in determining their preparation materials that allow it to be padded and have a tapestry that allows dissipate heat and moisture properly. These measures were established following some recommendations found in the literature (Oborne, 1999).

For classroom designing, furniture arrangement was first considered by reference to the information of the anthropometric measurements of students. The spacing between rows was set to 58 cm and the distance from the board to the front desk was 126 cm, equivalent to maximum shoulder width and space to allow free passage of two people, according to the recommendations of Oborne (1999).

The proposed distance between furniture can help improve social interactions of students which is part of the social requirements (territoriality and personal space) in a workplace (Oborne, 1999).

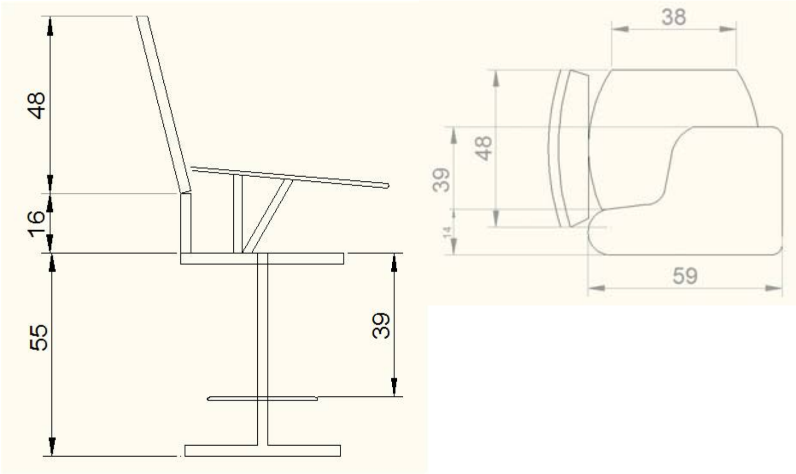

Figura 3. Dimensions for the Design of Proposed Desk

In relation to environment physical agents, these were defined according to the proposed by some researchers on the subject, the maximum allowable noise level in a school day (8 hour average) is 90 dB (Niebel, 2009). Temperature ranges are in summer from 20 °C to 24 °C and in winter, 19 °C to 21 °C, with a range of relative humidity of 40-60 % (Creus , 2011). Because of the psychological effects of the colors used in the workplace, the yellow or the equivalent for the walls and a gray color for floors and ceilings is determined to be used (Creus , 2011). The recommended light intensity was found in the range of 500 to 700 lux and it should be uniformly presented throughout the classroom (Ramirez, 1997).

Moreover the location of the screen or projection and work whiteboard should be located centered in front of the room at a height of 118cm with respect to the floor, this by reference of the variable height of eyes sitting showed in anthropometry table generated. A location of students considering heights, from taller to less taller, in the classroom is recommended for better appreciation and to meet the requirement of clearance of the sight line according to Oborne (1999).

The design of a Schoolroom for Higher educational level was obtained since the research was carried out, contemplating ergonomic principles and the needs of the current educational environment characterized by a focus on skills with a practical orientation to active participation of students (Figure 4).

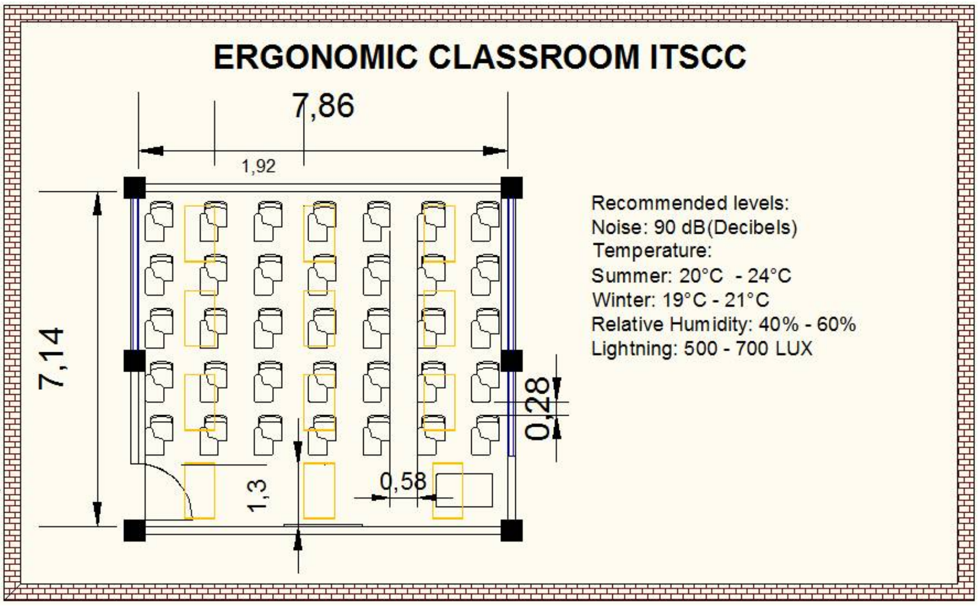

Figure 4. Layout of the proposed ITSCC classroom

5. CONCLUSIONS

Anthropometric table ITSCC student population was obtained as a basis for the design of the desk and Schoolroom.

Classroom design recommendations according to anthropometric measurements of students were established.

Schoolroom design to improve the level of learning was completed, that basically supported on ergonomics and physical design proposal for the same.

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ERGONOMICS EVALUATION OF THE EMERGENCY MEDICAL CARE COMPARTMENT OF A BASIC LIFE SUPPORT AMBULANCE

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Resumen: El cuidado de urgencias pre hospitalarias consiste en una serie de decisiones sobre tratamiento y transporte, que se basan en los hallazgos de la evaluación del paciente y deben ser tomadas de forma rápida y sin errores. Esta investigación tiene como objetivo establecer, a partir del concepto de ergonomicidad, las especificaciones técnicas de la disposición de los recursos físicos de apoyo, tales como equipamiento, insumos y soluciones que debe tener el habitáculo de cuidados de urgencias médicas de una ambulancia de soporte vital básico (SVB). En dicho estudio se aplicará un análisis de enlace y análisis postural a través de la observación de videos tomados durante la atención prehospitalaria de pacientes con trauma, de la misma manera que Ferreira, Jeremy y Hignett, Sue (2005), examinaron la disposición del compartimiento del paciente en una ambulancia del Reino Unido para determinar la eficiencia y seguridad del paramédico. Se concluye que la distribución del equipo médico y el espacio de trabajo contribuyen a la falta de eficiencia y a las malas posturas, por lo tanto es importante establecer datos técnicos que conformen un documento normativo para una propuesta de rediseño.

Palabras clave: Cuidado Pre-hospitalario, Paramedicos, Ergonomia

Abstract: The pre-hospital emergency care consists of a series of decisions about treatment and transport, based on the information provided by the patient evaluation, that must be taken quickly and without errors. This research aims to establish, from the concept of Ergonomics, the technical specifications of the available physical support resources such as medical equipment, inputs, and solutions that must have the patient compartment in a basic life support ambulance(BLS). In this study, a link analysis and a postural analysis will be applied through the observation of videos taken during trauma patient pre-hospital care, in the same way that Ferreira, Jeremy and Hignett , Sue (2005) examined the layout of the compartment of the patient of an ambulance in the UK to determine the efficiency and paramedic safety. It was determined that the distribution of medical equipment and the workspace contributes to inefficiencies and poor posture; therefore it is important to establish technical data that makes up a normative document for a redesign proposal.

Keywords: Pre-hospital Care, Paramedic, Ergonomics

Relevance to Ergonomics: Contribute and provide technical data that make up a policy document for a proposed redesign of the passenger compartment of emergency medical care, based on ergonomic principles, seeking to reduce the risks to the pre hospital staff undergoes and improve dynamics care patient.

1. INTRODUCTION

The pre-hospital emergency care can be understood as a complex system of interactions between the paramedic, the medical equipment and the ambulance in relation to the patient. In this context, the paramedic must take a series of quick and efficient decisions, in order to process and transport the injured or ill person, based on the findings obtained during the patient assessment and which require a suitable and effective physical environment. In this manner, the paramedic needs an intuitive interface that provides a reduction in the external, physical and psychological burdens that could impact positively on the recognition and interaction with his environment to be given optimally.

Within this research, by optimizing the relationship between the paramedic and the physical context, the provision of support elements plays an very important role, giving guidelines for the activities carried out by the paramedic, in which sense will impact the quality of care the patient receives. Precisely in relation to that aspect this research establishes, from the concept of Ergonomics, the technical specifications of the physical support resources layout such as medical equipment, inputs, and solutions that the patient compartment must have in a Basic Life Support ambulance (BLS) for optimal pre-hospital care.

The Mexican Official Standard of the Ministry of Health, responsible for the regulation of health care (NOM-237-SSA1-2004) establishes minimum the criteria in pre-hospital care of medical emergencies, the requirements and characteristics of the personnel involved, as well as the equipment and supplies minimum for the ambulance type land mobile units, which are mandatory for all public and private medical services. However, the standard only specifies the amount of equipment needed and the use of drawers and cabinets which are already pre-positioned in the vehicle; but no information on how the items should be placed in relation to the activities that the paramedic must perform with patient.

Of the activities performed by the paramedic during pre-hospital care, the assessment continue or transport phase, is one of the least studied; yet its importance is vital because proper a care determines patient survival short (hours) and long term (days). These activities establish efficiency of treatment used by the paramedic, that, will depend between other things of the interior design of the emergency medical care compartiment, and external factors such as noise and movement of the unit, mainly affecting the stability of the paramedical and of the medical team, complicating the location of inputs and frequency of team use. As of the above it is arise that the ambulance design must take into account the operation and the types of users who will perform such activities; since many of the units are designed to percentiles of other populations, causing problems in Mexican users to conduct their activities. The arrangement of equipment within units of basic support is conducted in an empirical way, without taking into account the ergonomic hazards that the distribution of the furniture and of the equipment generated about users.

The paramedics usually place the team in the inside according from the frequency of use, however the use of ambulances is random and exist no a person in charge or a system for establish the arrangement of the elements. This can cause a disorder in the location of the equipment in the compartments of the ambulance, as each paramedic, to supply their unit of work, they place the equipment according to your needs and experience, making it more feasible that it will prolonge the time of search and it will complicating the interaction in the case of other paramedics that they use the same vehicule.

To access the equipment located in the drawers and cabinets, the paramedic needs on several occasions during the journey, leaves his sitting posture, because with him it is impossible to reach the solutions and supplies because of the distance that the containers have and it is greater than its anatomical functional range. Two of the most important factors in the interaction of the paramedic whit elements are the patient location and movement of the vehicle that generates instability complicating the shunting up and may even affect the patient having to hold onto the stretcher to take the required solutions and supplies, like to lean and take the equipment found in the in lower zone. All this is maked by the space, distribution and distances, leading to paramedic to adopt awkward postures, which are musculoskeletal risk and can cause low efficiency in care.

In the previously investigations performed in different parts of the world, is mentioned the lack of integration of knowledge and it concludes that the most of the researches in the pre-hospital sector are conducted in isolation, without taking into account the performance the paramedic that is the that is involved in the use of equipment (Ferreira, Jeremy and Hignett, Sue, 2005).

The prehospital emergency medical service is a socio-technical system little explored. Its complexity requires a holistic view and detailed of all activities, with in order to understand the potential of the risks and errors that occur during the atention of ill or traumatized patients. Elements as the need for apply treatment in places various, dimensional differences of the comparments of emergency medical care, the variation in the arrangement of cabinets and medical equipment, limitation of movement and noise are essential factors that have impact in the paramedic and influence their performance.

The contribution of the research is important but very reduced as this system, in spite of have 20 years approximately in the field of research[1], has not been studied in depth from the point of view of the ergonomist, both in relation with the security of the

[1] One of the first work in this direction was developed by Doormaal et al, in the year 1995 (cited in Ferreira, Jeremy and Hignett, Sue 2005)

paramedics, as referent to the characteristics of emergency vehicles and equipment design in the pre-hospital sector. This scenario result challenging, mainly due to that not only is involved the direct user (paramedic), but also and with major degree the indirect user, in this case the patient.

The services of the emergency medical professionals are exposed to many occupational hazards Becker et al . , 2003 Cydulka et al. , 1989 , Gershon et al. , 1995 , Hammer et al. , 1986 , Kahn et al. , 2001 Maguire et al. , 2005 Maguire et al. , 2002 (quoted in J. Studnek , J. Mac Crawford , A. Fernandez (2012). It is also recognized that musculoskeletal injuries, such as back injuries are frecuently in this occupation. In this regard, the high incidence of problems of this type among ambulance services worldwide , described in the study of Boocock et al. (2002); Letendre and Robinson (2000), Rodgers (1998) . Doormaal et al, (1995), (cited in Ferreira, Jeremy and Hignett, Sue 2005), made that the researchers will focus as object of study the staff working in emergency medical system, seeing primarily interested in the analysis of the postural of the paramedics , firefighters and rescue workers in cargo-handling activities , in particularly in the work of lifting, carrying and moving the patient from a bed to a stretcher or of a gurney to another. For these studies, simulations were performed to allow the biomechanical analysis of each component of the task, they were made with in order to find where it was necessary the ergonomic interventions and the potential impact above the musculoskeletal risk.

Meanwhile Ferreira, Jeremy and Hignett, Sue (2005) examined the disposition of the patient compartment on an ambulance of the UK to determine the efficiency and safety of the paramedics under an analysis of link and postural analysis.

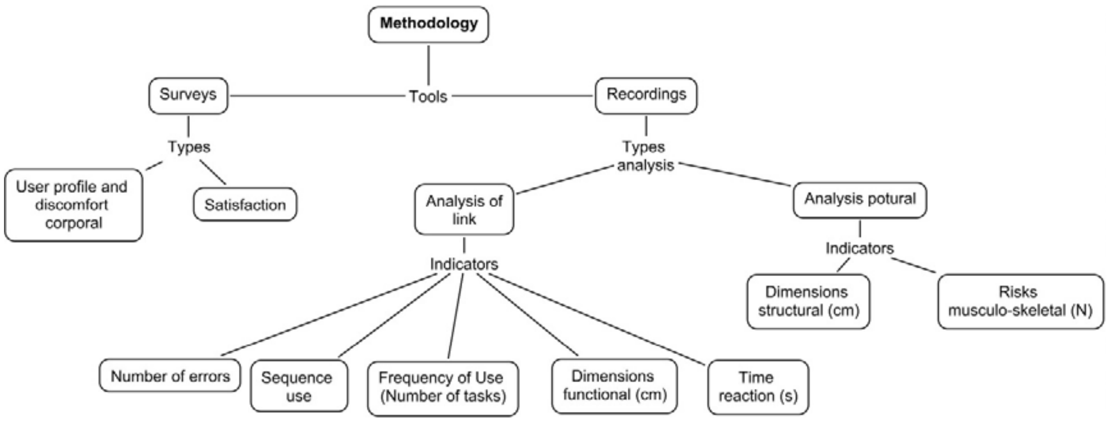
Part of the researches also mention how ambulance services and manufacturers of these vehicles in the UK, are trying to find solutions to improve the design of the patient compartment, but these solutions can be found to expense of clinical efficiency, users (paramedics and patients) and security, so it has not made a systemic approach and have not been able to establish technical specifications for ambulances at present (Ferreira, Jeremy and Hignett, Sue, 2005).

2. METHODOLOGY

To carry out the study in this investigation, 30 paper surveys apply in order to build the user profile and detect bodily discomfort and satisfaction in prehospital care institutions in San Luis Potosi and Jalisco. Is to obtain general information on the participant both men and women active in the institution, working on it as employees, volunteers and interns, with morning shifts, evening and night for 48 or 24 hrs. whit age 18 to 45 years. It seeks to expose the hardships that they believe have vehicles emergency medical care and highlight the relationship between ergonomic principles and perception.

As a second study tool, will be used to record video from portable cameras that record the dynamics in the interaction between the caregiver and the other components of the system, during the transfer of a patient with trauma inside the passenger compartment of care medical emergencies. With the above is to identify the set of tasks and frequency of actions involved in patient care, emphasizing the relationship between the distribution of equipment and performance protocol (treatment). For this two types of analysis will be used, a link analysis to observe the interactions between the paramedics and medical equipment, the location and arrangement thereof shall apply in the passenger compartment of care, in order to evaluate the efficiency of prehospital care during transport through the sequence and frequency of use, time, location and a postural analysis will be used to identify awkward postures that generates the distribution and location of medical equipment and furnishings that contribute to the quality of attention (concept Map 1).

1 Concept map



A pilot test was conducted at an institution of prehospital care in Jalisco, where 4 videos were analyzed and the involvement of 5 paramedics (2 women and 3 men) in two ambulances different pattern was observed during the course of the incident to the hospital. With the above, we sought to identify the set of tasks performed during prehospital care within the vehicle, the physical resources of support used, available on the carrier in relation to the action protocol, postures and scope of musculoskeletal higher risk, highlighting the main tasks, sequence and frequency of use in patient care.

3. RESULTS

In linkage analysis and position applied by Ferreira, Jeremy and Hignett, Sue (2005), oxygen saturation in the blood, oxygen administration, monitoring of the heart and blood pressure control is mentioned, how the clinic tasks more frequently in a prehospital care, also argued that access to equipment and supplies to support these tasks are designed for the front passenger seat (head of the couch), however, paramedics prefer to sit next to the couch, resulting in an increase in throw distance. Part of the analysis found that the most frequent tasks have more than 40% of working postures that require corrective action.

In the link analysis performed in the pilot test, highlights the most common tasks and their interaction with medical equipment and furniture in a service of blunt trauma (Table 1). Some of the most frequently applied interactions and errors are:

• The interaction between the caregiver based on stool 3 (T3) with the kit 2 (B2), in the work of pumping and storing medical equipment, with 7 errors that given by the lack of visibility, inadequate team distribution and the increasing distance affecting their functional scope, which generates an increase in the search time and response.

• The interaction between the caregiver based on stool 3 (T3) with stretcher (CA), in the work to remove and secure the patient and the preparation of medical equipment and treatment with 2 errors, which are due to design stretcher to remove and hold insurance, as it delays the patient's care.

• The interaction between the caregiver based on stool 3 (T3) with stool 2 (T2), in the work of pumping and storing medical equipment, with 2 errors given for the loss of time in the team reshuffle faster access.

Table 1. Analysis of link

Analysis of link				
Ubication of the paramedic	**Interaction (physical space)**	**Tasks**	**Frequency**	**Errors**
Stool 3 (T3)	**stretcher (CA)**	Remove insurance stretcher **Preparation of medical equipment and treatment.**	**13**	**2**
	Medical kit 2 (B2)	**Remove and save medical equipment**	**15**	**7**
	Stool **(T2)**	**Remove and save medical equipment**	**2**	**2**
	Stool 3 (T3)	Handling equipment	4	NP
	Paramedic	**Remove and save medical equipment**	2	NP
Stool 2 (T2)	Medical kit (B2)	Save team medical	1	NP
Stool 1 (T1)	Stool 1 (T1)		1	NP
	Total:		38	11

Many of the errors made by paramedics during prehospital care, happen when search of equipment in the drawers and cabinets, kits and their own belongings which delays the implementation of treatment and jeopardizes patient health must be addressed in a timely manner, complying with the protocol and thus holding on to what is called golden hour, which is the time during which treatment of shock or traumatic injury is more critical and the potential for survival is better (Aaos , Mexican Red Cross Staff, American Academy of OrthopaedicSurgeons / AAOS Staff . , 2009).

Other problems encountered in the analysis of bond are the risk stocks, which are tasks that involve the use of sharps, which can lead to accidents both the patient and the caregiver, by the movements generated in the transfer and dead tasks, formed by unnecessary actions by the caregiver, either a misapplication of protocol performance or poor distribution of medical equipment.

Furthermore, postural analysis recognizes that 80 % of the positions applied in the prehospital care requires corrective action, 3% of the positions affected by load management and the remaining 17 % do not require corrective action.

Table 2 shows the tasks that require corrective action and are affected by the location of furniture as in the case of taking vital signs with 24%.

Table 2 Analysis postural

Analysis postural		
Tasks		**Percentage**
No corrective action required	Remove insurance stretcher	4%
	Place the patient on a stretcher	4%
	Ensure the patient on stretcher	9%
Require corrective action	Remove and save medical equipment	18%
	Equipment handling medical	14%
	Preparation of medical equipment	13%
	Take vital signs	**24%**
	Physical examination	11%
Load Handling		3%

The analysis recognizes that the location of the paramedic on the ambulance is fundamental to establish the level of efficiency in conducting the task factor, which goes together with the arrangement and dimensions of the furniture and hallways. Was detected, from this analysis that appear obsolete areas and areas that prevent the proper development of the activities

To take the team drawers and cabinets, the distance from the stool to the drawers, is greater than the anatomical functional range Paramedic increasing the scope to take inputs from a safe position. In the case of the chair to the airway, space is limited and hinders the rotation of the trunk to take paramedic equipment required. The lack of visibility, lack of concentration due to noise and precision due to movement, Paramedic limit performance despite having adequate preparation for efficient care. The distance between the paramedic team and the patient, you are required to adopt awkward postures, which are a risk factor for developing musculoskeletal disorders.

4. CONCLUSIONS

Most positions require corrective measures are related to the tasks used by paramedics more frequently such as taking vital signs or remove and store medical equipment, among others. From the above, in order to carry out the ongoing evaluation efficiently, the medical team should be available to the paramedic immediately, preventing waste time in your search, and even the manipulation. The location of the paramedic in the ambulance determines the efficiency of performing the tasks, but this depends in turn on the distribution and dimensions of the furniture and hallways.

The distribution of workspaces plays an important role because it determines positions that often affect the paramedic health immediate or long-term and also becomes a factor that prevents can carry out activities efficiently and effective, which has serious implications, since it is a task that involves a person's life.

With the result of this research is to obtain a set of technical specifications that may be added to the rules to improve the provision of support elements inside the passenger compartment of emergency care and thereby contribute to the achievement of adequate attention to population. Standardizing the location of furniture and equipment in the passenger compartment of emergency medical care of an ambulance, can improve access to supplies and materials and equipment to facilitate handling during transport, which will impact on the effectiveness of prehospital personnel and allow to be more confident in carrying out their activities. This, in the end, will impact positively on the care the patient receives.

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ERGONOMIC RISKS ASSOCIATION TO WORKPLACE STRESS, FATIGUE AND INJURIES IN INDUSTRIAL WORKERS

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RESUMEN: Objetivo: Identificar las relaciones entre los riesgos ergonómicos y la presencia de trabajo estresante, la fatiga y la patología musculoesquelética en un grupo de trabajadores de la industria.

Metodología: Realizamos un estudio transversal de 984 trabajadores que trabajan en nueve compañías de fabricación en el centro de México.

La exposición a riesgos ergonómicos se evaluó con el cuestionario-ERGOEST UNAM; nivel de tensión laboral se determino mediante cuestionario JCQ de Karasek, socio-demográficos y la información de salud se obtuvo con un cuestionario.

Resultados: Los trabajadores expuestos a un modo de trabajo nocivo y posturas forzadas tuvieron un riesgo significativamente mayor de tener un trabajo muy estresante, fatiga excesiva y lesiones en las manos. Si bien, la repetición moderada de movimientos y la carga de trabajo moderada/leve eran protectores de estos efectos.
Conclusión: las intervenciones ergonómicas pueden ser beneficas en la reducción de los síntomas relacionados con el estrés y los daños musculoesqueléticos entre los trabajadores de la industria de la manufactura.

Palabras clave: Riesgo, ergonomía, estres, fatiga, mano

ABSTRACT: Objective: To identify the relationships among ergonomic risks and the presence of stressful work, fatigue and musculoskeletal pathology in a group of industrial workers.

Methodology: This is a cross-sectional study of 984 workers –working in nine manufacturing companies in Central México.

Exposure to ergonomic risks was assessed with the ERGOEST-UNAM questionnaire; job strain level was determined using Karasek´s JCQ questionnaire, socio-demographic and health information was obtained with a questionnaire.
Results: Workers exposed to a harmful work mode, and/or forced postures had a significant higher risk of having a highly stressful job, excessive fatigue and hand injury.

While, moderate repetition of movements and low/moderate workload were protective of these effects.

Conclusion: the ergonomic interventions can be beneficial in reducing stress related symptoms and musculoskeletal damages among manufacturing industrial workers.

Keywords: risk, ergonomic, stressful, fatigue, hand.

Relevance to Ergonomics:

1. INTRODUCTION

The presence of inadequate ergonomic conditions at the workplace is recognized as an important factor related to the production of discomfort and musculoskeletal injuries. Recently, it has been identified that ergonomic hazards are associated to negative psychosocial effects such as job strain and fatigue among other occupational risks.

Different authors have reported an association among unsatisfactory economic conditions and iso-strain (job strain with low social support), musculoskeletal complains and moderate or poor self-reported health; suggesting that workplace ergonomic improvements may improve self-reported health (Ferrand, et al 2012).

2. OBJECTIVES

We aimed to identify the relationships among ergonomic risks and the presence of stressful work, fatigue and musculoskeletal pathology diagnosed in a group of manufacturing industrial workers.

3. METHODOLOGY

We conducted a cross-sectional study of a group of 984 workers in Central México working in nine manufacturing companies.

The FES Zaragoza-UNAM, Research Committee, approved this study. Workers were provided of information about the study and those who agreed to participate signed an informed consent letter.

To identify the exposure to ergonomic risks the ERGOEST-UNAM questionnaire was used (Annex 1), this questionnaire assesses the risk related to work load, posture, repetition, use of tools and harmful work. Workers´ job strain level was obtained using a Spanish version of Karasek´s JCQ questionnaire (Tovalin, Rodríguez, Cruz, & Soto, 2008). In addition, workers answered a questionnaire to obtain their demographic and health information.

The data collected was captured in EXCEL and all statistical analyses were conducted using the IBM SPSS Statistics 20 for Windows (SPSS Inc., Chicago, Illinois). We estimated frequencies, Odds Ratio (OR), and corresponding 95% Confidence Intervals (95% CI). The OR is a measure of association that indicates the probability or risk of worker´s having the effects when exposed to the ergonomic hazards; when the OR value is greater than 1, this value means that the likelihood of having the effects is higher among exposed workers.

4. RESULTS

The associations between the ergonomic risks and a high job strain are presented in Table 1. Among men, workers exposed to forced posture and moderate load had a significant higher risk of having a highly stressful job (two times more likely) and when the frequency of repeated movements was moderate the risk was lower (60 % less). In women, those exposed to forced posture and a harmful work mode had a higher risk of a stressful job (two times more likely).

Table 1. Association between ergonomic risks and stressful job, by sex				
	High Job Strain			
	Female		**Male**	
Ergonomic Risk	**OR**	**CI 95%**	**OR**	**CI 95%**
Harmful work mode vs. right	**1.94***	**1.2-3.1**	1.5*	1.2-1.9
Forced posture vs. adequate	**2.4***	**1.3-4.5**	**2.3***	**1.3-3.7**
Moderate repetition vs. important	0.7	0.4-1.1	0.4*	0.3-0.6
Moderate workload vs. important	0.7	0.4-1.2	**2.1***	**1.4-2.8**
Inadequate use of tools vs. right	1.2	0.7-1.9	1.4*	1.1-2.1
*Significant				

Among men, the association between ergonomic hazards and excessive fatigue (See Table 2) was significant in those exposed to a harmful work mode (two time more likely), and a moderate repetition of movements was protective (80% less). In women these associations were not significant.

Table 2. Association between ergonomic risks and fatigue by sex				
	Fatigue			
	Female		**Male**	
Ergonomic Risk	**OR**	**CI 95%**	**OR**	**CI 95%**
Harmful work mode vs. right	1.4	0.7-2.9	**2.4***	**1.2-4.9**
Moderate repetition vs. important	0.5	0.2-1.1	0.2*	0.1-0.4
*Significant				

Table 3 shows the association between back injury diagnosed by a doctor and the exposure to ergonomic risks. In women, those exposed to a harmful work had a significant increased risk of a back injury (three times more likely), and in men those exposed to an inappropriate use of tools had a higher risk of back injury (two times more likely).

Table 3. Association between ergonomic risks and back injury by sex				
	Back injury			
	Female		**Male**	
Ergonomic Risk	**OR**	**CI 95%**	**OR**	**CI 95%**
Harmful work mode vs. right	**3.1***	**1.0-9.8**	1.3	0.8-2.5
Moderate repetition vs. important	0.5	0.1-1.3	0.5	0.3-1.03
Inadequate use of tools vs. right	1.7	0.6-4.4	**2.4***	**1.3-4.6**
*Significant				

The likelihood of a hand injury diagnosed by a physician (See Table 4) was higher in women exposed to an improper use of tools (four times more likely) and to a harmful work mode (three times more likely). In men a higher injury risk was related to an inadequate use of tools (three times more likely) and forced posture (two times more likely). Compared to workers with important repetition of movements and workload, the risk of hand injury was lower in both women and men with a moderate repetition and workload (80%, 80%, 95%, and 70%, respectively).

Table 4. Association between ergonomic risks and hand injury, by sex				
	Hand injury			
	Female		**Male**	
Ergonomic risks	**OR**	**CI 95%**	**OR**	**CI 95%**
Harmful work mode vs. right	**3.6***	**1.2-11.1**	1.4	0.6-3.2
Forced posture vs. adequate	**3.2***	**1.3-8.2**	**2.6***	**1.1-6.7**
Moderate repetition vs. important	0.2*	0.03-0.7	0.05*	0.008-0.4
Moderate workload vs. important	0.2*	0.1-0.5	0.3*	0.1-0.8
Inadequate use of tools vs. right	**4.2***	**1.6-11.1**	**2.9***	**1.2-6.9**
*Significant				

5. CONCLUSIONS

We observed a significant association between exposure to ergonomic risks and stressful work and excessive fatigue. This paper presents evidence of the differences between men and women regarding the relationship between non-ergonomic conditions and the presence of a stressful job as well as the production of an excessive degree of fatigue and musculoskeletal injuries.

The associations observed in men were of superior strength and were mainly related to posture, repetitive movements and inappropriate use of tools. The observed differences between men and women may be due to their positions, activities and performed tasks.

Our finding of increased likelihood (between two to three times) of having the effects related to the exposure to ergonomic hazards was substantial, and this situation definitively highlights the need to implement ergonomic measures of prevention and control in the studied work sites.

This is an important argument to promote preventive ergonomics programs at workplaces. The ergonomic interventions should include plans to improve the job design from a psychological perspective to decrease the physical and mental strain (Mahmud, Kenny, Zein, & Hassan, 2011). In conclusion, the exposure to inadequate ergonomic conditions is associated with discomfort and musculoskeletal injuries thus ergonomic interventions should be planned to improve the health of manufacturing industrial workers..

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COMPARATIVE ANALYSIS OF ERGONOMIC EVALUATION METHODS FOR WORKERS STRAIN POSTURE. INTEGRAL METHOD PROPOSAL.

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RESUMEN: INTRODUCCIÓN. La ergonomía es una disciplina científica que ha permitido mejorar las condiciones de confort y comodidad del puesto de trabajo. Los métodos de evaluación ergonómica son herramientas de análisis que se complementan entre sí, y hasta el momento no existe algún método integral, que incluya variables tales como grados de movimientos de cada segmento anatómico, tiempo de exposición, así como variables inherentes al trabajador. OBJETIVO. Comparar las características de los métodos de evaluación ergonómica para sobrecarga postural Ovako Working Analysis System (OWAS) y Rapid Entire Body Assessment (REBA) en trabajadores. MATERIAL Y MÉTODOS. Tipo de estudio cuantitativo. Diseño analítico, transversal, prospectivo. Procedimiento Análisis comparativo de las características de los métodos OWAS y REBA para crear matriz de análisis. RESULTADOS. El método OWAS permite la identificación de una serie de posiciones básicas de espalda, brazos y piernas, que codifica en cada Código de postura, sin embargo, no permite el estudio detallado de la gravedad de cada posición, deja a un lado mano, muñeca y cuello, segmentos anatómicos con amplia movilidad, y que en ocasiones condicionan lesiones a nivel de sistema músculo esquelético. El método OWAS se creó para evaluar el puesto de trabajadores de acero, y el método REBA fue construido para aplicarse en puestos de trabajadores de la salud y otras áreas no especificadas, entre ellas manufactura y electricidad. El método OWAS se utiliza frecuentemente para puestos en donde la postura del tronco es la que más se ve afectada, y el método REBA preferentemente en actividades con banda de producción. OWAS considera si hay trabajo de las extremidades superiores por arriba del hombro, y REBA considera grados de flexión a nivel de articulación de hombro y codo, penalizando si hay abducción y aducción, así como si existe apoyo de dicha extremidad. Por lo anteriormente expuesto, surge la propuesta de un método integral de evaluación ergonómica para sobrecarga postural. CONCLUSIONES. Los métodos de evaluación ergonómica existentes se complementan entre sí durante su aplicación para evaluación de puestos de trabajo, por lo que durante la práctica se requiere el uso de dos o más métodos de evaluación ergonómica con la finalidad de obtener un resultado más objetivo y completo, y a pesar de ello, se hace evidente la falta de un método integral que incluya la mayor parte de las variables a evaluar en los puestos de trabajo, para obtener de manera más confiable el grado de riesgo ergonómico a que está expuesto el trabajador en una actividad específica.

Palabras Clave: Posición no neutra, Análisis Matricial, Métodos Ergonómicos.

ABSTRACT: INTRODUCTION. Ergonomics is a scientific discipline that improves working conditions. The ergonomic methods are analysis tools, but it is needed an integral method that includes more variables for analysis. OBJECTIVE. Compare ergonomic assessment methods that identify strain posture, methods Ovako Working Analysis System (OWAS) y Rapid Entire Body Assessment (REBA). METHODOLOGY. This is a quantitative, analytical, cross sectional and prospective study. It was related to compare the OWAS and REBA in order to design an analysis matrix. RESULTS. The OWAS method was created for analyze basic postures of back, arms and legs, and it establishes a posture code in order to identify the ergonomic risk factor, but it does not mention the posture importance, nor does it consider the hand side, wrist and neck. The REBA method was design in order to identify strain posture in health workers, and other areas no specified as an example manufacture and electricity. OWAS is used in working activities that affect trunk posture, and REBA is applied in activities that work with production side. OWAS considers the importance of working above shoulder and REBA identifies degrees of flexion of shoulder and elbow joints. For de above, an integral method originates, which considers ergonomic evaluation for strain posture. CONCLUSIONS. Ergonomic methods complement each while they are applied at working places. It is needed the use of two or more ergonomic methods that get an objective and most complete result. It is obvious that an integral method is needed, which include the most of the ergonomic variables in order to assess the working postures in a better way.

Keywords: Strain Posture, Matrix Analysis, Ergonomic Methods.

Relevance to Ergonomics: This research is a pioneer in the design of ergonomic assessment methods from an analysis of postural overload and ergonomics variables.

1. INTRODUCTION

Ergonomics is a scientific discipline that has improved the conditions of comfort and convenience at the workplace, and thereby prevent loss of productivity, supporting his study in the ergonomic evaluation methods with different characteristics, and specific variables certain activities. Resulting methods are assessment tools that complement each other, and there is some time to complete, including variables such as the degree of movement of each anatomical segment, exposure time, including inherent worker variables, health status prior, age, gender and others.

The existing methods of ergonomic assessment for evaluating postural overload is not considered to be integral, ie, they do not encompass all the variables assessed in the workplace, considering some aspects individually, but including about three methods to evaluate a specific position, a greater approach to reality may be, and it is possible that more objective results are obtained. Moreover, in relation to any proposals or recommendations for corrective actions, methods ergonomic evaluation of existing postural overload, show very general information and the user interprets the proposal as it considers it appropriate, becoming subjective.

Whereas if a comprehensive evaluation criteria such as taking into account some factors specific to the worker and not only the angles of movement are met, such as age, gender, previous health status, the way in making the object, among others.

2. OBJECTIVE

Compare features ergonomic evaluation methods for strain posture Ovako Working Analysis System (OWAS) and Rapid Entire Body Assessment (REBA) in workers.

3. METHODOLOGY

A quantitative study, analytical, cross-sectional and prospective design. As a comparative test procedure the characteristics REBA and OWAS methods was performed to create a matrix analysis.

A step of analyzing each method considered ergonomic evaluation for desired purposes was established.

4. RESULTS

The OWAS method allows the identification of a number of basic positions back, arms and legs , which encodes each code position , however , does not allow a detailed study of the severity of each position , a left hand hand, wrist and neck, anatomical segments with extensive mobility, and sometimes determine lesions in the musculoskeletal system.

The OWAS method was created to assess the position of steel workers and the REBA method was established to engage in positions of health workers and other unspecified areas including manufacturing and electricity. The OWAS method is often used for positions where the position of the trunk is the most affected, and the method preferably REBA band in production activities . OWAS considered if work related upper limb above the shoulder , and REBA considers degrees of flexion at the shoulder joint and elbow penalizing if abduction and adduction , and if there is support of that limb. For the foregoing reasons , there is a proposal for a comprehensive ergonomic assessment method for postural overload.

5. CONCLUSIONS

The existing ergonomic assessment methods complement each other in evaluating the application for employment, so in practice the use of two or more ergonomic assessment methods in order to obtain a more objective and comprehensive outcome is required, and yet, the lack of a comprehensive approach that includes most of the variables assessed in the workplace, to obtain more reliably the degree of ergonomic risk to the worker is exposed in an activity is evident specific.

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Proposal for a procedure to calculate recovery time for the shoulder in highly repetitive work

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Resumen: Las lesiones musculo-esqueléticas (LME) relacionadas al trabajo industrial resultan en un importante impacto para las empresas. La dinámica de la economía global ha incrementado la demanda de bienes de producción que son manufacturados en líneas de producción, que requieren cada vez mayor eficiencia, exponiendo a los trabajadores a factores de riesgo de LME. El tiempo de recuperación para la fatiga muscular local ha sido uno de los factores que pueden ayudar a prevenir estas lesiones. El presente trabajo presenta un modelo estadístico para realizar el cálculo del tiempo de recuperación considerando variables personales y ocupacionales en lugar de variables biomecánicas como ocurre con la mayoría de los modelos.

Palabras Clave: Tiempo de recuperación, factores de riesgo, Fatiga muscular, modelo estadístico

Abstract; Work related musculoskeletal disorders (WMSD) have a great impact for manufacturing industries. Dynamics on global economy has increased the goods demand which are manufactured on production lines, requiring better efficiencies every day, exposing labor to some risk factors to WMSD. Recovery time on local muscular fatigue has been a control helping to prevent such disorders. This work, aims to present a statistical model to calculate recovery time considering personal and occupational variables instead the biomechanical variables using in mostly of current models.

Keywords: Recovery time, risk factors, local muscular fatigue, statistical model

Relevance to ergonomics. Risk factors for occupational diseases has been a major concern to work ergonomics design, the recovery time barely appears as a it, whenever, due to the industrial growing and people employed there, recovery time should be considered seriously as a potential risk factor. Here is a proposal to calculate this within the cycle time, based in personal and occupational characteristics, making easy to obtain without using moments and maximum voluntary contraction.

1.- Introduction

The twentieth century can be described, in the industrial environment, as the century of growth and consolidation of mass production and can be said that the automobile industry has been the engine of the industrial economy, in Womack et al (1992) is mentioned it as the industry of industries. One important characteristic of the industry is the large number of people employed by itself and associated companies supplying components.

To enhance the importance of the automotive industry in the creation of jobs, a report by the International Labor Organization (ILO, 2000) using the example of the industry in France, establishes the relation of jobs created; the auto industry held 313,000 workers, this has an impact on 773,000 jobs in the manufacturing industry

Even with the influence of the economic crisis, automobile production keeps growing, table 1.1 shows annual vehicle production worldwide. By 2013 there were 87,249,845 new vehicles from manufacturing industry all over the world, occupying around ten million people (the figure corresponds to 39 countries). The International Organization of Motor Vehicle Manufacturer (OICA, 2014) estimated at 5% the automotive industry involving in the creation of jobs worldwide.These data shows the magnitude of the manufacturing industry and its importance to the economy of countries.

Mexico is part of the scenario, with an annual production of 3,052,395 vehicles in 2013 and an occupation of more than 140,000 direct jobs, is among the most productive countries. Making true the proportion of OICA, it would estimate a population employed in industry has been increased to 2.5 million people.

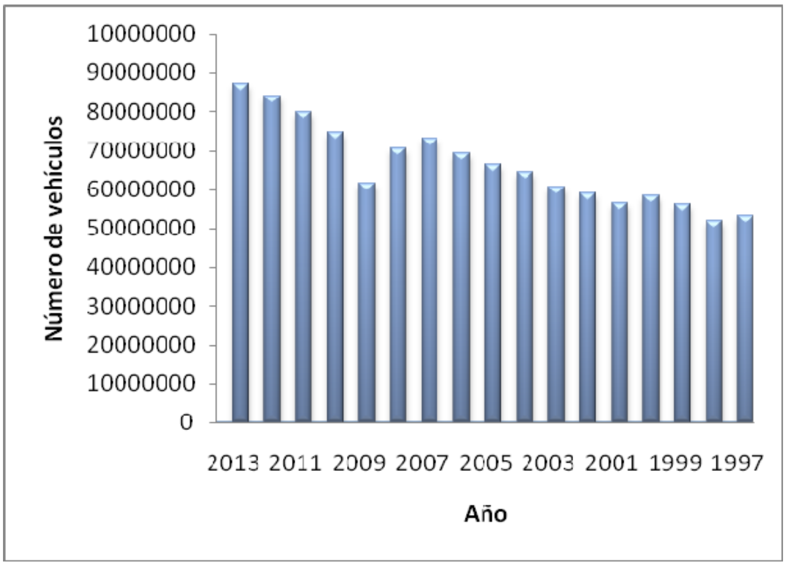

Figure 1. World production of vehicles.
Source: International Organization of Motor Vehicle Manufacturer (OICA, 2013)

The automotive industry allows an overview on employment and manufacturing in general. The relevance is about working in the industry,many of the tasks are doing by the hands as the main elementand this implies the displacement of the upper extremities to generate movement to assembly and to reach materials and tools.

The advancement of technology and industrialization has not stopped, Kumar (2001) mentions the influence on these processes in humans, none of the systems of the body was designed to support occupational stress, power demand, repetition activities or positions taken for prolonged periods of stress on human physical systems, is inherently unnatural.It concludes that, based on a complex multivariable system, there are a vast opportunities for the emergence of unexpected things.

In an attempt to control this type of injuries, it is essential to understand them. Bernard (1997) refers to this type of damage as a situation associated with the birth of industrialization in society, but it is up to the decade of the seventies that the causes of these lesions were studied using epidemiological methods.

In Britain, Muggleton et al (1999) refer to work-related injuries as typical of the twentieth century and considered as the most frequent type of workplace health problems. Of musculoskeletal injuries, those presented in the upper extremities are the most impact, just below the back injuries. The origin of this type of disorders is associated with the demands of the industry to increase productivity, while interest has presented health sector due to the rapid increase of disabilities and their impact on costs, costs for medical care, disability payments, lost workdays, employee turnover, absenteeism indirect costs including labor. Also affects the low morale of the workers and poor work quality. Emphasize the importance of prevention and to warn employers and employees about the problems caused by musculoskeletal injuries and the strategies that can be followed to avoid them.

In the report of the European Agency for Safety and Health at Work (2010),it mentions that musculoskeletal injuries (WMSD) are related to repetitive work, in 60% of cases it has been identified as a cause. The 30% of the WMSD are related to the shoulder-neck region. The WMSD can cost from 0.5% up to 2% of gross domestic product of the countries

According to the Bureau of Labor Statistics (BLS) in the U.U.S.S, in 2005 they lost 1 234.700 workday. In the same study reported 47.861 shoulder disordersand 92,576 disorders due to repetitive motion, 55% affected the wrist. For 2008 the BLS recorded in 29% of injuries in workplaces recognized as WMSD, this involved a median of 10 days lost through injury, the incidence rate is 33 cases per 10,000 full-time workers.In South Korea, 82% of occupational injuries are related to the manufacturing industry, Kun et al (2010).

In Mexico, in 2012 the InstitutoMexicano del Seguro Social (IMSS, 2014) reported 4853disorders related to the work, from these total 503 were classified as “entensopatias”, 430 assumed disorders on theshoulder anatomy and 233 carpal tunnel syndrome, most cases were about industrial and manufacturing companies. In addition, there is a concerning tendency affecting woman workers, around the 80% of these disorders were register on women. Regarding the recent years, the number of cases is increasing. The female population occupied in manufacturing industry, according to INEGI (2013) were 2,660,804women working there.

Can all this be summarized, according to Punnet and Wegman (2004) that the WMSD are common in many countries, with significant costs and impact on quality of life. Although not solely caused by work, constitute a significant proportion of all registered diseases and / or work-related compensable in many countries. Accurate data on the incidence and prevalence of WMSD are difficult to obtain, and official statistics are difficult to compare between countries.

1.1 Fatigue and recovery time.

Fatigue and its effect on the development of human activities has been studied for some time, Rohmert (1973) has been established as the basic reference on the subject. Law and Avin (2010) refer to research in sport, exercise, rehabilitation and ergonomics. In ergonomics is important to identify potential mechanisms or causes of injuries that affect the quality of life of workers and optimize production. Muscle fatigue is one of those processes implicated as a potential cause of WMSD, involving the relation duration of the task and load.

In the same way, Law and Avin (2010) mention endurance time or sustain maximum load (ET: endurance time) as a basic variable to quantify the development of muscle fatigue. The intensity and time of holding (ET) has been widely recognized as nonlinear. The interpretation of this relationship is used to relatively low-intensity activities can be development for long periods of time.

Muscle fatigue can be caused by static or dynamic work, Price (1990), differentiates depending on the frequency of the loads. Mentions as the emergence of local muscle fatigue when energy moderate loads are located in muscle groups.

Fatigue has been associated with physical activity, work is physical activity. Santy and Duwal (2010) found that fatigue occurs equally in performing light or heavy duty work. Pertinently mention the fact on fatigue as a cause of injury that has not been scientifically proven, however, has been the belief of many researchers that a fatigued muscle is more susceptible to injury. Abound in the various definitions of fatigue and lack of consensus on the issue. They conclude that the effect of fatigue can be mitigated more effectively by reducing the daily work. Reduce the daily work relates to allow workers time off to relieve muscle fatigue.

In relation to fatigue and work design, Wiker et al (1990) found that sustained periodic elevations dominant upper extremity above shoulder level caused discomfort and fatigue in light manual work and efforts demands a low level. They mention that dealing with work that requires elevation of the hands above the head should be avoided even in light work.

Developing models for estimating fatigue and recovery times are based on the calculation of maximum resistance (MET) based on the maximum voluntary contraction MVC. Several models are focused on getting the times before fatigue using the MET. There are few models aimed at calculating recovery times. In virtually all models have been used Rohmert curves (1973) for the estimates.

Curves to determine the exposure times Rohmert (1973) assume that efforts below 15% MVC can be repeated without any restriction it means do not produce fatigue. This suggests that the light work, for example manual assembly produces no physical fatigue. This assumption has motivated the search for fatigue prediction models for these jobs.

Mathiassen and Åhsberg (1999) propose a model in addition to the MVC based on age and gender,

$$LnTlim = \beta 0 + \beta 1 + \beta 2 * G * A * M + \beta 3 + \beta 4 + \beta 5 * GA * GM + \beta 6 * AM$$

Where G is the gender, A is the age and M is the MVC. After statistical analysis the final model was ***LnTlim = 3.704 - 0.097M***. Expressed linearly the model is;

$$Tlim = 40{,}609 * e{-.097M}.$$

In the final expression we see that the significant factor was the strength. This text makes a strong criticism of the application of the formula in the sense Rohmert 15% MVC mentioned in the previous paragraph.

The Rohmert formula appears in Garg et al (2002) noting that the MET calculations are over estimated for % MVC <45% andsub estimatedfor %MVC> 45%. Abound on the 15% MVC arguing that for 5% MVC subjects appear as unable to sustain the efforts indefinitely. The study tested for different angles of flexion in the shoulder and elbow for different% MVC for the MET. The formula used is: ***METime = 43.44 * (% MVC) -0.9027*** and statistical analysis mentioned a coefficient $r^2 = 0.8824$.

In the same way, ElAhrache et al (2006) have developed a model to calculate the MET for a given percentile. The following equation is proposed:

$$MET_{p\%} = e^{\left[\ln \mathrm{MAT_{moy}} + z_{p\%} + \ln\left(MET_{MEDIA} + \sigma\left|MET_{MEDIA}\right.\right)\right]}$$

Applying equation results represent the maximum time, in minutes, for different values of resistance of% MVC.

The model can be generalized to different parts of the human. For example, the average time for the 10% MET shoulder MVC is 17.75 minutes. For 15% MVC average time is 9.19 minutes.

In El Ahrache et al (2006) as part of its analysis also considered models and MathiassenandÅhsberg(1999) and Garg et al (2002) model:
Sato (1984);$0.398*^{fMVC-1.29}$and Rohmert FMVC (1986); $.2995*fMVC^{-1.658}$.

It has been mentioned that the formulas can be applied to different human joints.

Rose et al (2000) designed the model for the shoulder, adaptation is:
$MET = 20.6*e^{-6.04Mn}$, where Mn is the resultant moment in the elbow joint. Alternatively propose a model to calculate the time of resumption of a task. This refers to the time period of rest between tasks. This is different to the concept of recovery time. The resume time is given by;

$Tr = 0.0167\ e^{8.84/(1.46+0.346Mn)}$where ***Mn*** is the resultant moment.

LópezMillán (2013) found a statistical model that estimate recovery time for the shoulder, it does not require for physical calculations, just need some personal and operational variables; gender (0 for women and 1 for men), height (in centimeters), weight (in kilograms), effort time (sustained posture on the shoulder, in seconds), force (usually weight of tools or materials). The statistical model is:

$$RT=e^{-8.27-2.06Gender+.0375Efforttime+.0318Force+.0284Height+.0116Weight}$$

Where RT is the recovery time, in seconds, needed by the shoulder in order to minimize the local fatigue. The point here is that recovery time could be combined with productive time, this is, recovery time is a lapse of time while shoulder is in neutral posture, may be a flexion less than 45 degrees respect the vertical. The model was developed using lineal regression and de values for coefficients were***r=0.972***and***r^2=0.946***, that means that there is a little percent of variation unexplained for the model.

Fatigue is a common phenomenon in industrial work and even when there is no evidence for a relationship with WMSD, it was considered important in studies for MET, maximum endurance time. Most MET models are based on percentages of maximum voluntary contraction% MVC. In the literature review only Rose et al (2000) used different concepts.

Considering the background this work aimed to develop a statistical model through a set of variables and their relationship with fatigue and recovery times, in this case, for the shoulder muscle group.

3. METHOD

The calculation of recovery time for the shoulder will be using the statistical model in LópezMillán (2013). The result on recovery time are based on Rohmert (1973) formula, but the procedure to get it is different. There is not necessary calculate the moment for the shoulder and the maximum voluntary contraction (MVC) which is not necessary easy to obtain. Just need the general data for people, gender, height, weight, effort time and force being exerted.

Recovery time is calculated as follow:

Get the data corresponding for each subject; gender (0 for woman or 1 for man), height on centimeters and weight on kilograms. Observe a task and get the time, in seconds, for sustained posture on the shoulder and get the weight (on lbs) for tool or for materials or for insertion or force, push or pull. The last data can be obtained using a dynamometer.

Introduce each data on the following regression equation:

$$RT_{LR=}-8.27-2.06Gender+0.375Efforttime+0.318Force+.0284Height+.0116Weight \quad (Eq.1)$$

Once the recovery time for linear regression is obtained, use the result as the exponent for the ***e*** number. This procedure can be realized with a scientific calculator or using a Microsoft® Excel® function. The final result is expressed on seconds and it means the lapse of time that the shoulder needs on neutral position for every minute of work.

For instance, consider a women with 164.5 cm of height and 63.5 kg doing a task implicating a shoulder elevation for 6 seconds to extend the whole arm and using a 5 lbs weight pneumatic tool. First introduce data on equation 1

$$\mathbf{RT= -8.27-(2.06*0)+(0.375*6)+(0.318*5)+(0.0284*164.5)+(0.116*63.5)=0.9784\ sec}$$

Then introduce result from equation 1 as the exponent for the e number:

$$\mathbf{RT_N= e^{.9784} or\ RT_N= 2.66\ sec.}$$

This means that for every 6 seconds of elevation on the shoulder loading a 5 lbs tool should be 2.66 seconds for recovery time. The recovery time could be within the tasks doing repetitively on a minute cycle time but on a shoulder position in an angle below the 45 degrees respect the trunk.

The difference between women and men on recovery time result is sensible by the model. If used the data for the last example but change the gender, the result is as follow:

$$\mathbf{RT= -8.27-(2.06*1)+(0.375*6)+(0.318*5)+(0.0284*164.5)+(0.116*63.5)=-1.081\ sec}$$

Introducing the result from equation 1 as the exponent for the e number:

$$\mathbf{RT_N= e^{-1.081}\ or\ RT_N= 0.34\ sec.}$$

It means that there is almost not recovery time for a men.

3. CONCLUSIONS.

Is well known the risk factors for the occurrence of Work Related Musculo-Skeletal Disorders (WRMSD), those are awkward posture, basically shoulder elevation, the repetition rate for the awkward posture and the time the posture is held, Bernard et al (1997), Sommerich et al (1993) are coincident with the risk factors, but they included the insufficient recovery time as a risk factor too, especially on a long term of exposition. Experience has shown the importance to maintain in control the risk factors could decrease the rate of disorders and consequently lower the day lost and the cost of injuries.

The statistical model proposal is pretended to become and additional tool for ergonomists made a little bit easier the recovery time calculations from a physical variables like moment and maximum voluntary contractions to personal and operational variables by and easy procedure to get recovery time referencing to a 60 seconds cycle time.

Additionally, is used the local muscular fatigue concept, introduced by Chaffin et al (1999), the recovery time is a factor to minimize that and consequently reduce the risk of an WRMSD without the need to supply additional time for recovery, becoming the recovery time on a double added value, first for lower the risk and second by recovery within the cycle time.

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DETERMINATION OF PHYSICAL FATIGUE ON MUNICIPAL WORKERS

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Resumen: Debido al crecimiento de las empresas a nivel internacional se busca innovar su tecnología para ofrecer mejor calidad en los servicios y mejores niveles de productividad; La promotora ambiental de la laguna se ha visto en la necesidad de reformarse, por lo que se genero el proceso de barrido manual división Mochis-Guasave iniciativa que surgió en el departamento de servicios y operaciones. En Ahome se producen diariamente 450 toneladas de basura (promotora ambiental, 2009) de los cuales 280 a 300 provienen de Los Mochis. Esto representa el 22.1% del a basura acumulada en todo el Estado. Debido a esto, surge la necesidad de realizar un estudio para Determinar fatiga física de los trabajadores en el barrido manual y analizar los síntomas subjetivos que nos permitirá detectar áreas en las que hay que mejorar y a su vez crear métodos o herramientas para disminuir incapacidades y el desgaste del trabajador**;** Los sujetos de investigación fueron 14 que realizan barrido manual .La metodología que se aplico son los métodos subjetivos de evaluación de fatiga Yoshitake Y 4 puntos de Luke, además el mapeo de Corllet & Bishop para determinar en qué partes del cuerpo de los trabajadores se presentan molestias y/o dolor. Los resultados del cuestionario Yoshitake muestran que la frecuencia de quejas de fatiga fue mayor al salir del turno de trabajo que al inicio. Después de analizar los resultados del mapeo de Corlett &Bishop se detectó que la mayoría de los trabajadores presenta dolor en cabeza, muñecas y manos y hombros. Se concluye que se hace imprescindible y urgente realizar investigaciones de tipo antropométrico para verificar el diseño del carro utilizado para realizar esta actividad lo cual va a permitir elevar la seguridad y la productividad del personal que labora en esta área de la empresa.

Palabras Claves: Fatiga, Barrido Manual, Yoshitake

Abstract: Due to the growth of international companies looking for innovative technology to deliver better quality services and improved levels of productivity; Environmental developer of the lagoon has been in need of reform, so the process was generated division Manual scanning Mochis - Guasave initiative that emerged in the service department and operations. In Ahome produced 450 tons of garbage daily (environmental developer, 2009) of which 280 to 300 are from Los Mochis. This represents a 22.1 % of the accumulated rubbish around the state. Because of this, the need for a study to determine physical fatigue of workers in manual scan and analyze subjective symptoms that detects areas that need improvement and in turn create methods or tools to reduce disability and worker wear , research subjects were performing manual sweeping 14 the methodology applied are subjective methods of evaluation of fatigue Yoshitake Y 4 Luke points also mapping Corllet & Bishop to determine which parts of the body . workers discomfort and / or pain occur . Yoshitake questionnaire results show that the frequency of complaints of fatigue was higher when leaving the work shift at the beginning. After analyzing the results of the mapping Corlett & Bishop was found that most workers have pain in head, hands and wrists and shoulders. We conclude that it is essential and urgent to conduct research to verify anthropometric type design truck used for this activity which will allow increase safety and productivity of staff working in this area of the business.

Keywords: Fatigue, Manual Sweep, Yoshitake

Relevance to ergonomics: To know if fatigue is a cause of high rotation of staff and propose some recommendation to the company in order to increase the quality and productivity.

1. INTRODUCTION

Due to the growth of businesses and the public sector being generated internationally and as a result of greater specialization in each of their areas, looking to innovate their technology to provide better quality services and improved levels of productivity; environmental developer of the lagoon has been in need of reform, so the division Manual scanning process Mochis-Guasave initiative started in the service department operations and genre.

In Ahome produced 450 tons of garbage daily (environmental developer, 2009) of which 280 to 300 are from Los Mochis. This represents a 22.1 % of the accumulated rubbish around the state. (Atlas of natural hazards in the city of Los Mochis, 2012). Because of this the H. Ayuntamiento de Ahome began a program of renovation and cleaning of parks and gardens , standing in the city center 170 dumpsters pedestrian with a capacity of 100 liters , so that garbage to fill each of these gives an equivalent weight of 80 Kg the Promotora Ambiental SAB de la Laguna de C.V. the task of keeping clean these containers In addition to daily scanning staff has a hard working day, hence the vast amount of garbage generated daily in the main square of the city , road hazards , high temperatures, absorption occurred powders or solvents among others. Reflecting muscoesqueléticas injuries and illnesses among workers, generating economic and not very favorable for the company service situations. Seeking a study of physical fatigue to reduce injuries , workplace hazards , disabilities that affect the quality of life of the worker. And the motivation to achieve greater productivity and service quality.

2. OBJECTIVES

Determine the frequency of complaints of fatigue and analyze the subjective symptoms of fatigue presented in street sweepers from Downtown Los Mochis, Sinaloa. This research calculates general and weekly frequencies with a sample of 14 subjects.

3. METHODOLOGY

This work is based on the survey presented by H. Yoshitake studies (1978), which were intended to show the three characteristic patterns of subjective symptoms of fatigue, drowsiness and dullness, difficulty of concentration and projection of physical impairment. It also makes use of the methodology used by Dagnino, Leyva & Ramirez (2011) and Estrada, Leyva & Ramirez (2009), for the determination of physical fatigue.

Anthropometric measures are required to know the ergonomic conditions for workers to do their job, performing ergonomic redesign of manual sweeping carriage relying on anthropometric data. A study was applied to visualize the level of worker fatigue and possible DTA 's. in the activities of manual sweeping. There are 14 employees from 40 to 65, are distributed in two shifts, 8 are on the day shift and the night shift 6, Schedules Shift:
Daytime: 7:00 am- 4:00 pm (1 hr of food.)
Evening: 5:00 pm - 2:00 am approx. (1 hr for lunch)
In both shifts manually sweeping is done in 1290 miles between all workers. They are also responsible for collecting the bags of containers that are located in different parts of the city of Los Mochis.

To perform the measurement of fatigue symptoms and possible DTA methods are used:

- Symptom Questionnaire YOSHITAKE
- mapping format Corlett & Bishop, for possible DTA 'S

4. RESULTS

The objective was established as determining the frequency of complaints of fatigue and analyzes the subjective symptoms of fatigue from the Yoshitake questionnaire applied to 14 street sweepers this is due to the fact that those were the participants available for research development.

Data shows the following results: the sample is composed exclusively of men, who work 7 days a week for 8 hours daily, more than half of the workers smoke and consume alcohol.

The application of the questionnaire Yoshitake (see Tables 1 and 2), was divided into three categories, and it resulted in a frequency of 1.21 % for drowsiness and dullness, 2.32 % for difficulty of concentration and 0.43 % for projection of physical impairment at arrival time (see Table 3).

At departure time, drowsiness and dullness frequency increased to 4.54 %, 2.99 % corresponded to difficulty of concentration and 2.69 % frequency was directed towards projection of physical impairment (see Table 3). For a weekly analysis of the frequencies presented, see Table 4.

During the analysis of all symptoms presented by street sweeper, 30.57% and 44.4% of all symptoms are related to drowsiness and dullness at arrival and departure time, respectively, while 58.57% (arrival time) and 29.30% (departure time) of symptoms is related to the difficulty of concentration. The projection of physical impairment covered the 10.86% of all symptoms, at arrival time, and 26.30% at departure time (see Table 5 and Figures 1 and 2).

Table 1. Yoshitake Questionnaire Results Matrix (Arrival time)

	QUESTIONNAIRE YOSHITAKE (Arrival Time)								
	WEEK 1			WEEK 2			WEEK 3		
NO.	Drowsiness and dullness	Difficulty of concentration	Physical impairment	Drowsiness and dullness	Difficulty of concentration	Physical impairment	Drowsiness and dullness	Difficulty of concentration	Physical impairment
1	3	4	0	1	2	0	7	3	0
2	3	6	0	0	4	0	1	3	0
3	4	8	0	4	0	0	3	7	0
4	3	5	1	2	6	6	2	10	2
5	5	5	2	0	2	0	2	9	0
6	3	5	1	4	5	3	7	1	0
7	2	10	2	0	2	0	4	5	0
8	9	9	0	1	2	0	4	6	1
9	3	3	0	1	4	2	2	11	0
10	2	6	0	0	1	1	2	8	5
11	1	4	0	0	3	0	1	4	1
12	6	12	5	7	10	1	1	7	1
13	1	2	0	0	0	1	0	4	1
14	5	3	0	1	2	2	0	2	0
TOTAL	50	82	11	21	43	16	36	80	11

Table 2. Yoshitake Questionnaire Results Matrix (Departure time)

	QUESTIONNAIRE YOSHITAKE (Departure Time)								
	WEEK 1			WEEK 2			WEEK 3		
NO.	Drowsiness and dullness	Difficulty of concentration	Physical impairment	Drowsiness and dullness	Difficulty of concentration	Physical impairment	Drowsiness and dullness	Difficulty of concentration	Physical impairment
1	9	12	5	13	8	8	5	6	3
2	9	8	7	7	3	4	7	6	3
3	12	6	7	5	5	1	15	7	6
4	11	4	2	3	16	12	8	1	5
5	9	9	10	8	5	6	12	8	4
6	11	5	7	9	17	15	7	0	7
7	5	3	5	6	4	2	10	4	1
8	5	0	7	6	4	5	4	2	5

9	4	1	5	8	3	4	10	2	4
10	7	4	5	9	5	6	18	6	11
11	7	3	5	11	5	3	18	7	4
12	11	8	9	5	8	4	25	13	9
13	14	8	6	4	3	2	17	13	6
14	15	18	8	8	5	5	13	9	4
TOTAL	129	89	88	102	91	77	169	84	72

Table 3. Frequency of Complaint of Fatigue (Arrival and Departure time)

ARRIVAL TIME		
Symptoms	**Frequency**	**Percent**
Drowsiness and dullness	107	1.21
Difficulty of concentration	205	2.32
Physical impairment	38	0.43
No complaints	8470	96.03
TOTAL	8820	100
DEPARTURE TIME		
Symptoms	**Frequency**	**Percent**
Drowsiness and dullness	400	4.54
Difficulty of concentration	264	2.99
Physical impairment	237	2.69
No complaints	7919	89.78
TOTAL	8820	100.00

Table 4. Frequency of Complaint of Fatigue (Weekly analysis)

ANALYSIS PER WEEK (ARRIVAL TIME)			
Symptoms	**Week 1**	**Week 2**	**Week 3**
Drowsiness and dullness	1.70	0.71	1.22
Difficulty of concentration	2.79	1.46	2.72
Physical impairment	0.37	0.54	0.37
TOTAL	4.86	2.72	4.32
ANALYSIS PER WEEK (DEPARTURE TIME)			
Symptoms	**Week 1**	**Week 2**	**Week 3**
Drowsiness and dullness	4.39	3.47	5.75
Difficulty of concentration	3.03	3.10	2.86
Physical impairment	2.99	2.62	2.45
TOTAL	10.41	9.18	11.05

Table 5. Total Symptoms Analysis (Arrival and departure time)

ARRIVAL TIME		
Symptoms	**Frequency**	**Proportion**
Drowsiness and dullness	107	30.57
Difficulty of concentration	205	58.57
Physical impairment	38	10.86
TOTAL	350	100
DEPARTURE TIME		
Symptoms	**Frequency**	**Proportion**
Drowsiness and dullness	400	44.40
Difficulty of concentration	264	29.30
Physical impairment	237	26.30
TOTAL	901	100

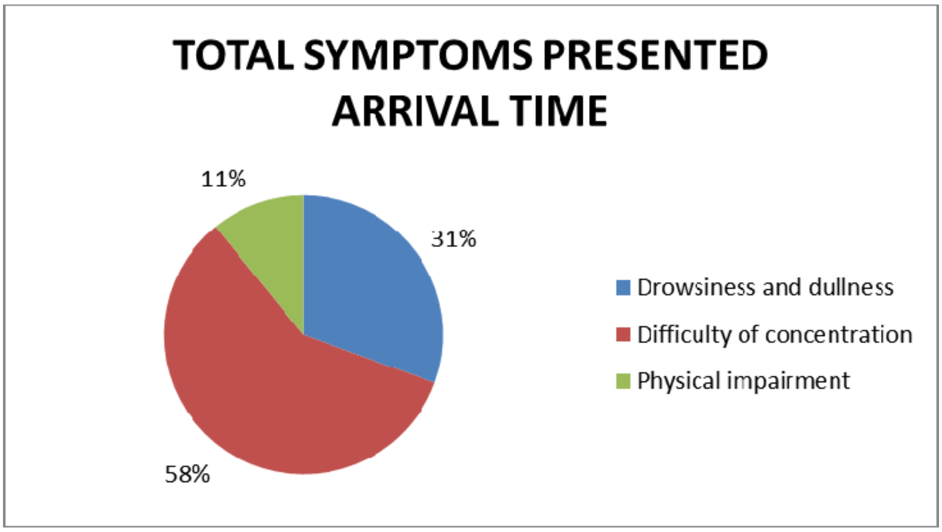

Figure 1. Symptoms experienced (Arrival time)

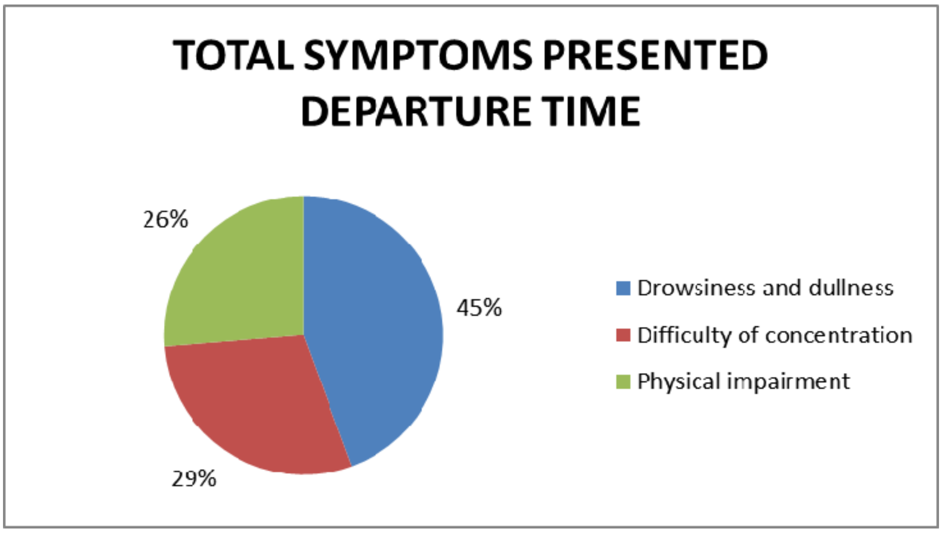

Figure 2. Symptoms experienced (Departure time)

Table 6. Symptoms experienced – Week 1

ARRIVAL TIME (Week 1)		
Symptoms	**Frequency**	**Proportion**
Drowsiness and dullness	50	34.97
Difficulty of concentration	82	57.34
Physical impairment	11	7.69
TOTAL	143	100
DEPARTURE TIME (Week 1)		
Symptoms	**Frequency**	**Proportion**
Drowsiness and dullness	129	42.16
Difficulty of concentration	89	29.08
Physical impairment	88	28.76
TOTAL	306	100

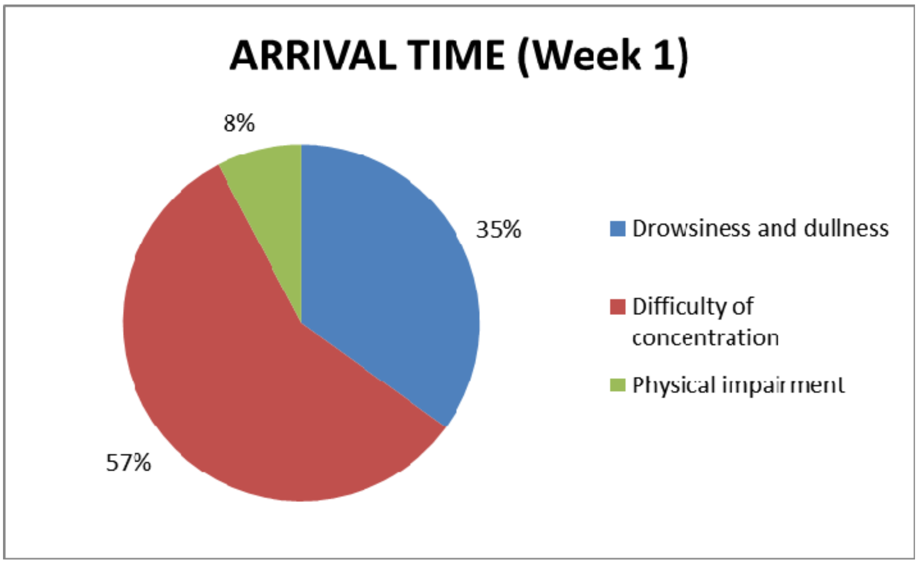

Figure 3. Symptoms experienced – Week 1 (Arrival time)

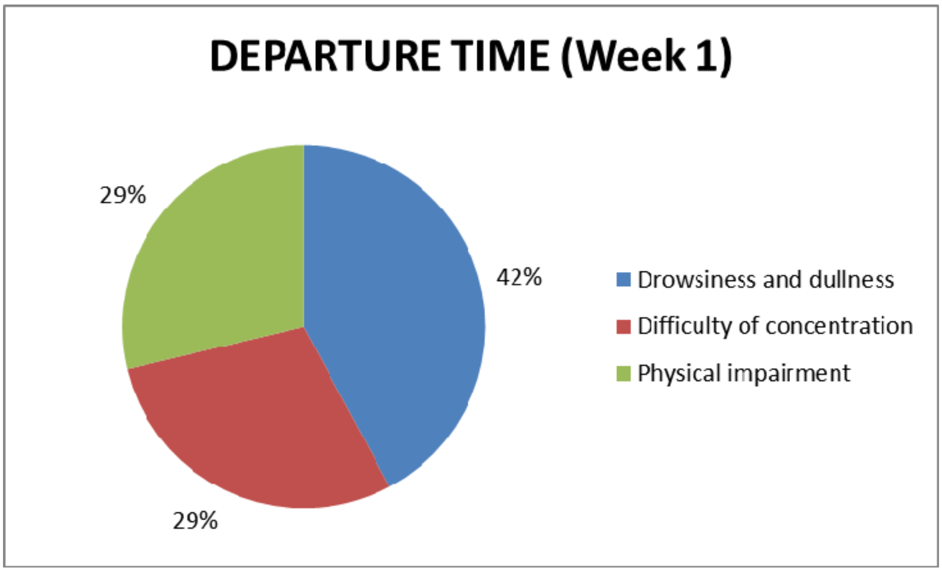

Figure 4. Symptoms experienced – Week 1 (Departure time)

Table 7. Symptoms experienced – Week 2

ARRIVAL TIME (Week 2)		
Symptoms	**Frequency**	**Proportion**
Drowsiness and dullness	21	26.25
Difficulty of concentration	43	53.75
Physical impairment	16	20.00
TOTAL	80	100

DEPARTURE TIME (Week 2)		
Symptoms	**Frequency**	**Proportion**
Drowsiness and dullness	102	37.78
Difficulty of concentration	91	33.70
Physical impairment	77	28.52
TOTAL	270	100

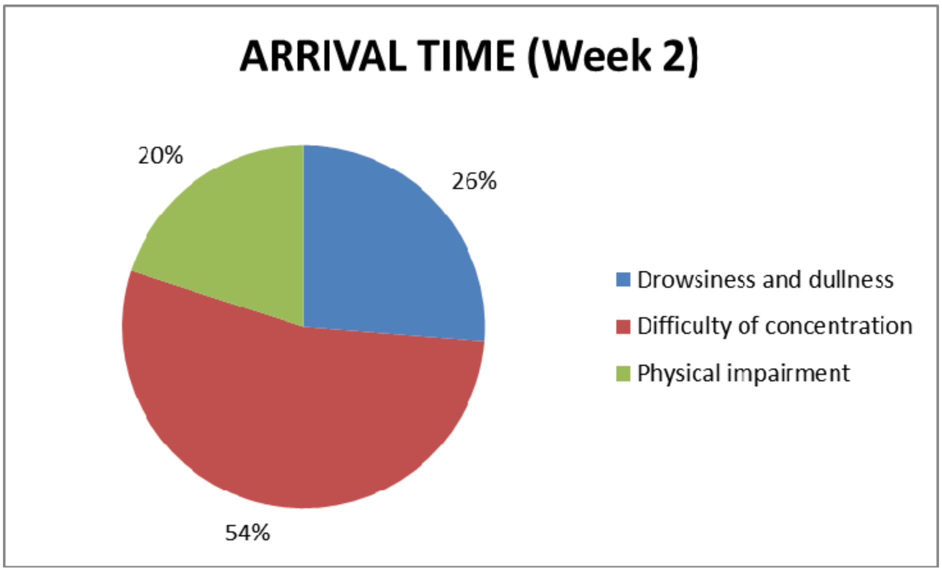

Figure 5. Symptoms experienced – Week 2 (Arrival time)

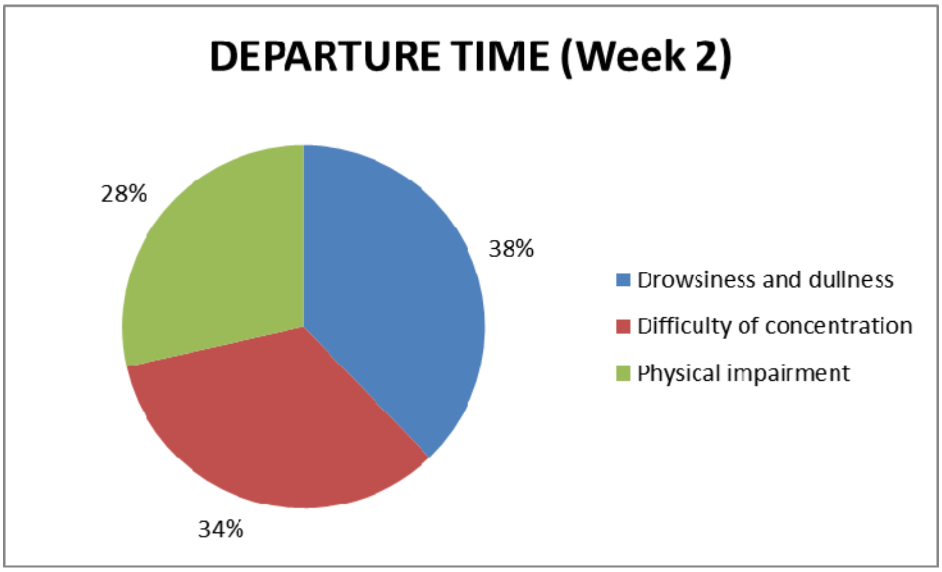

Figure 6. Symptoms experienced – Week 2 (Departure time)

Table 8. Symptoms experienced – Week 3

ARRIVAL TIME (Week 3)		
Symptoms	**Frequency**	**Proportion**
Drowsiness and dullness	36	28.35
Difficulty of concentration	80	62.99
Physical impairment	11	8.66
TOTAL	127	100
DEPARTURE TIME (Week 3)		
Symptoms	**Frequency**	**Proportion**
Drowsiness and dullness	169	52.00
Difficulty of concentration	84	25.85
Physical impairment	72	22.15
TOTAL	325	100

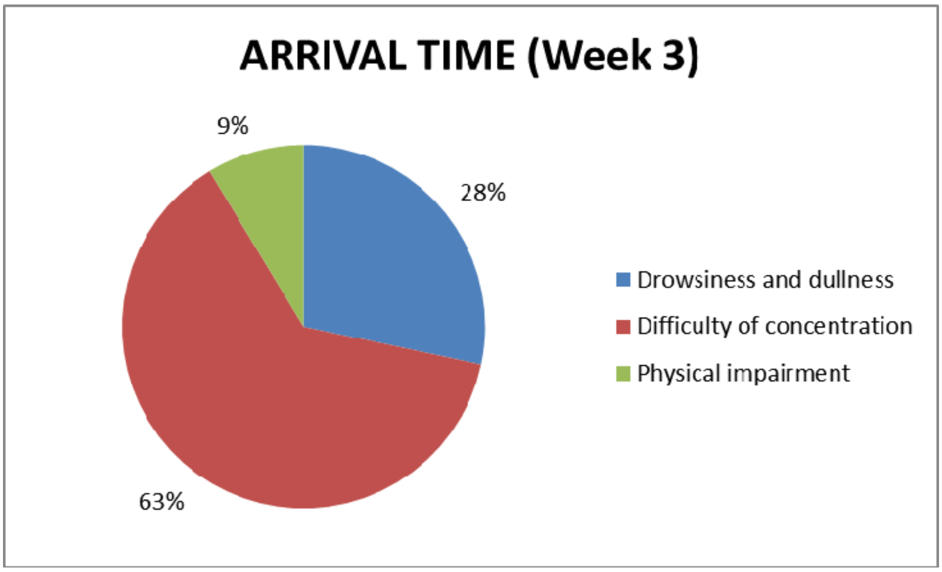

Figure 7. Symptoms experienced – Week 3 (Arrival time)

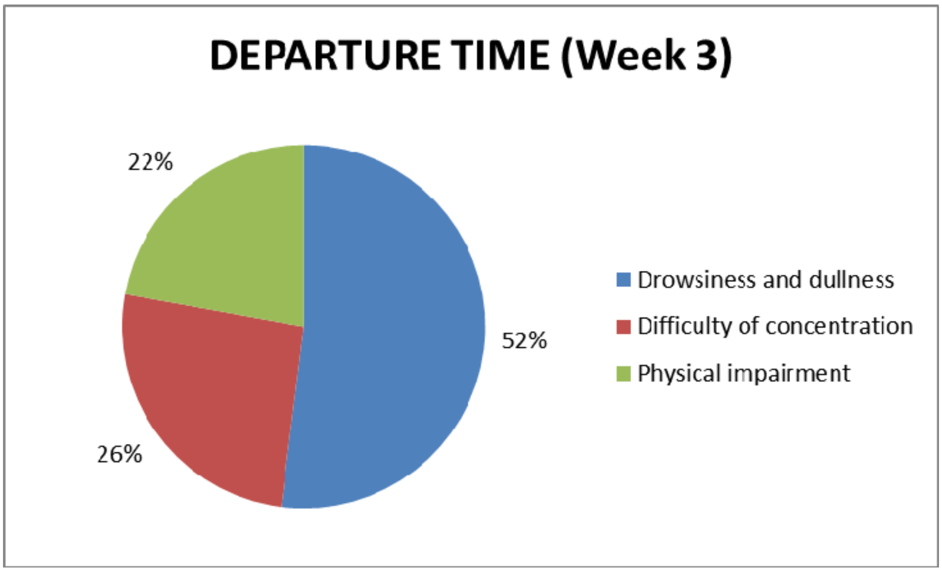

Figure 8. Symptoms experienced – Week 3 (Departure time)

5. DISCUSSION

In general, the frequencies obtained did not exceeded 10 %, considering separately the dullness, concentration and physical impairment. All frequencies showed an increase at departure time.

Additionally, at arrived time most of the symptoms correspond to difficult of concentration, next drowsiness and dullness and physical impairment at third place, but at departure time the main symptom is related with drowsiness and dullness, next difficulty of concentration and physical impairment at third place. Talking with the street sweepers they told us that the distance sweeped is approximately 2 kilometers dialy.

It is highly recommended to follow a healthy diet, exercise regularly, seek hobbies outside of work and use mental relaxation techniques. It also provides some guidelines to reduce the risk of exhaustion:

1. Establish an appropriate plan and time management and set realistic daily goals.
2. Learn some relaxation techniques and practice them regularly.
3. Take regular rest periods (breaks).
4. Follow a balanced diet and do not skip meals.
5. Develop a hobby that allows enjoying nature or playing sports.

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ERGONOMIC ANALYSIS IN THE MACHINING PROCESS OF A COMPANY

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Resumen: La ergonomía es la ciencia encargada de encontrar la correcta relación entre las personas, las características físicas de las máquinas y herramientas que manejan y el ambiente en el que se desempeñan. Los análisis ergonómicos son muy importantes ya que analizan de una forma detallada las actividades que se realizan en el día a día de los seres humanos. La finalidad de este trabajo es determinar si las actividades que conforman el proceso de maquinado representan un riesgo ergonómico para los empleados que laboran en el área. Para ello se realizó un análisis de las condiciones de trabajo y se aplicaron los métodos NIOSH, para evaluar la carga y REBA, para evaluar las distintas posturas adoptadas por el operadorpara realizar su trabajo. Una vez determinado el nivel de riesgo en el que se encuentran las actividades, se presentarán alternativas de mejora en el puesto, para disminuir o eliminar los riesgos, contribuyendo al cuidado postural de las personas y beneficiando también a la empresa, es decir generando un ganar- ganar entre las partes.

Palabras Clave: Ergonomía, Proceso, Lesiones.

Abstract: Ergonomics is the science that finds the correct relationship between people, physical characteristics of the machines and tools that are handled by the people and the environment in which they operate. Ergonomic analysis are very important because they provide detail for the activities that are made daily by the human beings. The purpose of this study is to determine if the activities that are part of the machining process represent an ergonomic hazard to employees working in the area. With that in mind, an analysis of the work conditions was performed and the NIOSH and REBA methods were applied to evaluate the load and the postures used by the operator to do the job, respectively. After determining the risk level for the activities, will be presented improvement alternatives for the work station, to reduce or eliminate the risks, contributing to postural care of the people and also giving a benefit to the company, generating a state of win – win between the two parts.

Keywords: Ergonomics, Process, Injuries.

Relevance to Ergonomics: Highlight the importance of ergonomic activities that are performed in everyday analysis.

1. INTRODUCTION

Production systems are directly related to the employee, and efficiency is on function with the environment, when this interaction is structured in the repetition of physically demanding activities, monotony, uncomfortable postures, mechanical stress, etc., lead to a risk, this is why the analysis of work stations, ergonomics, has been established as an important tool of industrial engineering (Escárcega, Medina, Vázquez, 2009).

According to statistics from InstitutoMexicano del Seguro Social, it is indicated that in Sonora people have presented lesions in at least 1,371 men and 662 women in the abdomen area, spine and pelvis due to lift, push and / or pull heavy objects, given the fact of doing this kind of activities, increases the risk of chronic, recurrent or permanent injuries, with the consequential loss of workdays (Memoirs statistics IMSS, 2012).

For the case study, the machining area has a set time of 1.5 hours average to make the tooling change of codes that are being handled. The range of these codesgoes from 54 inches (in) in diameter up to 74, weightingfrom 18 kilograms (kg) to 30. These operations are manual and should be made between two people to facilitate lifting, however, people are not always available, and then the work is done by one operator.

The operator remains stand in front of the machining, operating and repetitively assembling the piece; due to disabilities that have been presented they are late with 18 percent of production hours. During the first two months of 2013, 46 percent of disabilities have been filed by back injuries.

From the above we have the following approach: Do the operations of the machining process represent a risk to the physical safety of the operators?.

2. OBJECTIVE

To evaluate the tasks that are part of the machining process to determine their risk level and reduce disabilitiesby back injuries.

3. METHODOLOGY

For this study purposes an adaptation was made of the steps suggested by Llaneza (2007) and NIOSH and REBA evaluation methods by Asencio and Diego(2013). The steps used are: 1) Identify the study area; 2) Analyze the tasks observing the area and collecting data related to it; 3) Assess risk factors, analyzing the characteristics of the tasks that could generate; 4) Apply NIOSH method according to characteristics of the process tasks ; 5) Determine the riskiest activities through the five basic questions by

Diego González (2007) 6) Evaluate the body posture using the REBA method; 7) Develop a corrective plan for the improvement alternatives.

4. RESULTS

The identified area for carrying out the study are the operations that are part of the machining, with a code which has a diameter of 74 in and weighting 30 kg . Analyzing the tasks, it was realized that the activities performed by the operator are lifting and positioning metal objects. As mentioned before 46 percent of disabilities that have been presented are back injury.

For the activity lifting tools are not being used, the space is wide for carrying out the operation, the load is stable , the lifting is done with both hands , the movement of the operation is similar to assemble and disassemble the piece and the movement is not fast because of the risk of damaging the part. All codes are positioned at a fixed height of 135 cm, so it is a simple task. The piece requires positioning accuracy and should be positioned vertically to the machine to take it as a reference point of star, the positioning duration is 9 seconds. Because the machining process has a standard of 32 minutes, this lifting is repeated 20 times by shift, where this last has a duration of 11 hours.

Following the steps suggested by Asencio and Diego (2013), the following table is used to obtain the multiplier:

Table 1. Multipliers obtained Fate

Multiplier	EarnedValue
Constante de carga (LC)	23
Horizontal multiplier (HM)	1.00
Vertical multiplier (VM)	0.8245
Multiplier offset (DM)	1.2987
Asymmetricmultiplier (AM)	0.7568
FrequencyMultiplier (FM)	0.85
CouplingMultiplier (CM)	1.00
Total	
Recommendedweightlimit (RWL)	15.84 Kg
Indexsurvey (LI)	1.89

A rising rate of 1.89 was obtained, so the operation falls within the risk level two, namely, the task can cause problems in workers, so it is convenient to study the work station and make appropriate modifications.

To continue the study, the process was divided into five activities: take the part, lift, pre-place, position and fit, each activity went through the five basic questions Gonzalez (2007), resulting hazardous tasks the operator's posture when takes the piece, and also placing and holding the piece in the chuck. All three activities were analyzed with the

REBA method for the postures, in this evaluation the left side of the operator was took as a reference because the work force is concentrated at this side of the body.

To makethe positioning operation by the operator to take piece, the trunk is flexed 90°, the legs are in bilateral support without flexion, the neck angle doesn't show any flexion, the arm position is 90° extended without elevation or abduction of the shoulder, the forearm shows an angle of 30° and the wrists show a 20° flexion. During the evaluation, six points punctuation was obtained, indicating that it is medium risk and change soon to implement improvement proposals for this kind of activity, as shown in Figure 1.

Intheoperationof placing the pieceon the chuck, a torsion is made by the trunk generating a 41° angle, and there is an extremity inclination, there is a bilateral support from the legs, without significant angles, the neck shows a 23° torsion, the wrists shows a 47° flexion according to the forearm, and an abducted arm is showed in complain with a shoulder rise at an angle above 90°, obtaining a final punctuation often, which indicates high risk, as shown in Figure 2.

Subjecting the piece in the chuck, it has an angle of 34° with trunk torsion, there is bilateral support by the legs, a rising for the arm is showed in a 115° angle to realize the adjustment operation altogether with the shoulder rising, forearmis flexedless than60°andthe wristshows abendingunderforearmless than 18°; therefore was obtained nine final punctuation, which indicates high risk, as shown in Figure 3.

Based on the obtained results, it is known that there is a risk doing the machined area activities, especially in the lumbar area; that's why a corrective plan was proposed, heavy material will be used with cranes and cars to transport and lifting of the piece, all of this with the final function of evading non ergonomic moves, needing a $58,583.49 investment.

Actually, the investment is in accepting process, but also training courses were carried out on loads manipulation in accord to the InstitutoNacional de Seguridad e Higiene en el trabajo, to reduce lumbar injurydisabilities, there were used some protection strips too, and visual aids were established like a warning advise of lifting, in the area that the machines are used according to NOM-026-STPS-2008.

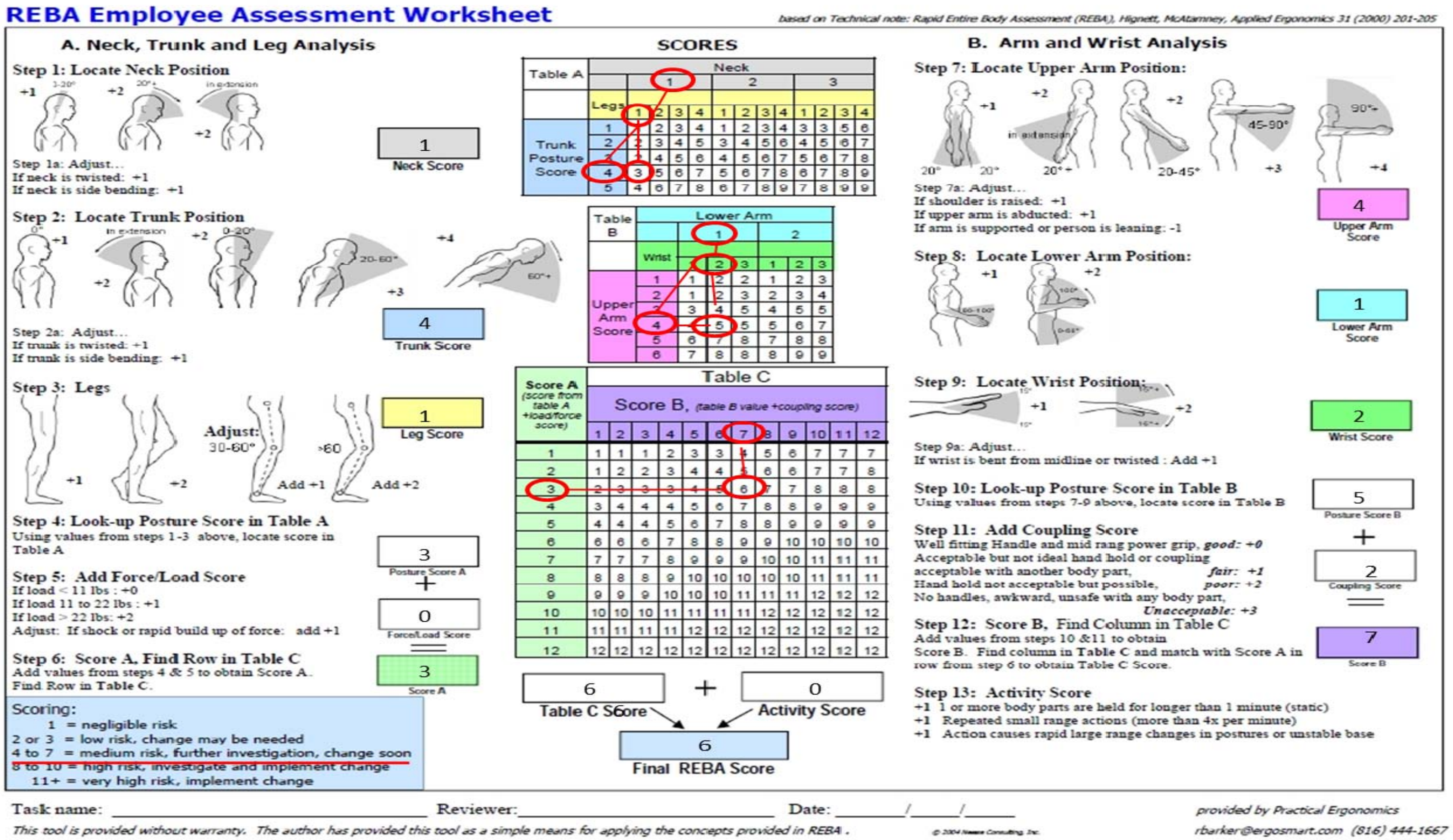

Figure 1. REBA evaluation of taken the piece.
Source: Format taken from Hignett&Mcatamney (2000), 2013.

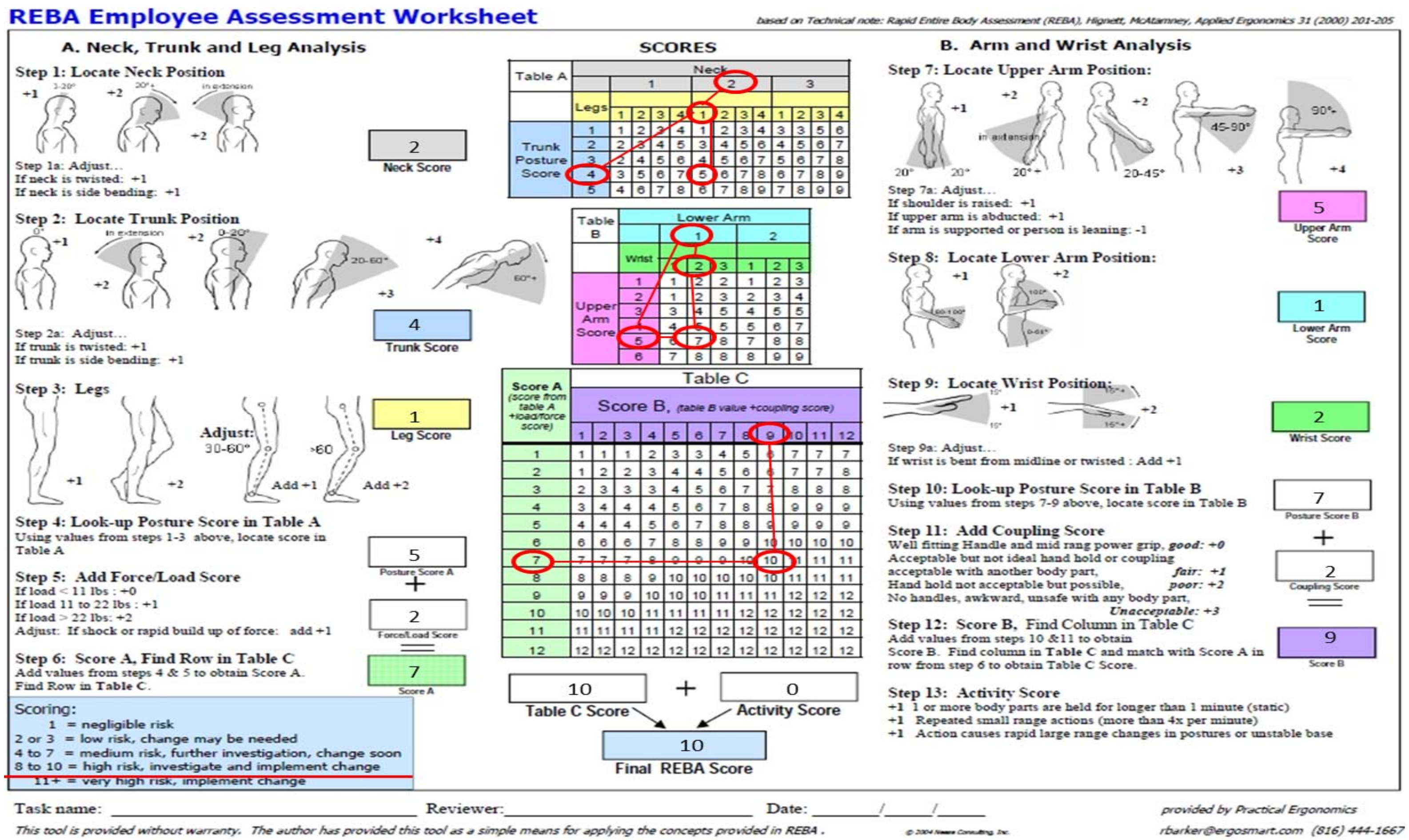

Figure 2. REBA evaluation of the positioning of the work piece in the chuck.
Source: Format taken from Hignett&Mcatamney (2000), 2013.

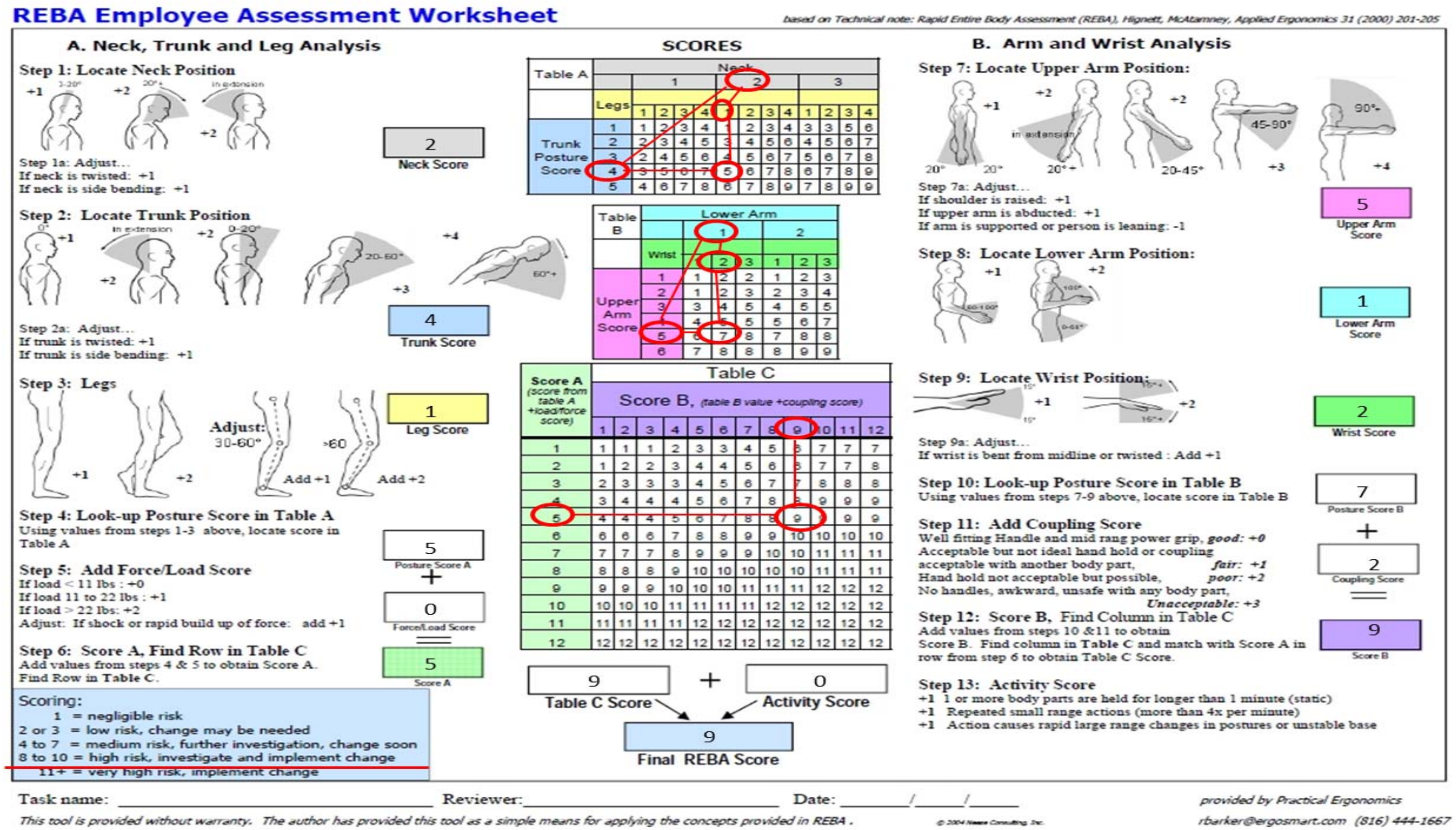

Figure 3. REBA Assessment of clamping the piece in position in the chuck.
Source: Format taken from Hignett&Mcatamney (2000), 2013.

5. CONCLUSIONS

Afterthe development of this study, it was conclude that the machined activities generate a significant risk to the operator; adopting the improvement proposals will reduce disabilities in the area, moreover will increase the operator performance. It is recommended that once implemented, the analysis methods usedbefore be applied again, to corroborate that the risk has reduced or has gone; the postures and moves that were used in the process should be checked after a four month period to determinate the percent effectiveness.

Carrying out this type of studies shows the risk that the operator is exposed to. The ergonomic analysis are very important, because when they are developed you obtain necessary information for changes in the work stations, generating a wining-wining feeling between the company and the employers.

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MULTIVARIATE MODEL ON THE IMPACT OF INDUSTRIAL ORGANIZATIONS RESULTS

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RESUMEN: El estudio de factores que afectan el ambiente o bien los resultados en una empresa se ha hecho con variables que en muchas ocasiones son fácilmente identificables. Sin embargo, pueden existir variables que influyan en las salidas de unos procesos pero de las cuales no se tenga conocimiento. El siguiente artículo muestra el desarrollo de un modelo que específicamente se aplicará en naves industriales. Se comenzará con la elaboración del estudio del estado del arte para poder identificar variables ambientales y propias del trabajador que influyan o presenten algún tipo de impacto en fenómenos o procesos que se lleven a cabo en naves industriales. Se muestra el desarrollo de modelos teóricos que relacionen variables relevantes con fenómenos que sean objeto de estudio para lograr de esta manera llegar a un resultado.

PALABRAS CLAVE: Ergonomía, factor-humano, multivariado

ABSTRACT: The majority of the studies of factors that affect the environment or results in a company have been done with variables that often are easily identifiable. However, there may be variables of which there is no knowledge that influence the outputs of some processes. This article shows the development of a model that includes a broader range of factors, which is specifically applied to industrial buildings. It begins with the review of the state of the art to identify environmental and worker-related variables that influence or present some kind of impact in phenomena or processes that are carried out in industrial buildings. We then describe the development of theoretical models that are related to relevant variables with phenomena that are being studied.

KEY WORDS: Ergonomics, human factor, multivariate

RELEVANCE TO ERGONOMICS: The contribution is a mathematical model with variables that have not been studied as others which will help to explain their interaction with the performance at a certain industrial job, so that, if controlled, it would benefit not only the company but also the worker.

1.- INTRODUCTION

The project involves the review of variables, and experimental development of a simulation model in which the interaction of variables least studied in an industrial environment is explained. We pretend to identify environmental or worker-related variables influencing or showing any impact on the processes that take place specifically in industries.

The purpose of this project is to implement a model applicable in industrial buildings where the input variables of the environment and the worker are identified and can be measured in a logical or coherent output variables, with the help of a mathematical model so that later it can be brought to a real scenario.

2.- OBJECTIVES

The purpose of this project is to design a model applicable in industrial buildings where the input variables of the environment and worker are identified (age, stress, security, worker's voice, etc.) and the output variables (productivity, quality, efficiency, customer's happiness, worker's happiness, etc.) are measured in a logical and coherent way.

3.- DELIMITATION

- Identify the input variables that affect the output variables, so that the most important variables are taken for testing on them.
- Variables will be selected throughout a simulation using simulation software, so we manage to make tests with the valuation of an expert to apply it in a real scenario.

4.- METHODOLOGY

The first activity was to study the state of the art, in which factors that have to do with the various phenomena that occur in a company were identified. The factors of interest were identified as follows:

1. Workspace safety
2. Workspace design
3. Symbols
4. Design of vertical displacement
5. Muscle injury / musculoskeletal disorders / dyslexia / injury
6. Employee personality
7. Need of a college degree
8. Age
9. Development of skills
10. Humanistic treatment by the employer (welfare worker)

11. Changes in the ecosystem (political claims based on ethical and humanistic values) (INTERNAL)
12. New workers
13. Workplace relations, Environment
14. Incentives
15. Communication between operators
16. Communication between managers and subordinates
17. Internal competition / mutual learning (rather than competition)
18. Minimize energy costs (hurry, cheap, similar times)
19. Emphasize responsibilities
20. Follow established patterns (light, different times, greater relaxation)
21. Worker voice (not heard)
22. Depression
23. Posture to perform work
24. Fatigue, Design, Visibility, Space
25. Stress, Fear, Posture, Personal Problems, Frustration
26. Methods to perform a task
27. Worker health
28. Economic and social change / economic crisis
29. Globalization
30. Technological development
31. Changes in the ecosystem (political claims based on ethical and humanistic values) (EXTERNAL)
32. Occupational overuse (ENVIRONMENT)
33. Occupational overuse (PERSON)
34. Worker Happiness
35. Productivity
36. Efficiency
37. Quality
38. Customer happiness

Subsequently, all these factors were classified as environmental / person, local / remote and constant / variable. The first type of classification refers to whether the factor affects the environment where the person works or is working within the warehouse. The second stresses if the variable is inside or outside the workplace, whether it affects the person or the environment. The last type of stratification is used to verify that it was actually a measurable variable and not just a scalar value.

The classification of the independent factors is:

Table 1. Variables classification

	Factor	**(E)nvironmental or (P)ersonal**	**(L)ocal or (R)emote**	**(C)onstant or (V)ariable**
1	Worplace safety	E		C
2	Workplace design	E		C
3	Symbols	E		C

4	Design of vertical displacement	E		C
5	Muscle injury / musculoskeletal disorders / dyslexia / injury	P		C
6	Employee personality	P		C
7	Need of a college degree	P		C
8	Age	P		C
9	Development of skills	P		C
10	Humanistic treatment by the employer (welfare worker)	P		C
11	Changes in the ecosystem (political claims based on ethical and humanistic values) (INTERNAL)	E	L	V
12	New workers	E	L	V
13	Workplace relations, Environment	E	L	V
14	Incentives	E	L	V
15	Communication between operators	E	L	V
16	Communication between managers and subordinates	E	L	V
17	Internal competition / mutual learning (rather than competition)	E	L	V
18	Minimize energy costs (hurry, cheap, similar times)	E	L	V
19	Emphasize responsibilities	P	L	V
20	Follow established patterns (light, different times, greater relaxation)	P	L	V
21	Worker voice (not heard)	P	L	V
22	Depression	P	L	V
23	Posture to perform work	P	L	V
24	Fatigue, Design, Visibility, Space	P	L	V
25	Stress, Fear, Posture, Personal Problems, Frustration	P	L	V
26	Methods to perform a task	P	L	V
27	Worker health	P	L	V
28	Economic and social change / economic crisis	E	R	V
29	Globalization	E	R	V
30	Technological development	E	R	V
31	Changes in the ecosystem (political claims based on ethical and humanistic values) (EXTERNAL)	E	R	V
32	Occupational overuse (ENVIRONMENT)	E	R	V
33	Occupational overuse (PERSON)	P	R	V

By using a model raised the manner in which the above-mentioned variables interact with output variables such as efficiency, productivity, worker's happiness, customer's satisfaction, etc. The following model shows the way in which we are considering the interaction of the included variables.

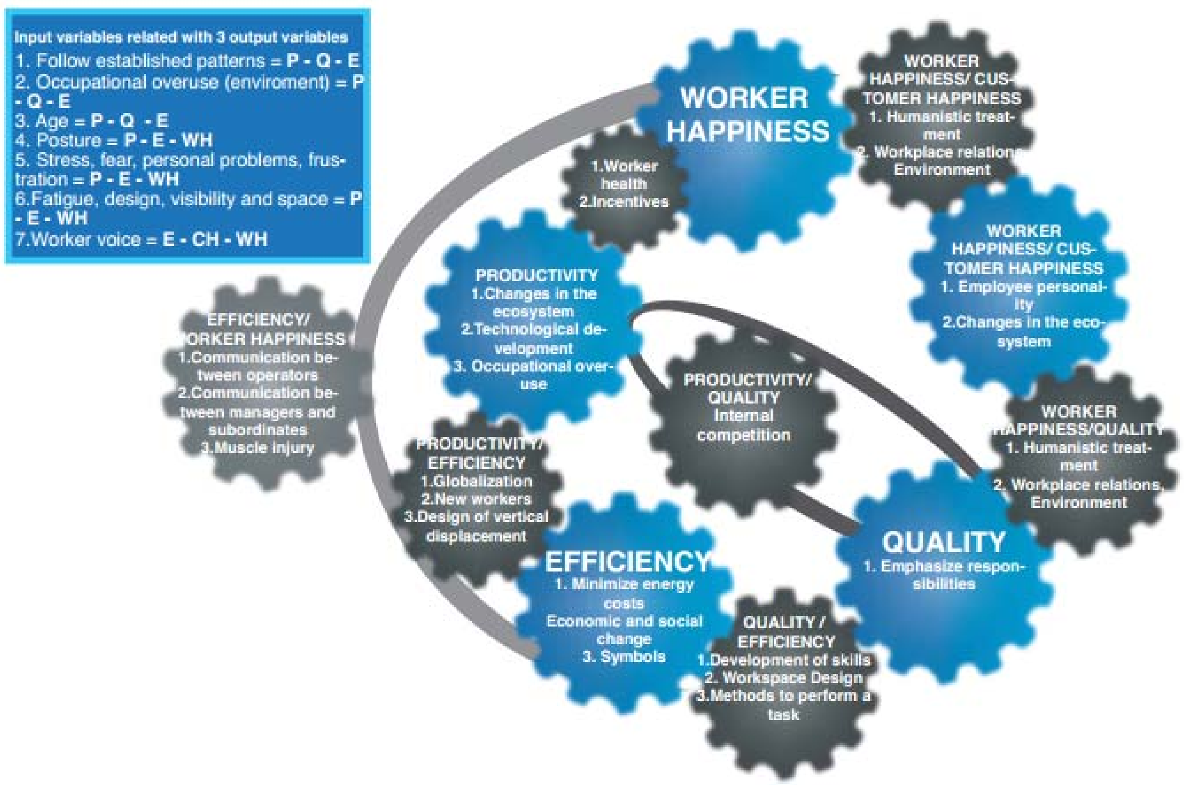


Figure 1. Input and output variables interaction model

This model explains the relationship we found between the input and output variables, just as trying to expose the fact that some output variables raised are even related to each other and also share more of a relationship with the input variables. It is noteworthy that this was the best way that once we found the right model to pose. However, it was found that this model does not allow us to meet another of the stages which seeks to simulate the relationship.

Due to the fact that the relationships of the variables were a little confusing in the model explained above, it was decided to implement a better way to raise the correspondence between the variables; the new proposed model is illustrated below:

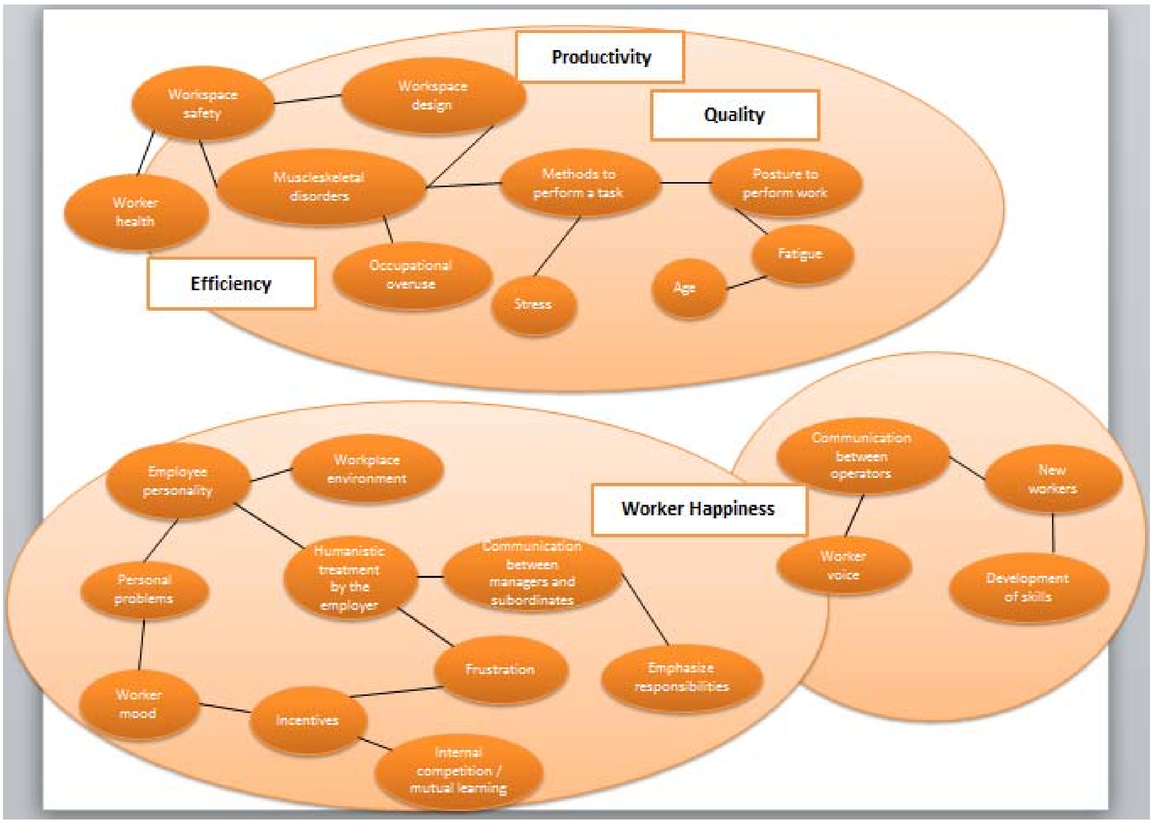


Figure 2. Input and output variables interaction model 2.

This model is proposed by 3 clouds of variables, where divisions between the large numbers of input variables can be seen. Consideration was raised it that way because we believe there are input variables that are more strongly correlated with certain output variables. This is why the division was performed. In the first cloud it can observed variables that we believe are related to the efficiency, productivity and quality of companies while in the clouds below variables are powerfully related to employee happiness. This model places special emphasis on the interrelationship that variables keep, meaning the relationship does not occur only in a linear fashion but there are branches which are connected to two or more variables.

This model still did not offer a clear way which could explain the relationship of the variables. With the help of Stella software, it was reduced the number of variables to be analyzed in order to make a model that would identify the interaction but mostly the impact of the variables of interest on the output mentioned above.

5.- RESULTS

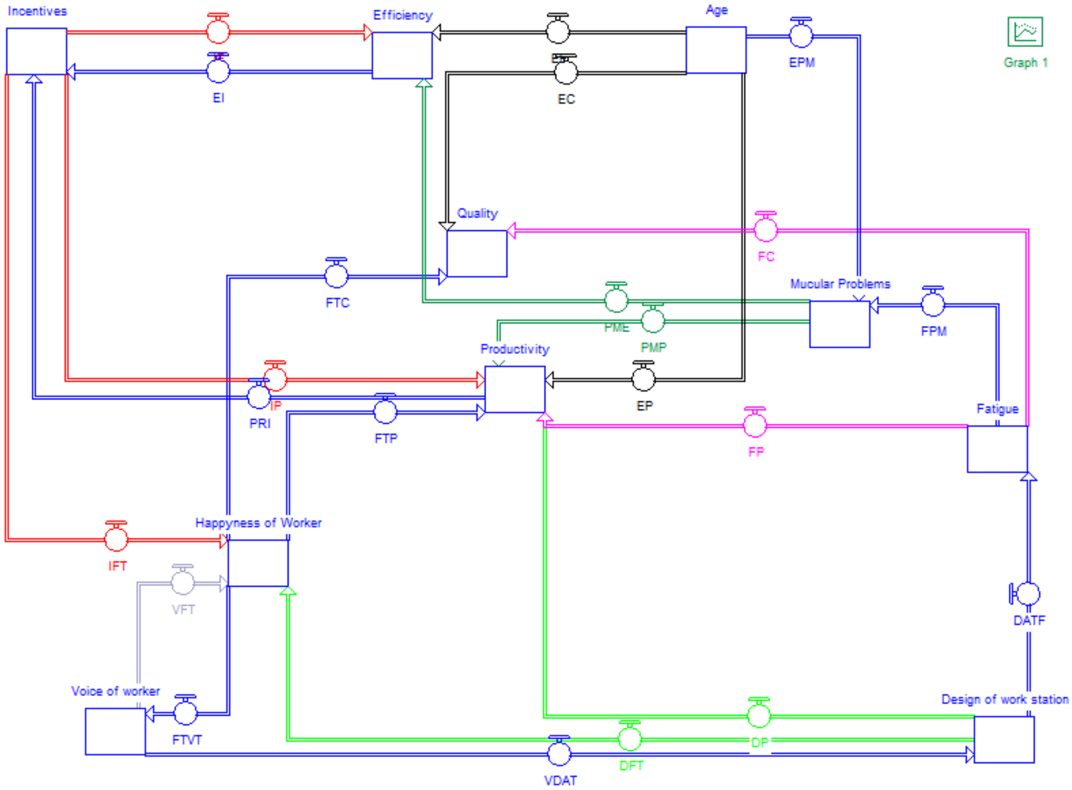
Six input variables of a total of thirty three variables were selected in order to initially have a particular vision of how they affect the four proposed output variables (worker happiness, productivity, efficiency and quality).

Selected input and output variables are shown in the following table:

Table 2. Variables analysis

Input variables	Output variables
Incentives	Worker happiness
Worker voice	Productivity
Fatigue	Efficiency
Muscleskeletal problems	Quality
Workplace design	
Age	

The following figure shows the proposed model using the Stella software:



figurf

Figure 3. Stella model before simulation

This model uses four variables of interest and six normal variables in order to start visualizing and simulating the project.

Based on our experience, we provided an estimated numerical relationship between the variables, and thus see which are most strongly correlated. This estimate will be based on experiences and using values that could be considered real.

This is a proposed relationship between these variables based on the experience of the authors. Each variable received a value from 1 to 5; 1 meaning no relationship and 5 meaning they are strongly related.

The summary variables numbers placed at exposed below:

Table 3. Suggested values

From	Value	To
Incentives	5	Worker happiness
Worker voice	3	Worker happiness
Worker happiness	3	Worker voice
Worker happiness	4	Productivity
Fatigue	2	Productivity
Fatigue	4	Muscleskeletal problems
Incentives	3	Efficiency
Muscleskeletal problems	1	Efficiency
Efficiency	5	Incentives
Worker voice	1	Workplace design
Workplace design	4	Productivity
Workplace design	3	Fatigue
Workplace design	2	Worker happiness
Worker happiness	1	Quality
Fatigue	2	Quality
Age	2	Quality
Age	3	Efficiency
Age	2	Productivity
Age	5	Muscleskeletal problems
Productivity	5	Incentives
Incentives	5	Productivity
Muscleskeletal problems	2	Productivity

In order to simulate the model, the four output variables were given a value of one thousand, making the program able to begin the process. This would be modified depending on the correlation that was being given to the input variables. The obtained results show the variable that mostly increases.

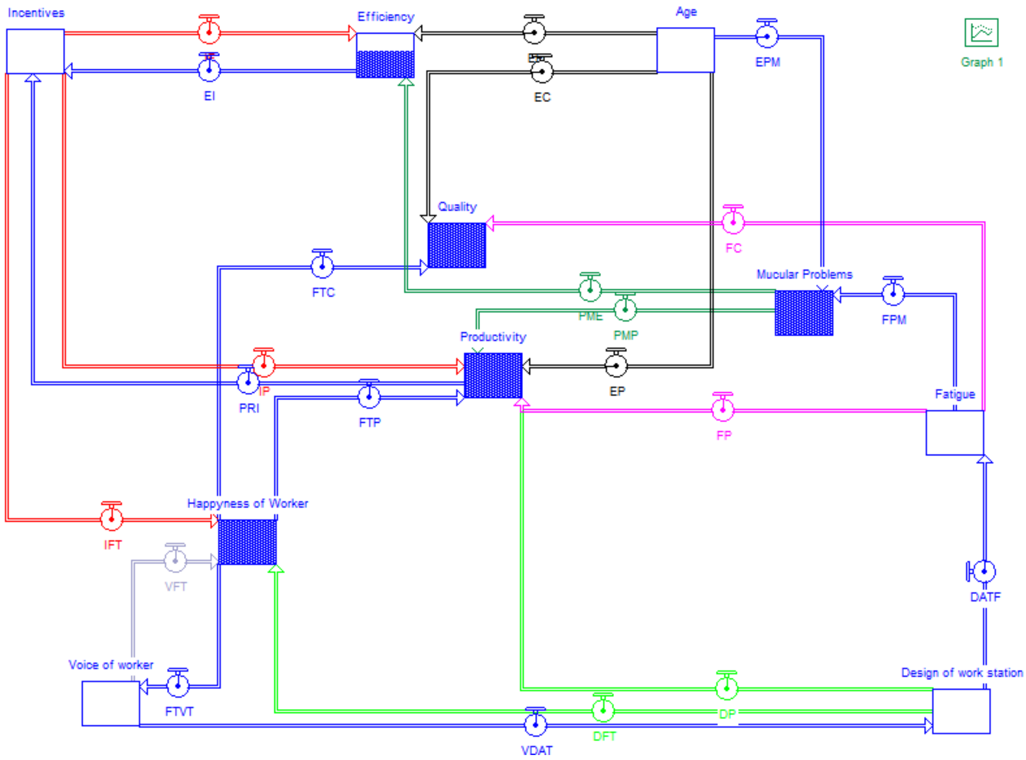


Figure 4. Stella model after simulation

It can be observed that in this model the variables that were filled in are the ones that grow in value over time. Variables left in blank are the ones that give more than they receive over time.

Figure 5. Variables of interest graphics

In the figure above it can be observed how over time variables of interest tend to grow in the multivariate model that takes into Stella. However, it can be appreciated that likely at the end these variables do not grow a lot, doing so at much lower rates. As efficiency begins to decrease very rapidly, it is believed that age grows much longer and stops giving units to variables as it is not fed from any other variable. Therefore, efficiency begins to decrease. This has coherence because as employees grow older, they lose efficiency without losing quality. New employees will not have the same efficiency because they do not have the experience to make the process as the elder ones.

6.- CONCLUSIONS AND FUTURE WORK

The model shown in the previous section require laboratory tests to tell us if the manner in which it is proposed is correct or if it is necessary to make some type of modification for proper interpretation.

Work on the next phase of this project is to identify whether the reduction and application of values in the variables of interest are correct. This can only be achieved by performing laboratory tests or even trying to apply the proposed model in a real scenario.

ACKNOWLEDGMENT

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METHODOLOGICAL PROPOSAL FOR THE IMPLEMENTATION OF A PROGRAMME OF ERGONOMIC HAZARDS MANAGEMENT IN A CAR PARTS MANUFACTURING PLANT IN HERMOSILLO, SONORA.

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Resumen: El objetivo es diseñar una propuesta metodológica para la implementación de un programa de gestión de riesgos ergonómicos para su identificación, evaluación y control, producidos por posturas no adecuadas y movimientos repetitivos. Se hace referencia a conceptos de ergonomía, métodos de evaluación ergonómica, programas de gestión de riesgos ergonómicos, entre otros. La propuesta metodológica a ser abordada en el estudio, trata de lo siguiente: una vez identificado el problema a ser estudiado, se comienza por hacer una revisión bibliográfica de conceptos, modelos, casos de estudio, entre otros aspectos, relacionados con el estudio. Posteriormente, realizar visitas a la organización en donde se comience a reconocer el riesgo presente en las estaciones de trabajo, establecer conversaciones y entrevistas con los operadores y administradores del área bajo estudio. Después, realizar un análisis e identificación de los riesgos, mediante la aplicación de métodos de evaluación ergonómica, mismos que serán definidos según las características del puesto de trabajo. Seguidamente, se persigue el desarrollo del estudio ergonómico propiamente dicho. Se trata de la aplicación de herramientas diseñadas para cada caso en particular. Se recogen datos específicos que después de su procesamiento se derivan en la elaboración de un informe del estudio ergonómico integral. Por último, se realiza la implementación de las acciones de mejora. Algunas herramientas utilizadas en el estudio fueron el método de evaluación ergonómica Susan Rodgers y la Encuesta de Sintomatología Osteomuscular. Los resultados obtenidos son: conocimiento del área bajo estudio, como procesos que se llevan a cabo en cada una de las estaciones, principales tareas que desempeñan los trabajadores. Así también, mediante la aplicación de la encuesta mencionada anteriormente, se obtuvo la identificación de las principales posturas que adopta el trabajador durante la jornada laboral; si transporta o no cargas mayores a 12.5 kilogramos; identificación de la principal mano que utiliza para el desarrollo de sus actividades. Además con la aplicación del método Susan

Rodgers se obtuvo el nivel de riesgo al que están expuestos los trabajadores en cada una de las estaciones bajo estudio. Por último se muestran las conclusiones obtenidas en dicha investigación.

Palabras clave: Ergonomia, Administración de riesgos ergonómicos, Susan Rodgers

Abstract: The objective is to describe a methodological proposal for the implementation of an ergonomic management program for risk identification, evaluation and control created by inadequate postures and repetitive movements. References are made to concepts of ergonomics, methods of ergonomic evaluation, programs of management of ergonomic hazards, among others. The methodological proposal to be addressed in the study is about the following: once the problem studied is identified, the study is begun by doing a bibliographical revision of concepts, models, study cases, among other concepts related with the study. Previously, realizing visits to the organization in which a risk is starting to be recognized in the work stations, establish conversations and interviews with the workers and administrators from the area under study. After, making an analysis and identification of the hazards, through the application of methods of ergonomic evaluations, same will be defined according to the characteristics of the job position. Fallowed, the development of the ergonomic study is pursued. It is about the application of designed tools for each particular case. Specific data is collected that after its process is derived in the elaboration of one uniform of the integral ergonomic study. Last, the implementation of bettering actions is realized. Some tools that were used in the study were the method of ergonomic evaluation of Susan Rodgers and the Musculoskeletal Symptomatology Survey. The results obtained were: knowledge of the area studied, such as processes carried out in each one of the stations, top tasks that the workers perform. Also, through the application of the survey mentioned previously, the identification was obtained of the top postures adopted by the workers during a workday; if the worker transports or not loads heavier than 12.5 kilograms; identification of the main hand used in the development of their activities. In addition of the application of the method of Susan Rodgers, the level of hazard that the workers are exposed to in each one of the stations studied was gotten. Lastly, the conclusions obtained in such investigation were shown.

Key Words: Ergonomics, Management of ergonomic hazards, Susan Rodgers

Relevance to Ergonomics: The result of this investigation helps to provide a series of steps that can be taken to practice, and at the same time, can be adapted with any organization in which management and control of hazards is seeked for the area of work the workers find themselves in. Also, some tools that can facilitate the obtaining of results for certain phases that can be presented in a study were released.

1. INTRODUCTION

The study describes and develops a methodological proposal for the implementation of an ergonomic risk management programme, starting from the identification and evaluation of ergonomic hazards, especially those caused by inadequate postures and repetitive movements. It should be noted, that it is still in progress, and it is being held in a car parts manufacturing company in Hermosillo, Sonora.

1.1 The Ergonomics

According to Hollnagel (2014) which cites Dul et al., (2012) ergonomics is a scientific discipline that treats the comprehension of the interactions between human beings and the elements that form part of a system, like the principal theories, data and methods for the welfare and performance of the workers.

The basic objectives that ergonomics pursue are: bettering the personal interrelation of worker and machine, control of the job positioning surrounding or of the place of the behavioral interaction, generate interest for the activity endeavoring the signal of the system being significant and assumable by the person. (Mondelo, 2000)

It is for this, that the importance of Ergonomics is made noticed in a job layout, having the human being like the most important factor to take in consideration, now that the welfare, health and comfort of the worker will depend on its efficiency in the job.

To deliver a real ergonomic design in a work area is a complex task; however, great benefits to workers and employers can be gathered by this effort. Thus, the ability to know some of the benefits of applying ergonomics increases the importance, now that it can be established that its application may allow better results at designing or redesigning a work station.

On another part Hollnagel (2014) signals that the real challenge of ergonomics is for the design of interphases, interaction and job surroundings, to have to go further than the concept that is obtained of traditional ergonomics and search to understand the form in which this will change the future and at the same time modify ourselves to continue existing in the environment that we have modified.

1.2 Musculoskeletal Disorders (MSDs)

Musculoskeletal disorders (MSDs) represent one of the most serious consequences of an inadequate work routine design. The symptoms are described as pain in one or more regions of the body. Also, these disorders can be caused by repetitive workloads (Roman-Liu, 2013).

Furthermore, from the anatomical point of view, according to Frievalds (2004) it can be classified in six basic types which are: tendons, muscles, nerves, vascular, pockets and bone/cartilage.

1.3 Methods of Ergonomic Evaluation

Now, for ergonomic evaluation methods, the analysis of work positions can be an effective tool to assess activities at work. An important factor to implement corrective actions is the risk of muscle skeletal injuries that are associated with aggravated postures caused by efforts and repetitive movements (Hignett & McAtamney, 2000). Some ergonomic evaluation methods are: RULA method (rapid upper limb assessment) that allows rapid assessments of postures in neck, trunk and upper extremities. Characteristic of this method is that it indicates the level of intervention required to reduce ergonomic hazards (McAtamney & Corlett, 1993). OWAS (Ovako Work Analysis System) method, considered a relevant method for the identification and evaluation of positions characterized by providing data in short time periods (Karhu, Kansi, & Kuorinka, 1977).

1.4 Programme of Management of Ergonomic Hazards

Actually, it has been paid a major attention to the systems of integrated security, which has obligated the companies to manage in a systematic form the sources of risk (Gnoni & Bragatto, 2013). The ergonomic evaluations are increasing the work done like in the standardization of processes, for example when the practice guide is used in the work NIOSH (Törnström, Amprazis, Christmansson, & Eklund, 2008).

Ergonomic participation programs in the workplace are frequently used for ergonomic strategies that allow the reduction of muscular skeletal disorders in the workplace (Rivilis, y otros, 2008). An incident-free "culture" demands employees and employers participation for the Elimination of injuries, workplace assessment, as well as an efficient communication of the administrative organization (Morag, 2007).

Also Mondelo (2000) signals that an ergonomic intervention doesn’t limit itself to identify the factors of hazard and the inconveniences, but to propose positive solutions, and the economic viability that frames any project.

2. OBJECTIVE

To describe a methodological proposal for the implementation of an ergonomic management program for risk identification, evaluation and control created by inadequate postures and repetitive movements.

3. METHODOLOGY

A methodological structure is shown that was elaborated by the Health and Safety Management System (HSMS), shown by Ontario Safety Association for Community and Healthcare (OSACH), (2010). The focus of the investigation is mixed, since is a combination of the quantitative and qualitative focus. Also, the type of investigation is descriptive, since it is to specify the characteristics and profiles of the people, groups or processes to be studied (Hernández, 2010).

The methodological proposal to be addressed in the study is about the following: once the problem studied is identified, the study is begun by doing a bibliographical revision of concepts, models, study cases, among other concepts related with the study. Previously, realizing visits to the organization in which a risk is starting to be recognized in the work stations, establish conversations and interviews with the workers and administrators from the area under study. After, making an analysis and identification of the hazards, through the application of methods of ergonomic evaluations, same will be defined according to the characteristics of the job position. Fallowed, the development of the ergonomic study is pursued. It is about the application of designed tools for each particular case. Specific data is collected that after its process is derived in the elaboration of one uniform of the integral ergonomic study. Last, the implementation of bettering actions is realized. Next, in a delicate manner a methodological proposal is shown:

3.1 Recognition of the risk:

This phase tryes to identify the risks that exist in the manufacturing plant under study, work processes, statistical information on accidents, incidents and associated costs in a certain period of time.

An instrument that can be used to identify the hazards, is the Musculoskeletal Symptomatology Survey (Osteomuscular, 2007) that covers aspects like top postures that the worker adopts during his or her day, the main hand used by the worker in the development of their activity in their area of work, the carrying of loads, among other more aspects.

3.2 Identification and assessment of risk factors:

It is required for each position or task, to identify the type of ergonomic risk by the use of ergonomic assessment methods, according to the particular conditions in the associated work station. An ergonomic assessment method that can be used, Susan Rodgers is the method, which assesses muscle groups as: neck, shoulders, back, arms and elbows, hands, wrists and fingers, knees and legs and feet and ankles, and that as Uribe, De la Vega, Lopez, & Duarte (2013) citing Chengalur, Rodgers & Bernard (2004) discussed a method that seeks to recognize muscle fatigue, caused by the intensity of effort, duration of effort, and the frequency of effort per minute in each muscle group in performing an operation.

3.3 Management and Control of risks:

Once risks have been identified and assessed, the following task is to make use of mechanisms for their control, and subsequent reduction or elimination. For example: implementing control strategies basic hazard management, improvement proposals for the work stations to reduce the level of hazard, implement specific hazard controls, fostering a culture of organizational security. One aspect that can be considered for the establishment of proposed improvements is to take into account the anthropometric measures of staff working in the organization, so that the design is done, appropriate to the physical dimensions of personal working in the organization.

3.4 Assessment and corrective actions:

This stage focuses on tracking of ongoing assessment and corrective action on occupational hazards. One of the actions that can be performed at this stage is to make the assessment again at the workstation that was previously evaluated and which changes were made to improve it. So it is recommended to apply the same method that was used before the implementation of improvements again.

3.5 Strategic review and continuous improvement:

This stage is to communicate and follow up on the targets set in the programme; review of risk levels periodically; and to assess the opportunities for continuous improvement. One of the actions to do, is to make use of a risk review format, it is regularly used (every 3 to 6 months) in order to monitor risks in workstations and verify whether these risks have decreased. For example, compare the number of injuries that have occurred on shoulders in the current year, with the number of injuries obtained in the previous year.

4. RESULTS

4.1 Recognition of risk

First it was come to know each of the workstations that make up the study area, to have knowledge of the operations, major movements and postures that adopt a worker during the work day. To which the Survey of Symptoms Musculoskeletal applied to three shifts of the organization, only that provision of the Organization, some questions of the original format of the survey were omitted and which were discussed were concerning: Name, age, sex, season, time in office, main positions adopted by the employee during the workday, cargo transport and last main hand is used for development activities.

It should be noted that the study was developed in an area which has three main stations, named Carousel 1, carousel 2, carousel 3, in which components are manufactured car part. Each of the three carousels, are composed of different stations, which processes that contribute to the manufacture of components are carried. In Figure 1, shown the results obtained in the carousel 1, for identifying positions.

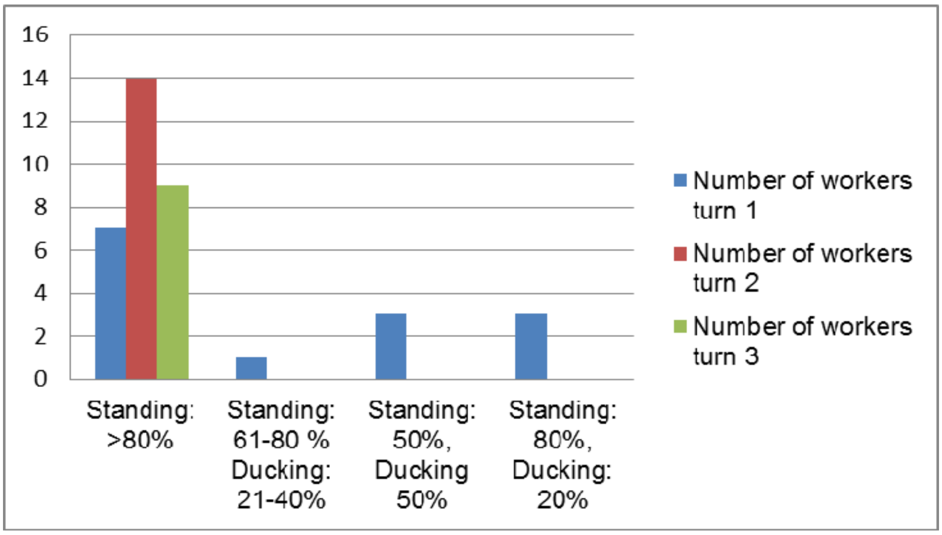

Figure 1. Identification of positions, carousel 1

In the previous graph, it can be seen that most of the workers belonging to the carousel 1 in three shifts, over 80% of the time duration of the working day are standing in their work areas. But also, on turn 1 it can be seen that a certain percentage of the time taken other positions like squatting. In Figure 2, the results obtained for the transport of loads on the carousel 1 are shown.

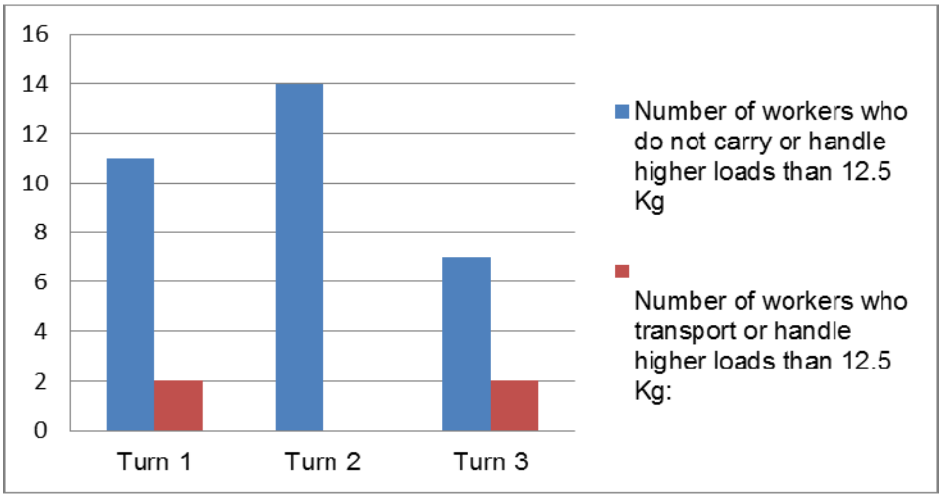

Figure 2. Cargo transportation, carousel 1

For the carriage of cargo, in the figure above can be seen that most of the workers do not carry or handle higher loads at 12.5 kg and assume only an amount greater loads to transport 12.5 kg. Figure 3 shows the main hand that is used for development activities.

Figure 3. Main hand is used in the development of activities, carousel 1

According to the previous figure, the development of the activities made by the workers in their work areas, most make use of both hands, but there are also workers that make use of the right hand.

Also, the results obtained in the carousel 2 were the following: as to the identification of postures all workers belonging to carousel 2 in three shifts, most of the time remain standing in their work areas. Moreover, for the transport of loads, most workers do not carry or handle higher loads than 12.5 kg and only a small number of transport workers bear greater loads than 12.5 kg, finally in the development of their activities within their work areas, most workers make use of both hands, but there are also those who use the right and left hands.

The results on the carousel 3 were: to identify positions, the majority of workers, great part of the time working hours remain standing in their work areas. Regarding transportation of loads on the carousel 2 in three shifts, workers are not carrying or handling higher loads at 12.5 kg. In the development of activities, most make use of both hands, but they use the left and right hand especially.

So also for the recognition of hazard, statistical records of the organization for the period January to November last year, about accidents and incidents that occurred in that period, in the area under study, in order to detect available were consulted major regions with the highest incidence. Figure 4 shows the data obtained.

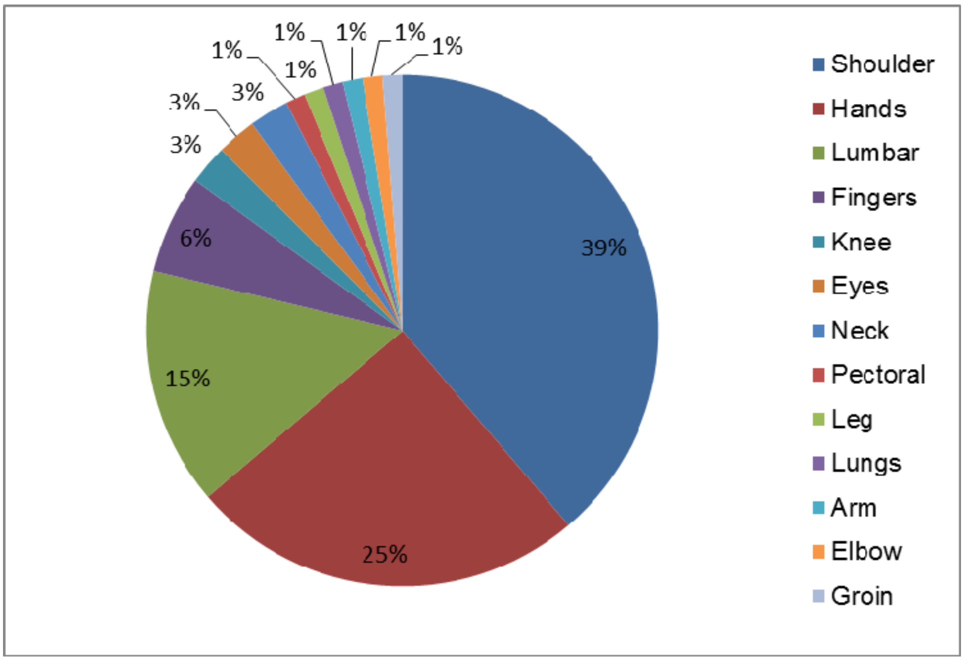

Figure 4. Accidents and incidents by regions of the body

Figure 4 shows that the main regions of the body that had a higher incidence or accidents, was shoulders, hands and back, so that these data may indicate that workers are exposed to risk factors in their work areas.

4.2 Identification and evaluation of risk factors:

At this stage the identification and assessment of risk factors was performed using the method of ergonomic evaluation of Susan Rodgers, it was applied to each of the stations that are part of the three carousels belonging to the study area. Each of these carousels performs trades manually and some make use of any tools or equipment. However, according to visits to the area and according to the survey results shown above, we have that for the performance of each of the activities performed in workstations, they are done standing and they also make use of both hands to carry out activities.

It is noteworthy that one of the activities that were made during the assessment with the method mentioned above, was the filming of tasks to be analyzed in more detail, and with this power detecting certain body angles that are formed when different postures are adopted in task performance, as this is often complicated when viewed directly to the worker. The results obtained are shown below. Table 1 shows the results of evaluation on the carousel 1:

Table 1. Susan Rodgers Ergonomics Assessment stations Carousel 1

Carousel 1					
Group of muscles	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**
Neck	9	2	5	2	6
Shoulders	9	6	10	5	6
Back	9	6	10	6	6
Arms and elbows	9	2	5	6	1
Wrists, hands and fingers	9	2	10	6	1
Legs and knees	9	4	7	5	6
Ankles, feet and toes	9	4	7	2	1

Source: Data obtained from ergonomic evaluation calculations.

According to that observed in the previous table, station 1 has a high level of hazard in all muscle groups, station 2 has a low level of hazard in neck, arms and elbows, wrists, hands and fingers, legs and knees, ankles, feet and toes and in turn, has a moderate risk on the shoulders and back. Furthermore it can be seen that station 3 is the one with a higher level of hazard, unlike other stations, since it has very high level of hazard on the shoulders, back, wrists, hands and fingers. Table 2 shows the results of evaluation on the carousel 2:

Table 2. Susan Rodgers evaluation stations Carousel 2

Carousel 2				
Group of muscles	**Station 1**	**Station 2**	**Station 3**	**Station 4**
Neck	8	1	6	1
Shoulders	8	1	1	1
Back	8	1	1	1
Arms and elbows	8	1	1	1
Wrists, hands and fingers	8	1	1	1
Legs and knees	8	1	1	1
Ankles, feet and toes	8	1	1	1

Source: Data obtained from ergonomic evaluation calculations.

In the previous table it can be noted that most stations have a low level of hazard for each muscle group, except for station 1, which has a high level of hazard in all muscle groups. Table 3 shows the results of the evaluation are shown in the carousel 3:

Table 3. Susan Rodgers evaluation stations Carousel 3

Carousel 3				
Group of muscles	**Station 1**	**Station 2**	**Station 3**	**Station 4**
Neck	2	7	2	2
Shoulders	2	10	2	2
Back	2	7	2	2
Arms and elbows	2	5	2	2
Wrists, hands and fingers	2	7	2	2
Legs and knees	2	7	2	2
Ankles, feet and toes	2	7	2	2

Source: Data obtained from ergonomic evaluation calculations.

The above table shows that in most of the stations the hazard level is low. However, in Station 2 it can be seen that there is a high level of hazard on the shoulders, and a moderate level of hazard in neck, back, arms, elbows, wrists, hands and fingers, legs, knees, ankles, feet and fingers.

The above results show the stations with high level of hazard, which, seek to establish improvement proposals that may decrease the level of hazard in order to reduce accidents, labor sicknesses and to increase the welfare, health and Accordingly to worker productivity.

6. CONCLUSIONS

Conclusions about the implementation of the methodology so far are preliminary. However, until now, the conclusions about the importance of implementing an ergonomic hazard management program to improve the workplace. With this study, reference information is found to carry out the implementation of the program. In addition, a flexible methodology that can be adapted to organizations, according to the conditions present in the work areas, as well as the characteristics of the jobs, since according to the above, it may use different methods addressed ergonomic evaluation. Moreover, what made the study so far , it could recognize this risk in the study area , as some characteristics of the jobs , as the main positions adopted by the employee during the workday were found whether or not handle heavy loads , as well as the main hand you use to develop their activities. Besides the major regions of the body where injuries occurred over a period of time was found.

Finally the level of hazard in each of the workstations in the study area, so with this, you can identify the main stations which should seek to establish proposals to decrease the level of hazard was obtained.

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EDUCATIONAL SOFTWARE APPLIED TO THE ERGONOMICS FOR THE EVALUATION OF JOBS, ERGONOV

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RESUMEN: El impacto social de las Tecnologías de la Información, va muy de la mano con el área de la educación, propiciando transformaciones en las formas tradicionales de enseñar y aprender.

En un contexto social actual buscamos cubrir las expectativas que la sociedad requiere para elevar la calidad de la educación, en un proceso del cual no puede excluirse el uso de este tipo de tecnología que más que un medio, constituye un recurso en el cual se sustentan las exigencias actuales y que nos proporciona un ambiente amigable para el momento de realizar los estudios y evaluaciones de los puestos de trabajo.

Es importante añadir que el uso de estas tecnologías tiene muchas ventajas y entre ellas podemos encontrar que sus costos serian cada vez más bajos, un mayor nivel de interacción hombre – máquina, el indiscutible aumento de la capacidad de almacenamiento de la información y por supuesto el continuo desarrollo de las tecnologías avanzadas.

Palabras clave: Tecnología, educación, dinamismo**.**

Abstract: The social impact of the technologies of the information goes very hand in hand with the area of education, promoting transformation in traditional teaching and learning forms.

In the current social context we seek to meet the expectations that society requires to raise the quality of education, in a process which can not excluded the use of this type of technology rather than means, constitutes a resource in which underpin the current demands and that it provides us with a friendly atmosphere for the time of studies and evaluations of the job.

It is important to add that the use technologies has many advantages and including the man-machine interaction, the undisputed increase storage capacity and of course the continuous development of advanced technologies.

Keywords: Technology, education, dynamism.

1. Introduction

Is currently observed in the educational institutions technological upper level where are taught some subjects with practices that use some software for the analysis of jobs, use becomes complicated when being manipulated by students while in other institutions do not use any software for this analysis, for example on the subject of ergonomics/human engineering of industrial engineering career. Due to this situation is proposed "ERGONOV", a software dedicated and designed for application within the evaluation of positions focused ergonomics at the time to carry out a job.

2. Objectives

1. Bring about a transformation of teaching resources that are used the learning of students.
2. Promote the investigative experience that not only with the theory that you can provide them, if not also to apply to provide a solution to any problem that arises at the moment of passing to his professional life.
3. Provide the user with the basic tools that enable you to:
    - Perform a sampling, design a simple experiment and collect data in a way appropriate for evaluation of work.
    - Analyze data obtained in descriptive way and make an interpretation of the results.
    - Apply the inferential techniques appropriate to the problem at hand and interpret their results.

3. Methodology

He was sampled through the application of surveys in various institutions of higher level and nearby businesses to the suburbs Tampico-Madero-Altamira, in races that integrate ergonomics as a subject in the curricula. Through direct interview aimed to find out if students and teachers would be willing to acquire educational software designed to facilitate the implementation of methods of evaluation of jobs, an important issue within the field of ergonomics.

4. Results

As a result it was obtained that both students and teachers are willing to purchase software that can be used as a tool to make more practical a dynamic experience in ergonomics class.

5. Conclusion

On the basis of the results according to the techniques used and the market research carried out theoretically, it has been determined that the creation and marketing software “ERGONOV” is a technical and commercially feasible since it showed that this product provides an innovate solution to the problem before posed besides having an acceptance of 92% of the market raised goal in a first stage of the project.

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EVALUATION OF SAFETY AND HEALTH WORK STANDARDS IN A FLOUR MILL

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Resumen: El presente trabajo tiene como objetivo evaluar las condiciones de trabajo presentes en un molino harinero del noroeste del país, mediante la verificación del cumplimiento de las normas de seguridad y salud en el trabajo. Para ello, fue necesaria la identificación de las normas que aplicaban a la empresa mediante un asistente de identificación que proporciona la STPS. Los resultados de la evaluación fueron aceptables, sin embargo se programaron acciones correctivas y preventivas, de las cuales algunas se presentan en este trabajo con evidencia fotográfica.

Palabras clave: Salud ocupacional, Salud y Seguridad en el trabajo, Norma Oficial Mexicana

Abstract: This paper aims to assess the present working conditions in a flour mill in the northwest of the country, by checking compliance with health and safety standards at work. Consequently, it was necessary to identify the standards that apply to the company through an identification wizard that provides STPS. The evaluation results were acceptable, however corrective and preventive actions were performed, some of which are presented in image evidence.

Keywords: Occupational Health, Safety and Health at Work, Official Mexican Standards

Relevance to ergonomics: To maintain a safe and healthy workplace, you must meet certain requirements that allow the worker develop their activities healthily and achieve and it will increase in productivity. Ergonomics encompasses different working conditions such as job design, lighting, noise , vibration , temperature, machinery, among others, all these conditions are set out in the safety and health at work , therefore , conduct an assessment of compliance standards is a major contribution to ergonomics, as the main aim is the welfare of the people.

1. INTRODUCTION

Job is an inherently human activity; however, according Varona et al. (2012), there is no safe job, in fact, the risk is present in all jobs or job activities. This is reflected in the high number of accidents that have been occurred.

In Sonora, the number of accidents is increasing, in 2012 according to the Ministry of Labour and Social Welfare (STPS in spanish) (2012) there were register 17,688 crashes, 309 occupational diseases , 918 disabilities and 35 deaths.

Somavia (2005), argues that experience shows that a strong culture of safety prevention is something positive for workers and employers. One way of doing this is conducting a program of safety and health, governed under the Official Mexican Standards.

Safety and health at work is regulated by various provisions contained in the Political Constitution, the Organic Law of the Federal Public Administration, the Federal Labor Law, the Federal Law of Metrology and Standardization, the Federal Rules of Safety, Health and Work Environment, the official Mexican standards of security, among others.

Mexican official standards are issued by the STPS, which determines the minimum conditions necessary for the prevention of occupational risks, and are characterized by their intended attention to risk factors to which workers may be exposed. Currently, 41 standards are valid and grouped into five categories: safety, health, organization, specific and product (STPS, 2012).

2. OBJECTIVE

Evaluate job conditions that exist in a flour mill situated in the northwest of the country, by verifying safety and health standards.

3. DEMILIMITATION

The study was realized in a flour mill, a company dedicated to the production and sale of wheat flour. The company is divided into five areas: administrative offices, patios, warehouses, wheat and milling receivers, but the evaluation will take place in milling (Figure 1), because in this area there have been more than 50% of the accidents recorded in the period 2012-2013.

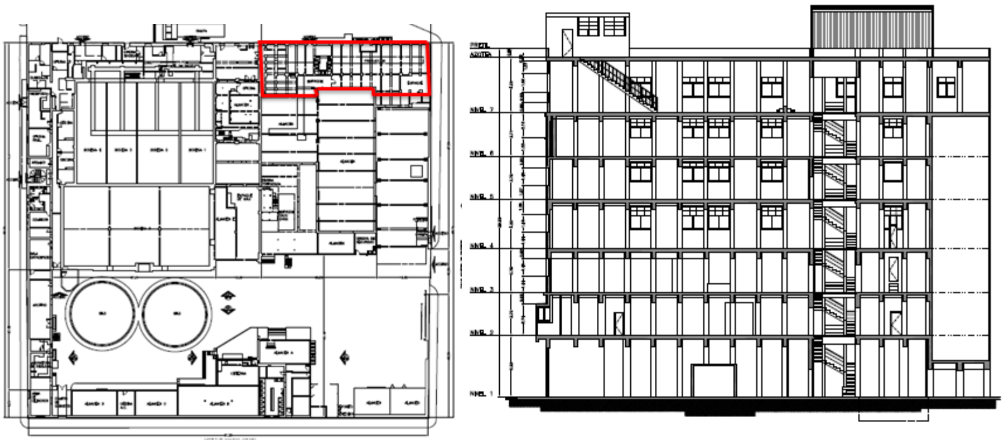

Figure 1. Milling área of the company

4. METHODOLOGY

To meet the stated objective, a diagnostic is made from the Safety and Health Evaluation Standards guide providing by the STPS. The steps for diagnostic are:

Knowing the area of study
A tour in the enterprise in order to know, about machinery and equipment, staff, materials used fire extinguishers, signage, evacuation routes, protective equipment and first aid equipment, among others.

Identify applicable Standards
To evaluate you must know which standards apply to the workplace, for that reason, the identification wizard that is provided by STPS will be use. From a series of question, the wizard facilitates the identification of the regulations that are applicable, according to economic activity, dimension and risk factors associated with the production processes of the company.

Verify compliance of the Standards
This step will consist in a tour inside the company to review in detail the operations and conditions of it. To verify compliance of the standards, a guide that is provide by STPS will be use. Guide for Evaluation Compliance of Safety and Health Standards at Work is divided into four sections, in the same way as the official Mexican standards: safety, health, organization and specific. To answer the guide there will be some ways to do it: interviews, documentary and physical evidence, and registry evidence.

Evaluate results of compliance
An evaluation based on result score and percentage of compliance will be made for each Standard: safety, health and organization, and finally full compliance area.

5. RESULTS

Diagnostic results are:

Knowing the area of study
A tour in the milling area was conducted, the dimensions were obtained, the machinery that is used, the materials, emergency exits and signs were identified. At the same time, irregularities were later corroborated in the evaluation guide.

Identify applicable Standards
To answer the questionnaire identification wizard, interviews for the Security Chief of the company and Production Manager were conducted. The Standards obtained were nine of safety, five of health and six of organization. The results are shown in table 1.

Table 1. Applicable standards

NOM	
Security	
NOM-001	Buildings, premises and facilities
NOM-002	Prevention and protection against fire
NOM-004	Systems and safety devices in machinery.
NOM-005	Handling, transport and storage of hazardous substances
NOM-006	Material handling and storage
NOM-009	Working at height
NOM-022	Static electricity
NOM-027	Welding and cutting
NOM-029	Maintenance of electrical installations
Health	
NOM-010	Pollutant chemicals
NOM-011	Noise
NOM-024	Vibes
NOM-025	Lighting
Organization	
NOM-017	Personal protective equipment
NOM-018	Identification of hazards and risks from chemicals
NOM-019	Health and safety committees
NOM-021	Information about workplace hazards
NOM-026	Color and safety signs
NOM-030	Preventive health and safety services

Verify compliance of the Standards
Due to the different types of verification, different types of activities were made. For physical testing was necessary to make a tour of the area and take note of the irregularities and breaches of relevant standards, revisions to programs, studies, procedures and records were made for fill documents and interviews with the production staff . Table 2 shows the results that were found.

Table 2. Results found by standard

Standard	Problem found
NOM 001	• Non-skid tape was in poor conditions in stairs. • Emergency doors obstructed. • Floor full of flour.
NOM 002	• Review of fire extinguishers missing last month. • Fire extinguisher obstructed.
NOM 004	• Equipment without safety protection.
NOM 005	• There is not a first aid manual for emergency medical care, drawn from the results of the study to analyze potential risk of hazardous chemicals.
NOM 006	• There are not procedures of heatlh and safety with instructions for maintenance hoists and winches. • Workers are not informed about the potential risk they are expossed by handling materials.
NOM 009	• There is not an analysis of the conditions for work at height.
NOM 010	• Missing tags of pollution sources, areas where is a risk of explosions and the number of potentially exposed workers to contaminants.
NOM 019	• Committee of health and safety (CSH) is not updated.
NOM 022	• There are not records of the resistance measurements of the ground network.
NOM 026	• Damaged signs.
NOM 029	• Potential risks for certain maintenance activities of electrical installations are not determined.

Evaluate results of compliance

The obtained results were captured in a table of scores and percentages by standard, where it was observed that the compliance of health milling area get the lowest percentage, because it shows that there are deficiencies in the Noise Standard (NOM-011) and Pollution Chemicals Standard (NOM-010). Regarding safety standard, in spite of being a high compliance rate, Maintenance of Electrical (NOM-029) indicates a low level of compliance. The overall score was 95.27 % (Table 3).

Table 3. Evaluation results

NOM			
Security		**1959.00**	**94.86 %**
NOM-001	Buildings, premises and facilities	193.50	98.00
NOM-002	Prevention and protection against fire	341.50	97.57
NOM-004	Systems and safety devices in machinery.	90.50	98.00
NOM-005	Handling, transport and storage of hazardous substances	175.00	95.89
NOM-006	Material handling and storage	152.50	93.85
NOM-009	Working at height	415.00	100.00
NOM-022	Static electricity	132.50	94.64
NOM-027	Welding and cutting	185.00	97.37
NOM-029	Maintenance of electrical installations	273.50	81.64
Health		**552.50**	**91.32%**
NOM-010	Pollutant chemicals	103.00	89.57
NOM-011	Noise	182.00	88.78
NOM-024	Vibes	142.50	91.94
NOM-025	Lighting	125.00	96.15
Organization		**852.50**	**98.27%**
NOM-017	Personal protective equipment	72.50	93.55
NOM-018	Identification of hazards and risks from chemicals	257.50	98.10
NOM-019	Health and safety committees	287.50	100.00
NOM-021	Information about workplace hazards	30.00	100.00
NOM-026	Color and safety signs	117.50	100.00
NOM-030	Preventive health and safety services	87.50	94.59
Global classification		**3364.00**	**95.10%**

When the qualification of compliance was obtain, a corrective and preventive actions were identify in the evaluation. Some of them were fix and are shown next. Other actions were program for next processing.

Corrective and prevention actions

NOM 001
Non-skid tape was place in stairs in order to prevent falls of staff. Figure 2 shows the evidence of this action.

Figure 2. Non-skid tape in stairs

In order to avoid obstructions or failures in emergency exit doors, a maintenance procedure was realized (figure 3).

REPORTE DE REVISIÓN A PUERTAS DE EMERGENCIA

PUERTAS DE EMERGENCIA								
No.	Área	Bisagras		Barra antipánico		Cerraduras		Observaciones
		CUMPLE		CUMPLE		CUMPLE		
		si	no	si	no	si	no	
1	Cuarto de aspiraciones							
2	Cuarto de elev. De harina							

Figure 3. Emergency doors maintenance procedure

Another action was to conduct cleanup activities in affected areas. To monitor compliance with this point an example of a before and after performing the action is shown (figure 4).

Figure 4. Before and after cleaning milling area

NOM 002

One of the findings presented regarding the standard 002 was the lack of review of fire extinguishers for the last month and for this we applied a check list where each of the points of the standard were check. Here it was fixed the second finding of obstruction of extinguishers (Figure 5).

Figure 5. Corrective action in fire extinguishers

A check list review of fire emergency devices (Figure 6) and emergency lamps (Figure 7) were performed.

REPORTE DE REVISIÓN DE DISPOSITIVOS DE EMERGENCIA

DISPOSITIVOS CONTRA INCENDIOS

No.	Área	Energi-zado		Carcasa		Sensor		Alarma		Carcasa		Energi-zado		Sirena		Luz estrob		Carcasa		Tablero eléctrico		Limpieza		Batería		Alam-brado		Observaciones
		CUMPLE		CUMPLE		CUMPLE		CUMPLE		CUMPLE		CUMPLE		CUMPLE		CUMPLE		CUMPLE		CUMPLE		CUMPLE		CUMPLE		CUMPLE		
		si	no	si	no	si	no	si	no	si	no	si	no	si	no	si	no	si	no	si	no	si	no	si	no	si	no	
1	Cuarto de elev. Har.																											
2	Piso de neumáticos																											
3	Piso de retentores																											
4	Piso de cernidos																											
5	Piso de purificadores																											
6	Piso de tubos																											
7	Piso de bancos																											
8	Piso de transmisiones																											
9	Amacén A, B, C, D y E																											
10	Oficina de calidad																											
11	Laboratorios																											
12	Sala de juntas																											
13	Oficinas administrativa																											
14	Oficinas GEMSO																											
15	Oficinas de Direcciòn																											
16	Recepción de trigo																											
17	UNIFAMA																											

Figure 6. Emergency devices checklist against fire

REPORTE DE REVISIÓN DE DISPOSITIVOS DE EMERGENCIA

LÁMPARAS DE EMERGENCIA

No.	Área	Energizada		Funciona-miento		Batería		Observaciones
		CUMPLE		CUMPLE		CUMPLE		
		si	no	si	no	si	no	
1	Cuarto de aspiraciones							
2	Cuarto de elev. De harina							
3	Piso de neumáticos							
4	Piso de retentores							
5	Piso de cernidos							
6	Piso de purificadores							
7	Piso de tubos							
8	Piso de bancos							
9	Piso de transmisiones							
10	Almacén de PT No. 1							

Figure 7. Emergency lamps checklist

NOM 004

Figure 8 shows the evidence of the corrective action of placing a safety guard in machinery. In addition to this, the importance of compliance with these security measures was report to the staff, in order to reduce risk.

Figure 8. Placing safety guard in machinery

6. CONCLUSION

Prevent the risks of work is an important task in any workplace, one way to make it is to carry out an assessment of compliance of safety and health at work , so that the company can take control and act proactively , thereby achieving a healthy working environment which will be reflected positively on productivity.

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EFFECTIVENESS OF WARNING TOXIC SUBSTANCES´PICTOGRAM, ON CHILDREN´S HAZARD PERCEPTION

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RESUMEN: Las intoxicaciones son una de las principales causas de mortalidad y morbilidad en niños menores de seis años. Debido a la falta de habilidad de lectura del niño, de supervisión de los adultos e ignorancia en el almacenaje de productos peligrosos, estos accidentes no intencionales ocurre con mayor frecuencia en el hogar. Los pictogramas constituyen uno de los mecanismos para informar y disuadir a los individuos de poner en riesgo su salud, en la manipulación de envases con sustancias tóxicas. En este sentido, con el presente estudio se busca evaluar la efectividad del pictograma de precaución de sustancias toxicas establecido por la Norma oficial NOM-003-SEGOB/2011 de protección civil de México. Para esta investigación se examinaron algunos trabajos sobre la efectividad de los pictogramas de advertencia que han sido soporte teórico y conceptual y han contribuido en el planteamiento metodológico. El estudio será dividido en dos etapas y se realizará con un total de 120 niños de 3 a 6 años de edad. En la primera parte los participantes evaluarán individualmente, por medio de un diferencial semántico si el pictograma les remite a algo bueno o malo. En la segunda etapa se evaluará si el pictograma aplicado en una etiqueta de un envase disuade al niño de manipularlo o si por el contrario hacen caso omiso de él. Los resultados indicarán si el pictograma es percibido como peligroso o no por los niños y en este sentido si es efectivo como señal de riesgo.

Palabras clave : Percepción de peligro, pictograma de advertencia, niños.

ABSTRACT: Poisonings are a significant cause of mortality and morbidity in children under six years old. Due to children do not have reading skills, inadequate adult supervision and lack of knowledge in hazardous products storage, these unintended accidents occur most often at home. The pictograms are one of mechanisms to inform and dissuade risky behaviors while containers of toxic substances are handled. In this sense, the present study is to evaluate the effectiveness of warning pictogram of toxic substances established by the official standard of civil protection of Mexico NOM-003-SEGOB/2011. For this research, some studies on the effectiveness of warning pictograms have been theoretical and conceptual support and have contributed to the methodological approach. The study will be in two stages, and it will need 120 children aged 3-6 years. In the first part, the participants will assess, through a semantic differential if the pictogram refers them a good or a bad thing. In the second stage will be assessed if the pictogram applied on a label of a container dissuade children to

handling it or if instead they ignore him and make contact with the container. The results would show if the pictogram were hazard perceived or not for the kids and in this sense if it is effective as a risk signal.

Keywords: Hazard perception, warning pictogram, children

Relevance to Ergonomics: Ergonomics seeks the safety, effectiveness, and comfort of the system between man, object and environment. The basic visual communication system: sender (pictogram warning of toxic substances), along with the message (danger toxic substance) and receiver (subject), it seeks to be clear and easy to identify to reduce the frequency of unintentional poisonings in public and private places. The correct perception of form and color in the visual communication system considers the adequacy of the same needs and characteristics of the activities of the subjects. To assess if a pictogram is really effective in a vulnerable population is vital in order to help improve the security of the population in general.

1. INTRODUCTION

According to the National Health Information System (SINAIS), poisonings are one of the leading causes of mortality and morbidity in the Mexican population. They showed, especially in environments such as dwelling houses, greatly affecting the child population under 6 years old (SINAIS, 2008) those accidents have been linked to the uptake of products with a toxic substance commonly used in this context, such as cleaning products, personal maintenance, medicine, and others (Shannon M. 2000).

This negative circumstance responds to different situations such as deficiency of adult supervision, ignorance regarding the storage of potentially harmful products, circumstances related to socioeconomic factors (Sevilla, Gomez, Chavez, Orozco and Celis, 2011) and even with the packaging, the appearance of the substances and the lack of information or clarity in the containers features. Government, through the consultative commission on civil protection standards developed, the Official Standard NOM-003 SEGOB/2011, seeking to establish signage for toxic products, underlining in specific and appropriate characteristics according to the context of use and risks, in this sense it could be possible to offer a set of graphical components for use in potentially risky products.

Avoiding poisoning requires work from many fronts, the information about accidents through caution or warning symbols becomes one of the most important factors because it is present information at the time of handling substances. In this regard, it is essential to recognize whether the characteristics of such graphics are clear and thus effective for individuals to understand the risks to which they are exposed.

However, so far there seems to be no concrete evidence of the effectiveness of symbol or pictogram warning and even less it is effectiveness related to the most vulnerable population conformed by children under six years old as it was mentioned in previous lines. Under this idea, this research project is focused on the assessment of the skull and crossbones pictogram warning of toxic substances, proposed by the Official NOM-003-SEGOB/2011, used as warning labeling on packaging with a toxic substance in products for home (Figure 1).The assessment is intended to recognize the children's hazard perception from pictogram, in several school gardens from Guadalajara, Jalisco, Mexico. This study focuses on the children not just because they are more vulnerable people, because of their perception of information could be different from how adults can understand the warning symbols.

Warning toxic substance

Color: Safety yellow background
Contrast: black
Shape: Triangle
Symbol: Skull head with two long bones crossed behind
Text: Toxic Substances (optional)

Figure 1. Warning toxic substance pictogram

According Kalsher and Wogalter (2008), most of the warning information about the accidents in children is made for adults for three particular reasons: the first is the primary responsibility that adults have in relation to childcare; the second refers to the very young children have not developed the necessary cognitive abilities to understand the messages, and third, those who acquire products are adults, so the warning should be a first filter to acquire and if so, locate and proper place in the home. Nevertheless, these authors argue that, even when adults play a critical role in preventing accidents, warnings designed to enable children to understand the weight factor if it is to dissuade a child to act in risky way. This is very important in the Mexican background, where, the social circumstances lead to leave the children alone more time and in that way are more likely to interact with substances that may be harmful to them (Sevilla, Et al., 2011), at this, information for them can become an essential element to avoid having negative consequences. However, the emphasis is on the importance of information directed particularly to children because they could assess some signals in a different and risky ways, compared with the adults; an example of this is mentioned by Ustinova the " pediatricians and poison control specialists note that young children are poisoned often when they mistake dangerous chemicals and their packaging for consumable foods and beverages "(cited by Kalsher and Wogalter, 2008, p. 529)

Regarding to the above, in other circumstances have been put into consideration the required characteristics pictograms focused on the pediatric population, as in the case of research (Pittsburgh Poison Center, Mr. Yuk, 1971), reaching conclusions and new proposals, different that arise from the regulations. Schneider states "children who are not told otherwise may interpret the ubiquitous skull and crossbones pictograph to mean" pirate food "(cited by Kalsher and Wogalter, 2008, p. 531). This is precisely the pictogram used by the standard applied in Mexico, which reinforces the importance of making an assessment.

Besides of the lack of knowledge regarding how the standard pictogram is perceived, several variations of the symbol on existing products on the market have been identified, which puts emphasis on it, in one hand the phenomenon of missing the correct application of the pictogram, and on the other hand, the question as to whether within the compositional graphic elements, there are some more relevant than others. Below (Figure 2) are presented some of the different applications of the pictogram on bottles of products on the market. Notably, the pictogram whose shape is a rhombus is utilized as a signal in the dangerous substance transport, however, are included as a warning on the substances packaging.

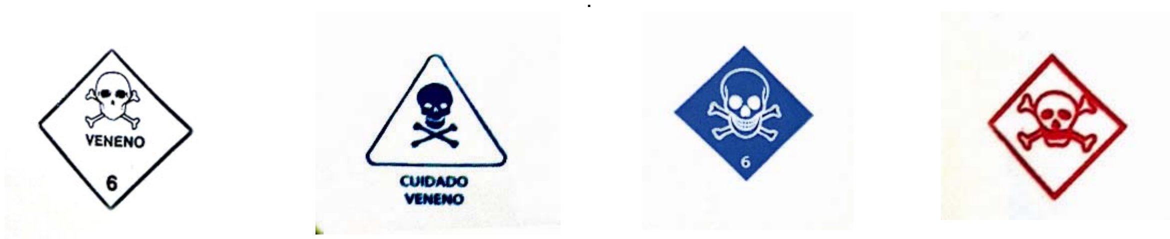


Figure 2. Several applied pictograms on market packaging

2. METHODOLOGY

A review of experimental and observational studies has been conducted. The literature search was in the Sciencie Direct data base with the keywords: warning labels, signs, children, safety, hazard perception, sybols, pictograms and poisoning.

The inquiry was supplemented in the reference lists of relevant articles on effective p ictograms for children. The items collection period was since 09/01/13 to 02/28/14 in English and Spanish languages without a specific time range.

The selection criteria were: Studies that examined the effectiveness of pictograms warning, Items with an experimental design with pictograms, Studies that analyzed subjects under eleven years old, studies that analyzed the perceived hazard.

3. RESULTS

In this review, we have included only six studies as most relevant to the issue of perceived danger in pictograms studies that have been published in not more than five years ago. Most of the studies presented have been developed in different countries but mainly with adults participants except by one. Table 1 presents the main characteristics of the six included studies.

The first article was a comparison of different cultural groups of people, first group of 40 subjects from the U.S. and 44 subjects from China. The main purpose of this study was to evaluate words and symbols of danger and labels determining the level of risk perceived by the participants. Warning labels are for communicate the level of danger associated with the use of a product and a method for reducing or avoiding the hazard. The instrument used was a scale of 1 to 9, with 1 being “no danger at all” and 9 "extremely dangerous." The result in this study on the perceived level of danger in the skull symbol with crossed bones, showed that categorize U.S. citizens with a higher level of toxicity hazard to the symbol than China citizens, (Lesch, Rau, Zhao & Liu, 2009).

The second paper investigated the effects of background color on the safety symbols and their relation to the perception of danger. It was held in Hong Kong with 31 adult subjects and using three safety symbols in total with eight different backgrounds. The measuring instrument was a subjective scale of 1 to 9 attributes from not dangerous to extremely dangerous. In most results with 96% of the subjects identified the risks involved toxics. In the symbol substances were identified as red color with a high level of risk, (Or KL and Chan, 2010).

The third study was carried out with military flight manuals containing three types of warnings: warning, caution and note. Information is essential to the subjective assessment of loss of life and body injury. The effectiveness of these warnings is crucial for a safe flight. Three symbols were designed and evaluated for the flight manual. Their variables were comprehension and hazard perception; In this research study were involved 54 pilots from Turkey and the instrument was designed to relate concepts presented with three symbols, e.g.| loss of life, body injury and essential information. This article is especially relevant for the present investigation since the pictogram of toxic substances was associated with a 92.6 % loss of life and body injury concepts, (Erdinc, 2010).

The fourth revised study and inspiration of this research was done in London where continuously reported accidents on train stations, involving children. In this investigation, a study was initiated to design pictograms for children to interpret the hazards and risks that they could have when travel by train. The study that involved 210 children from a elementary school involved activities in a classroom with children aged five to ten years. The results of this study yielded information regarding how children perceived facial expressions in pictograms and gave specifics how red color was perceived as dangerous and green was perceived as safe. The main method used allowed the development of a list of recommendations for future research with children and pictograms. (Waterson, Pilcher, Evans and Moore, 2012)

The fifth study presented here is on unintentional injuries in pediatric poisoning. His method was descriptive longitudinal study and was carried out in an emergency room of a hospital in Cuba between 2009 and 2011. Pediatric accident as mechanical, thermal and toxic qualified, but only toxic trauma for the study was recorded. Of the total of 156 injured patients, 75 cases were related to poisoning accidents, male gender was predominant with 61% and the age group of 1-5 years constituted 70% of patients. The injuries observed were mechanical first row of toxic accidents and finally thermal (Perez Gallardo, Castro, Yunaka and Abreu, 2012).

The sixth study was an observational surveillance research unintentional childhood injury, carried out in developing countries with various samples of children under eleven years and both gender. Among the participating countries are Bangladesh, Colombia, Egypt and Pakistan. Using surveillance data from the emergency departments in a four-month period in 2007, found a total of 1559 children affected of which 65 % were male, and 60 % (941) were aged less than 5 years. The lesions observed were related to falls, traffic, burns, drowning and poisoning, 56% of the reported cases occurred in the home. (Hyder, Sugerman, Puvanachandra, Razzak, El Sayed, Isaza, Rahman and Peden, 2009).

Table 1. Summary of included studies in the review.

	Autor(s)/year	Countries	N	Age mean/ range	Age mean SD	Independent variables	Dependent variables	Study design
1.	Lesch, Rau, Zhao and Liu, 2009	USA/China	84	20.5/21.6	2.00/1.17	warning components (colors, signal words and symbols)	Perceived Hazard	Experimental
2.	K. L. Or and Chan, 2010	China	31	16 to 25	No Data	Background color of 21 safety symbols	Perceived Hazard	Experimental
3.	Erdinc, 2010	Turkey	54	29.91	3.620	Three pictorical symbols: Skull and cross bones for Warning Plane with a broken wing for Caution Exclamation mark for Note	Perceived Hazard Comprehension	Experimental
4.	Waterson, Pilcher, Evans y Moore, 2012	United Kingdom	210	4 to 11	No Data	Prototype design for a new safety sign	Perceived Hazard	Experimental
5.	Pérez, Gallardo, Castro, Yunaka and Abreu, 2012	Cuba	76	1 to 5	No Data	Unintentional injury	Toxic trauma	Observational
6.	Hyder, Sugerman, Puvanachandra, Razzak, El Sayed, Isaza, Rahman and Peden, 2009	Bangladesh, Colombia, Egypt and Pakistan	1559	1 to 11	No Data	Unintentional injury	Toxic trauma	Observational

The methodology to be applied in this research is described, giving the number of sample needed and material to be applied in assessing the warning toxic substance pictogram.

The main purpose of this study involves two stages to cover in two periods of time; both will be developed in classroom´s activities with the children. In the first stage, the experiment seeks to detect possible bias in the study focused to evaluate the hazard perception in the children in front of the skull and bones pictogram out of context. The stage two will focus in the assessment of applied pictogram in context labeled on a bottle that will represent the toxic substance container in household use and its possible relation with the depend variable of hazard perception.

Subjects: It will give a summary of the research to parents, guardians and teachers as well as a consent form to be signed. Participants will be 120 preschool children divided into two groups (3-4 and 5-6 years) will be recruited by convenience. Subjects would be selected from kinder garden schools with a low income level of Guadalajara.

Materials: In the first stage, a set of eight cards 10 cm x 10 cm with several variations, (figure 3) of the skull and crossbones pictogram set by the Nom -003-SEGOB /2011, official Mexican standard signal and notice of civil protection to rate in children aged 3-6 years old. Two boxes will be required also to work like containers, each of them with a round face on front to represent a good or bad semantic meaning of the pictogram, (Figure 4).

Figure 3. Pictogram's variations for the first experiment.

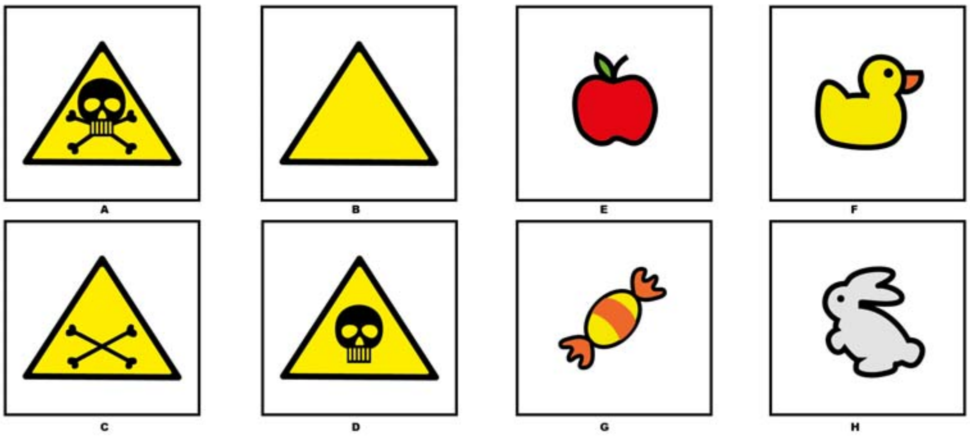
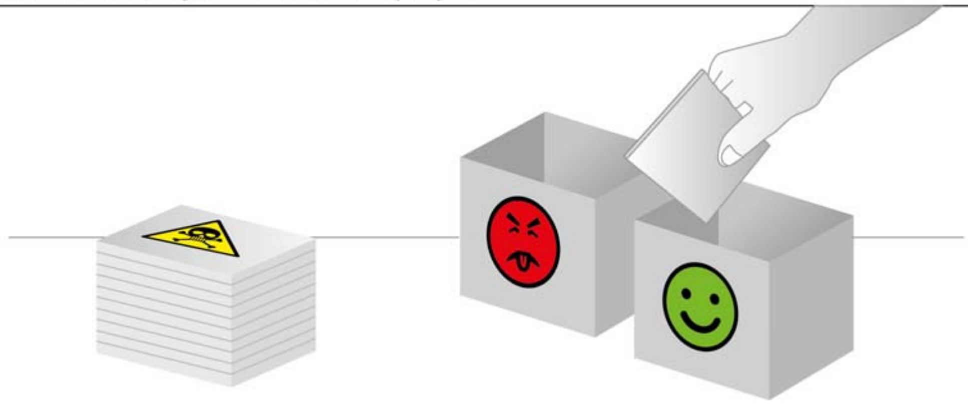


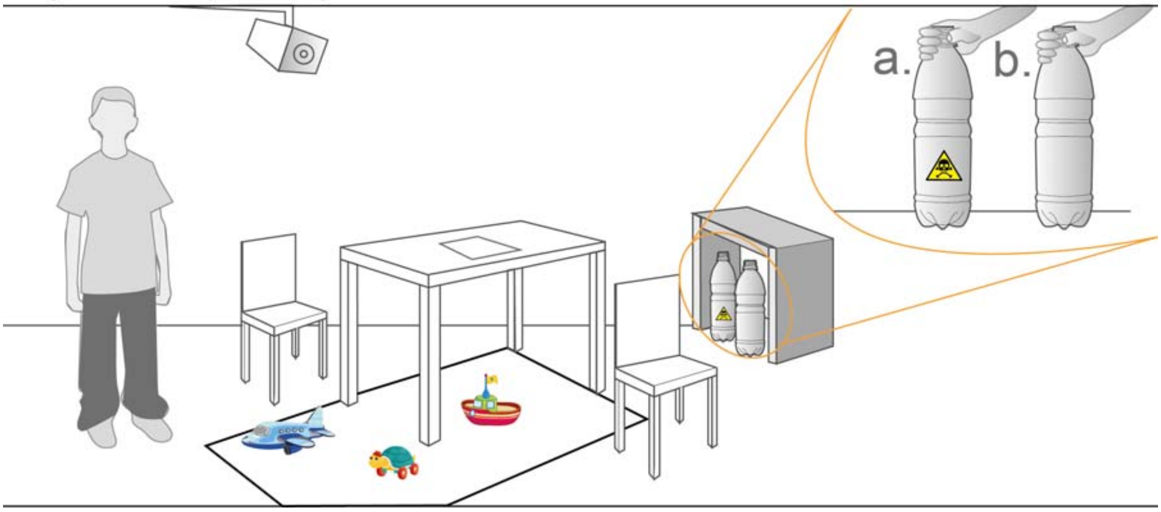
Figure 4. Semantic meaning instrument to assess the pictogram.



In both phases a video camera will be needed, but only in the second stage, two child-sized chairs and a table over a rug with some toys, as well as a white bottle similar to containers of toxic household substances labeling with the skull and crossbones pictogram. It will be filled with drinking water for subject´s safety, (Figure 5).

Procedure: To determine the effectiveness of the warning toxic substance pictogram established by the Mexican Official Standard NOM -003 -2011 - SEGOB , signs and notices for Civil Protection, It was considered the children´s danger perception, assessing the child's contact with a labeled drinking bottle to accept it or reject it.

Figure 5. Second experiment stage.



In this study, the qualitative variable perceived hazard will be measure with the warning of toxic substances pictogram by children aged 3-6 years with a subjective evaluation of a semantic differential, with the extreme qualities of good or bad, they will interpret individually when they observe the image. It will seek to capture the facial reaction of the children when they observe for first time the warning of toxic substances pictogram, it will be used a video recording experience once the child's decision interpreting the pictogram as good or bad. They will deposit it in one of the two boxes representing the semantic differential.

The second stage procedure with two bottles, a bottle labeled with the warning pictogram and other with nothing on the label, with the intention to watch the child's behavior when choosing any of the two bottles will be placed, and the child's individual decision, which one to choose and take it with, or without pictogram. Then determine the effectiveness of risk perceived by the child in the pictogram.

4. CONCLUSION

The type and quality of information plays an essential role in the search for help in the prevention of accidents related to intoxication. In that sense the graphic elements used and the existing regulations that establishes the caution information requierements, should be analyzed and evaluated to determine whether it is appropriate raised in complex scenarios faced or requires different features according to the characteristics of the population to which it has been addressed.

While the poisonings panorama has different perspectives that need to be taken into consideration, it has been considered that the issue of the warning signs can help significantly to prevent accidents, acting as latest barrier between the subject and substances that may be potentially hazardous to health. In Mexico, the family dynamics in sectors of the population with low incomes, in which children must remain a considerable time without adult supervision, increases the possibility of suffering an accident (Sevilla, Et al, 2011); this requires a review of possible prevent mechanisms to avoid exposing children to hazardous situations. In this sense, the design of clear warnings could become one of the most effective ways to combat accidents and improve safety in the home.

Although this study is a small part of the complete picture of the situation analyzed, it seeks to provide information which constitutes a support to refine and develop ways to improve the proposed warning signs and in that sense, help in the consolidation of a more reliable standards.

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VIBRATION EXPOSURE LEVEL FOR MASS PUBLIC TRANSPORTATION VEHICLE DRIVERS IN BOGOTÁ

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Resumen: En el documento se presentan los resultados obtenidos a partir de una investigación relacionada con la exposición a vibraciones trasmitidas a cuerpo entero en conductores de vehículos articulados de transporte masivo de pasajeros en la ciudad de Bogotá. Para determinar la exposición se seleccionaron las rutas que abarcaban la mayor longitud en su trayecto (5), tres tipos diferentes de carrocería y la totalidad del tiempo de operación. Para la medición se utilizó un analizador de vibraciones SVANTEK, ubicando el sensor del Acelerómetro en el asiento de la cabina de vehículo en el que desarrolla su actividad el trabajador. Tomando como referencia la Normativa ISO 2631 – 1 se determina que el 66.66% de las mediciones se clasifican en el rango inconfortable y el 33.33% restante en el de muy inconfortable. Se observa que los picos más representativos en la medición se presentan cuando el estado de la vía se encuentra en malas condiciones, cuando aumenta la cantidad de pasajeros que transportan, según el estado de mantenimiento del automotor, y por imprevistos en la vía que hacen que el conductor deba desacelerar el vehículo de forma no programada.

Palabras Clave: Salud Laboral, Vibración, Transporte

Abstract: This paper presents the outcomes from a research conducted in connection with whole-body vibration exposure transmitted to mass transportation articulated vehicle drivers in Bogotá. To establish exposure, the following elements were selected: 5 (five) routes that covered the longest distances, 3 (three) different types of bodywork, and the entire operation time. To carry out such measurement, a SVANTEK vibration analyzer, placed in the accelerometer sensor on the seat of the vehicle cabin where workers perform their job, was used. Based on ISO 2631 Guidelines, percentages of

such measurements were determined under the following ranges: 66.66% (Uncomfortable), 33% (Very Uncomfortable). It is observed that the most representative peaks of such measurements are present when the roads are in bad conditions and when the number of passengers increases; also these peaks are affected by vehicle maintenance and road unforeseen events that make drivers slow down unexpectedly.

Key words: Occupational health, vibration, transportation

Relevance to Ergonomics: The study of whole-body vibration exposure transmitted to mass transportation articulated vehicle drivers in Bogotá gives insights into the conditions under which this important job to the social and economic development of the city is performed.

Key words: Occupational health, vibration, transportation.

1. INTRODUCTION

When performing their job, mass transportation articulated vehicle drivers are exposed to whole-body vibration levels so far not studied in Colombia. Hence, the importance of this activity in the social and economic development of Bogotá and the likely health adverse effects that may derive from such exposure give rise to this first approach to determining the vibration intensity levels such drivers face.

For this particular study, whole-body vibrations are defined as follows: "Those vibrations the body perceives when most of it is resting on a vibrating surface - seat or back of the driving seat in a mobile machine, vibrating platforms, etc. - (National Institute for Safety and Hygiene in the Work Place – INSHT for its Spanish acronym, 2010). Also, exposure to this type of vibrations "leads to workers´ health and safety risks, in particular, back pain and spinal injuries" (INSHT, 2010).

Upon determining the conditions under which this job is performed and that directly affect the vibration intensity levels drivers face, we can provide recommendations and take action to minimize the adverse effects that may involve drivers.

2. OBJECTIVE

The main objective of this study is to determine whole-body vibration exposure transmitted to mass transportation articulated vehicle drivers in Bogotá

3. SCOPE

This study was carried out in fifteen (15) routes of Bogotá´s public transportation system.

4. METHODOLOGY

4.1 Route, Vehicle and Schedule selection.

From the entire operation in Bogotá, the longest routes were first selected. Then, the following 5 main routes were measured:

- Portal Suba – Portal Américas – Portal Suba
- Portal Suba – Portal Norte – Estación Banderas
- Portal Suba – Portal Usme – Portal Suba
- Portal Suba – Portal Tunal – Portal Suba
- Portal Suba – Portal Sur – Portal Suba

For a closer look at the entire system operation, 3 different types of bodywork - *Marcopolo, Comil* and *Buscar* – were measured.
To determine whether there was any measurement variation due to schedule, it was established to carry out such measurements during the entire system operation, i.e., from 5 a.m. to 11:45 p.m., thus covering express and easy routes.

4.2. Measurement equipment selection

A SVANTEK vibration analyzer, Model SV106, Serial 20648 was used to obtain data for all measurements.

Figure 1. SVANTEK SV106 Equipment

Measurements

The following steps were taken into account when carrying out all measurements:
- The accelerometer is calibrated at the place and time of each and every measurement.
- The accelerometer sensor is placed on the seat of the vehicle cabin where workers perform their job.

- Measurement parameters are set.
- Environment conditions and operation variations are recorded in the travel logbook.
- Finally, data obtained by the accelerometer is downloaded.

Figure 2. Location of accelerometer sensor

5. OUTCOMES

Table 1 shows the outcomes obtained during the measurements carried out to articulated vehicle drivers using the accelerometer. The chart also shows the 5 (five) routes that were measured. The description of these routes is as follows: Easy Route and Express Route, schedule according to passenger volume, acceleration values of the three axes (RMS), and classification under ISO 2631-1 Guideline.

Table 1. Accelerometer Measurement Outcomes

ROUTE	TYPE OF ROUTE	TYPE OF HOUR	RMS	CLASSIFICATION
PORTAL SUBA – AMERICAS – PORTAL SUBA	EXPRESS	NON-RUSH	1,68	UNCOMFORTABLE
PORTAL SUBA – AMERICAS – PORTAL SUBA	EXPRESS	NON-RUSH	1,84	VERY UNCOMFORTABLE
PORTAL SUBA – AMERICAS – PORTAL SUBA	EXPRESS	NON-RUSH	1,76	UNCOMFORTABLE
PORTAL SUBA – PORTAL NORTE – BANDERAS – PORTAL SUBA	EXPRESS	RUSH	1,81	VERY UNCOMFORTABLE
PORTAL SUBA – PORTAL NORTE – BANDERAS – PORTAL SUBA	EXPRESS	RUSH	1,64	UNCOMFORTABLE
PORTAL SUBA – PORTAL NORTE – BANDERAS – PORTAL SUBA	EXPRESS	RUSH	1,73	UNCOMFORTABLE
PORTAL SUBA – PORTAL USME – PORTAL SUBA	EASY ROUTE	NON-RUSH	1,60	UNCOMFORTABLE
PORTAL SUBA – PORTAL USME – PORTAL SUBA	EASY ROUTE	NON-RUSH	1,54	UNCOMFORTABLE
PORTAL SUBA – PORTAL USME – PORTAL SUBA	EASY ROUTE	NON-RUSH	1,65	UNCOMFORTABLE

PORTAL SUBA – PORTAL TUNAL- PORTAL SUBA	EASY ROUTE	RUSH	2,02	VERY UNCOMFORTABLE
PORTAL SUBA – PORTAL TUNAL- PORTAL SUBA	EASY ROUTE	RUSH	2,07	VERY UNCOMFORTABLE
PORTAL SUBA – PORTAL TUNAL- PORTAL SUBA	EASY ROUTE	RUSH	2,05	VERY UNCOMFORTABLE
PORTAL SUBA – PORTAL SUR – PORTAL SUBA	EXPRESS	NON-RUSH	1,61	UNCOMFORTABLE
PORTAL SUBA – PORTAL SUR – PORTAL SUBA	EXPRESS	NON-RUSH	1,68	UNCOMFORTABLE
PORTAL SUBA – PORTAL SUR – PORTAL SUBA	EXPRESS	NON-RUSH	1,64	UNCOMFORTABLE

From the fifteen (15) measurements carried out and under ISO 2631-1 Guideline, it was determined that 66.66% (10 measurement cycles) correspond to Uncomfortable Range, and 33.33% (5 measurement cycles) to Very Uncomfortable Range.

Classification	Number	Percentage
Comfortable	0	0%
Uncomfortable	5	66.60%
Very Uncomfortable	10	33.30%

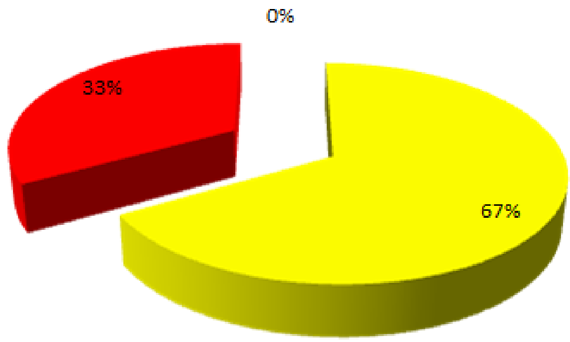

Figure 3. Classification of vibration acceleration intensity under ISO 2631-1 Guideline

When analyzing the behavior of the vibration intensity in every travel, important peaks are observed when the road on which the articulated vehicle moves is in bad conditions (holes, ups and downs as well as fissures); when the number of passengers increases, thus showing that, in some cases, the maximum capacity established by the manufacturer is exceeded; vehicle maintenance (tire pressure calibration, alignment, balancing, cushioning, braking, etc.); and finally, when unexpected road situations arise, which, in most cases, have to do with unsafe crossings made by pedestrians, thus making the vehicles slow down unexpectedly.

Additionally, it is observed that seats do not meet the biotype of some mass public transportation vehicle drivers, thus resulting in inadequate driving posture.

6. CONCLUSIONS

As the outcomes of whole-body vibration exposure measurements resulted in discomfort ranges, it is necessary to implement intervention measures to minimize those effects that may trigger drivers´ health problems.

System operators need to establish adequate procedures to check vehicle maintenance, carry out an anthropometric analysis to establish the characteristics of all system drivers to, then, determine the conditions of the seats to be installed at the vehicle cabin; also, an analysis of the operational characteristics needs to be carried out in order to determine the measures leading to diminishing the number of passengers per vehicle at rush hours.

Finally, Bogotá´s administration is accountable for road maintenance; hence, the city´s entity responsible for this process shall establish policies that ensure, as soon as possible, the improvement of road conditions.

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MICROCONTAMINACION OF AIR GENERATES THE SICK BUILDING SYNDROME IN OFFICES OF INDUSTRIAL PLANTS IN MEXICALI

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Resumen: Se realizó un estudio ambiental para evaluar las condiciones en las oficinas de cinco plantas industriales relacionados con la industria electrónica en la ciudad de Mexicali. Se evaluaron los microclimas como factor principal con parámetros de humedad relativa (HR) y temperatura, que influyeron en la generación de microorganismos (MO) en el interior de estas oficinas. Esto llevó a la generación y proliferación de las infecciones respiratorias agudas (IRA) en el personal que labora en las áreas mencionadas en las empresas evaluadas y una disminución del rendimiento laboral de las personas. De acuerdo a esto, se realizó una correlación de las condiciones ambientales con concentraciones de sulfuros y micro-partículas, condiciones climáticas y los índices de IRA, generados en el personal que trabaja en dichas empresas. El análisis mostró el efecto adverso causado por la contaminación de este agente gaseoso que es una sustancia ácida indispensable para el desarrollo de ciertos MO. Esto causó molestias respiratorias en algunas personas con este tipo de síntomas, en relación con los aspectos de ergonomía con las condiciones ambientales. La generación y proliferación de las IRA causaron otros síntomas en las personas de las oficinas de las plantas industriales evaluadas y don se llevó a cabo el estudio, tales como dolores de cabeza, de estómago y dolores en el cuerpo y malestar principalmente. La ocurrencia de este fenómeno es llamado como el síndrome del edificio enfermo (SEE), que es muy común en los interiores de los edificios, pero a pesar de que es considerado como un problema menor con poco efecto, sin consecuencias graves , tuvo un efecto negativo en el rendimiento operativo de la gente al no cumplir las metas de la empresa. Además, se elaboró una evaluación de las consecuencias de este fenómeno; donde el SEE causó un aumento en el ausentismo y por lo tanto una disminución de la productividad, la disminución de la capacidad operativa de los servicios en las oficinas y por lo tanto las demoras en las diversas actividades. Esto afectó a las operaciones de reclutamiento de personal, compra de materiales, las ventas de productos terminados entre los más importantes. El estudio se realizó en cinco empresas ubicadas en la ciudad de Mexicali, en el período 2011-

2012. El análisis se hizo sobre MO con la técnica de Microscopía de Barrido con Electrones (MBE).

Palabras clave: Ergonomia, síndrome del edificio enfermo, atmosfera corrosiva, plantas industriales

Abstract: An environmental study was done on the conditions in offices of five industrial plants related to the electronic industry in the city of Mexicali. The main factor evaluated were conditions of microclimates with parameters of relative humidity (RH) and temperature, which influenced the generation of microorganisms (MO) in the interiors of these offices. This led to the generation and proliferation of Acute Respiratory Infections (ARI) in the personnel that work in the areas mentioned at the evaluated companies and decreased people's performance. On this basis, a correlation of environmental conditions with concentrations of sulfides and micro-particles, climatic conditions and the rates of ARI generated in staff working was carried out. The analysis showed the adverse effect caused by the contamination of this gaseous agent which is an acidic substance indispensable for the development of certain MO. This caused respiratory discomfort in certain people with this type of symptoms, regarding a case of ergonomics with environmental conditions. The generation and proliferation of the ARI caused other symptoms in the personnel that work in the places where the study was carried out such as headaches, upset stomach and body aches, and mainly. The occurrence of this phenomenon is called as the sick building syndrome (SBS), which is very common in interiors of buildings, but although it is considered as a minor problem with little effect without serious consequences, had a negative effect on the people's operating performance, causing that company goals are not met. In addition, an assessment of the consequences of this phenomenon was prepared; SBS caused an increase on absenteeism and thus a decrease in productivity, decreasing the operational capacity of departments in offices and thus delays in various activities. This affected the operations of personnel recruitment, purchase of materials, sales of finished products among the most important. The study was conducted in five companies located in the city of Mexicali in the period from 2011 to 2012. An analysis was done on MO with the technique of Scanning Electron Microscopy (SEM).

Key words: Ergonomics, Sick Building Syndrome, Corrosive atmospheres, Industrial plants

Relevance to ergonomics: The ergonomics studies evaluate the necessity to maintain the adequate conditions of people who work in industrial plants as companies located in the Mexicali city in the northwest of Mexico. This is city is considered as an arid zone with extreme climatic factors and in sometimes of the year with ranges of relative humidity higher than 80% can generate MO that have a negative effect in persons that work in closed rooms of industries. For this reason is very important this study, to determine the principal causes that originate the ARI in people and decrease their productive yielding. With the analysis was evaluate the inadequate conditions that were generated by aggressive environments with air pollutants as sulfurs that are very common in the air pollution of this city and penetrate to indoors of companies in offices departments.

1. INTRODUCTION

The presence of infections in closed places, which lead to develop SBSs, can cause absenteeism, being one of the main concerns for managers, since they tend to cause people to get sick and when people get mentally disoriented, can generate minor or even fatal accidents[2]. All buildings must have Antibacterial Filters (AF), to not allow the entry of MO or MB, in addition to dust, as it happens in the city of Mexicali, which is a desert region in the Northwest of the Mexican Republic. In this area of the country, wind erosions occur and storms with particles smaller than 10 microns or smaller scale once in a while happens, causing sometimes the dust to penetrate to the Interior of the buildings. This combined with the MB and MO, cause respiratory infections that cause an unusual environment that is part of the sick building[3]. The main objective of the managers is always to maintain the optimal conditions, but It is difficult to maintain this environment due to the lack of specialized filters, which were not available and managers considered to obtain after they saw this study.

Evaluation of the Antibacterial Filter Operation:

(AF) antibacterial filters are installed on the upper part of the internal structures of buildings, their function is not to allow the entrance of MO or MB or particles that damage people's health who work in offices and hospitals[4]. Only when the AF are not working properly, a congestion of the MO and MB is generated, forming a large number of organic and inorganic matter (dust and gas), which deteriorates the environment of the offices and areas of the buildings. The presence of a greater number of MO and MB by the ineffectiveness of the FA, generates viruses with different characteristics to the original properties of these, being sometimes, more resistant to disinfection processes. For this reason, the use of disposal methods such as the systems of atmospheric aerosol, to support better environmental conditions which are favorable for health, that are reducers and removers of MO and MB in the premises being evaluated[5].

Sick Building Syndrome

The term of the SBS is applied to describe situations in which the occupants of the building experience health and discomfort effects that seem to be related to the time that they have been in a building. But no disease or specific cause can be identified. A report by the World Health Organization in 2010, suggested that up to 30% of new and remodeled buildings worldwide may be subject to SBS related to the poor quality of its interiors. Sick Building causes are often related to failures in heating, ventilation and air conditioning systems. Other causes have been attributed to contaminants produced by degassing of certain types of building materials, volatile organic compounds (VOC), MO and MB. In addition, contaminants from the outside, mainly sulfides, which penetrate to the Interior, can cause environments not suitable to stay for several hours in the buildings. Other factors causing the SBS are light industrial chemicals used within the building as well as the lack of filtration by reducing the entry of fresh air[6]. To avoid the SBS occur, there are antibacterial and specialized filters that do not allow the input of pollutants from outside, or dust; but that sometimes don't work properly. This happened in the five companies being evaluated, where were presented ongoing cases, especially in winter, due to the AF were saturated and not working properly, allowing the entry of MO and MB, as well as air contaminants with particles less than10 micron that promote conditions for the growth of MO and MB allergens[7].

Acute Respiratory Infections:

Also known as ARI, respiratory diseases represent a medical term which encompasses the pathological States affecting the organs and tissues that make possible the exchange of gases in higher organisms. It includes the conditions of the upper airways, trachea, bronchia, bronchioles, alveoli, pleura and pleural cavity, and the nerves and the muscles of the respiratory system[8]. Respiratory diseases range from minor such as the common cold, up to serious level, as the symptoms that threaten life such as bacterial pneumonia, pulmonary embolism and lung cancer. Respiratory diseases can be classified in many different ways, either by the organ or tissue involved, by type, the pattern of signs and symptoms associated, or the cause (etiology) of the disease. One of the diseases of high risk is the one that originates in the lungs, being the main, Chronic Obstructive Pulmonary Disease (COPD). Asthma is an example of an obstructive lung disease (and an inflammatory disease of the lungs). This type of disease occurs in the muscles of the bronchia, making it difficult to get air into the lungs and can be caused by the SBS[9]. Asthma causes difficulty in breathing causing wheezing due to inflammation of the bronchia and Bronchioles, causing a restriction in the flow of air in the alveoli. Infections of the respiratory tract, which can affect any part of the respiratory system, are also presented. They are traditionally divided into upper respiratory tract infections and infections of the lower respiratory tract. Upper respiratory tract infections are the one that most frequently happens, as the common cold[10]. In addition, infections of specific organs of the upper respiratory tract, such as sinusitis, tonsillitis, middle otitis, pharyngitis and laryngitis are also considered Upper respiratory tract infections. One of lower respiratory tract infections most frequently is pneumonia (in lungs), which is often caused by bacteria, particularly Streptococcus pneumoniae. Worldwide, tuberculosis is a major cause of pneumonia. Other pathogens such as viruses and fungus can cause pneumonia, i.e. respiratory syndrome and acute pneumonia. Pneumonia may develop complications such as pulmonary abscess; a round cavity in the lung caused by infection, or may extend to the pleural cavity. All of the aforementioned cases may cause negative effects on the functioning of the cardiac system, sometimes leading to death[11, 12].

Mexicali. An industrial desert area:

The city of Mexicali is located in the Northwest of Mexico, with a vast desert area, where companies in the electronic industry are established, electronic manufacturing related companies are the largest number of industrial plants, in addition to the medical, metalworking and aerospace, mainly[4]. This region, due to its proximity to international airports of USA including San Diego and Los Angeles, is considered of great importance by moving fast raw material and product to different areas of the USA and other countries such as Japan, South Korea, Germany and China, in particular. One of the only downside of this region is the type of soil that is made up of very fine particles of up to 2.5 microns that need to be analyzed with specialized environmental equipment[13, 14]. Another important factor is that levels of air pollution are high and above safety limits continuously affecting the quality of the outdoor air. Both fine dust particles and pollutants, being sulfides expelled by the Geothermic Industry of Cerro Prieto that supplies electricity to the city of Mexicali and its Valley, in addition to cities in the border with USA; they penetrate to the Interior of industrial plants (manufacturing, warehouse and office areas)[15]. This contaminates the atmosphere at the interiors of the companies, causing the causes for the SBS and the generation and proliferation of the ARI, as well as side effects symptoms**.**

2.- OBJECTIVES

Assess the causes that generate the sick building syndrome in offices of five industrial plants in Mexicali, dedicated to the manufacturing of electronic product and develop relevant improvements to reduce cases of the SBS in these companies and propose the improvements for other areas of these companies, as well as other companies or Government and private institutions

3.- DELIMITATION

Research was developed only with staff in the office areas of the five manufacturing plants in the city of Mexicali, in the period from 2011 to 2012.

4.- METHODOLOGY

The research included an analysis of the following stages, developing the mathematical analysis with the MatLab program:

(a) ARI cases presented in the five companies. We evaluated cases of ARI, classifying them by their main types and allergens generated by them in the city of Mexicali. The top ten diseases that occur frequently in this city are EPOC, pulmonary vascular disease (PVD), sinusitis, tonsillitis, middle otitis, pharyngitis, laryngitis, rhinitis, chronic bronchitis and pneumonia.

(b) Evaluation of the environment with the Sulfation Plate Technique (SPT). It was carried out to determine the concentration levels of sulphides in the interiors of offices, and thus correlate them with ARI indexes and other diseases related to these.

(c) Climate Variation Analysis. Climate is an important factor in the generation of ARI and other kind of diseases of this type, since the levels of cold and heat are an essential part in the formation of MO and MB. This is why the interest of both to assess levels of relative humidity and temperature, and correlating them with levels of sulphides obtained by the technique of SPT to ARI.

(d) Microanalysis using Scanning Electron Microscopy. This was done to know in detail the types of MO and MB formed in the offices of the companies evaluated. This allowed knowing with greater certainty the type of MO and MB, which will generate the SBS and the ARI.

5. RESULTS

Research shows that environmental conditions, in the five companies evaluated, are not a high risk for personnel, but since the offices are closed spaces it has a negative effect on the people's health working in these workplaces. This is because there are no antibacterial and air exchange filters resulting in the generation and proliferation of ARI by the presence of MO and MB, as well as the micro-particles of dust and contaminants from the air as sulfides that are undetected and penetrate the respiratory tract. This was the cause, that certain workers mainly women, had absences or came to work sick, causing lack of control and under performance of these areas in the companies. With the proposals to control the microclimate in the five offices it was observed a better performance of the personnel at work by reducing symptoms and discomfort generated by IRA and thus fewer absences. To improve the environmental conditions, it was designed and manufactured an electronic system with automated control in conjunction with antibacterial filters, reducing to the minimum the MB and MO.

Correlation analysis:

A correlation analysis using MatLab program was made on levels of relative humidity and temperature, in conjunction with the levels of concentration of sulfides in the interiors of each office of the evaluated companies, related to concentrated ranges of ARI. Assessments were made in offices because it presented continuous cases of people who suffered from some kind of respiratory disease mentioned in the methodological development. The process of the cases of ARI that got subsequently complicated began with a common cold and if they were not quickly treated, on the grounds that it was a temporary symptom, a more serious disease could be generated. This is why the cases of all those affected were evaluated and classified according to severity indices. This is presented in the table 1, showing the types of diseases, number of cases, duration of symptoms, correlated with the levels of SO_2 and climate factors, separated by periods of winter and summer of 2011 and 2012. To obtain a detailed analysis, evaluations were performed in all four seasons of the year, whereas the periods of summer and winter are with the higher incidence. The number of office workers, where the evaluations were performed in the study period, was 73 in company 1, 58 in company 2, 53 in company 3, 49 in company 4 and 38 in company 5. The number of cases was the sum of persons who were cared in the same company by medical staff and nursing, where it was considered that if a person who had suffered some kind of ARI, and fell sick again and returned for medical care, is counted as another case. The ages of the evaluated workers ranged between 18 and 65 years, where the most affected staff was above 50 years old. In addition, it was considered, even though it was not a necessarily relevant factor before starting the study, but to take it into account as something secondary, those persons with a professional level, showed fewer cases than those who did not have that level of studies. In the section on diseases or symptoms types, even though they were of different types, only the two with highest rates were presented. Relative Humidity and temperature were monitored, using a digital hygrometer and digital thermometer, in the interiors of the offices of the companies. In periods where the Relative Humidity and indoor to the outdoor temperature values were similar, was because in certain seasons of the year, it was allowed to keep some windows and doors open. This has resulted in a negative effect since it is more easily that pollutant such as SO2 and other smaller-scale, as well as dust particles to penetrate the offices, causing the ARI. The days mentioned in the table, indicate the average time period in which sick people remained incapacitated to work. This caused an income los for such persons; in addition, the operating performance of departments was decreased. In addition, even if there was personnel to cover the activities of ill persons who were not at work, errors were generated and thus delays in certain operations affecting the companies. This put a lot of stress and tension on managers and office workers, when a person fell sick again with symptoms of disorders in the heart and respiratory system. All the evaluated companies are located in various areas of the city of Mexicali, being all in the periphery. An important factor for the generation of MO and MB is the relative humidity in industrial plants, which have levels of relative humidity a little higher than average levels from abroad. This process is still under evaluation, we don't have a complete verification that those indices of relative humidity of the interiors of offices, will be a little higher than outdoor levels, by having a greater number of areas of green areas near the offices. Previous studies have shown that levels greater than 75% of relative humidity can generate, sometimes, ARI symptoms to some people. Another aspect of interest in the generation and proliferation of ARI, are the levels of SO_2, which even though antibacterial filters are in place, helped some companies to reduce the amount of ARI. The five companies are located on a map that represents the urban area of the city of Mexicali in Figure 1.

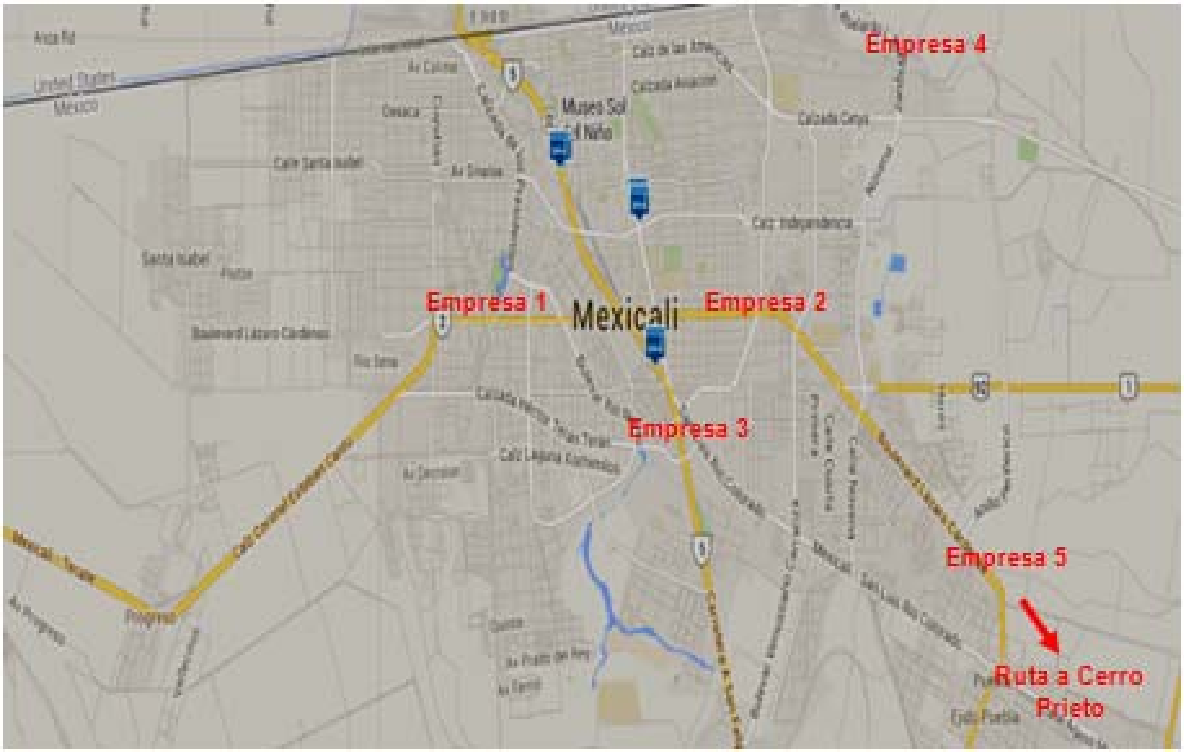

Figura 1. Location of the companies being evalaured in Mexicali
Map Source. http://www.clubdereservaciones.com/es/25226_mexicali/mapa/

As shown in Figure 1, the companies were located in different areas of the city to carry out a comparative study by areas in Mexicali, showing that the company 5 is the closest route to the Geothermic Industry of Cerro Prieto, which will generate electricity that is supplied to large part of this region. It is there in conjunction with the traffic of vehicles from where the greatest amounts of sulfur from air pollutants are emitted, and by chemical reaction with the atmosphere, they are converted to sulfides. These particles and gases from outside sources penetrate the cracks, holes, air conditioners or antibacterial filters in bad condition towards the Interior of companies to the manufacturing areas, stores and offices where the study was conducted. The location of the companies was of great importance to know the factors that generate rarefied atmosphere in offices that later triggered the generation and proliferation of ARI.

Numerical and Microscopy Analysis:

This analysis was done to observe in detail the correlation process in the summer and winter of 2011 and 2012 periods that the company with higher IRA rates. A big focus effort was made on this company, because of the high absenteeism. This led, once the analysis stage was finished on the five companies, to focus on the company 5 to develop strategies to reduce the absenteeism due to ARI. Figures 2, 3, 4 and 5 show the correlation obtained for the climate, environment and ARI factors, where you can see various approaches in the analysis. It should be noted that the four figures show only analyses of a company for the periods of summer and winter of 2011 and 2012, which presented higher rates with respect to the generation and spread of ARI. In Figure 2, is the analysis of the seasonal period of summer 2011, showing the mathematical correlation in the Matlab, by ranges of sick people being most frequent in intervals of 30-80% RH and almost 20 °C to 40°C shown in Figure 1a. Figures 2b and 2 c, represent MO formed in 2011, and evaluations done, daily, monthly and seasonal assessments to a scale of 250X and 5X, where you can see the types of MO, which are still being evaluated if they exist in the registered bibliographic scientific MO. The same is true for the Figure 3a, 3b and 3 c, which outlined processes similar to those mentioned in the previous figures with different RH rates from 18% to 65% and 8 °C to 30 °C. Even when you know that the temperatures in the summer are high, analyses show the offices had conditioning systems lit from 10 pm to 5 am. In Figures 4a, 4b and 4 c; there are climate and air pollution indexes, with an increase in the cases of ARI that was due to increases, in small scale, of the RH and temperature, as well as the concentration of the SO_2 levels. This means that each year the levels of climate agents will continue to increase and with that the percentage of ARI. In figures 5, 5b and 5 c, with levels of 5% to 75% of RH and 3°C to 28°C. This indicates that even at low levels of RH, MO and MB are generated.

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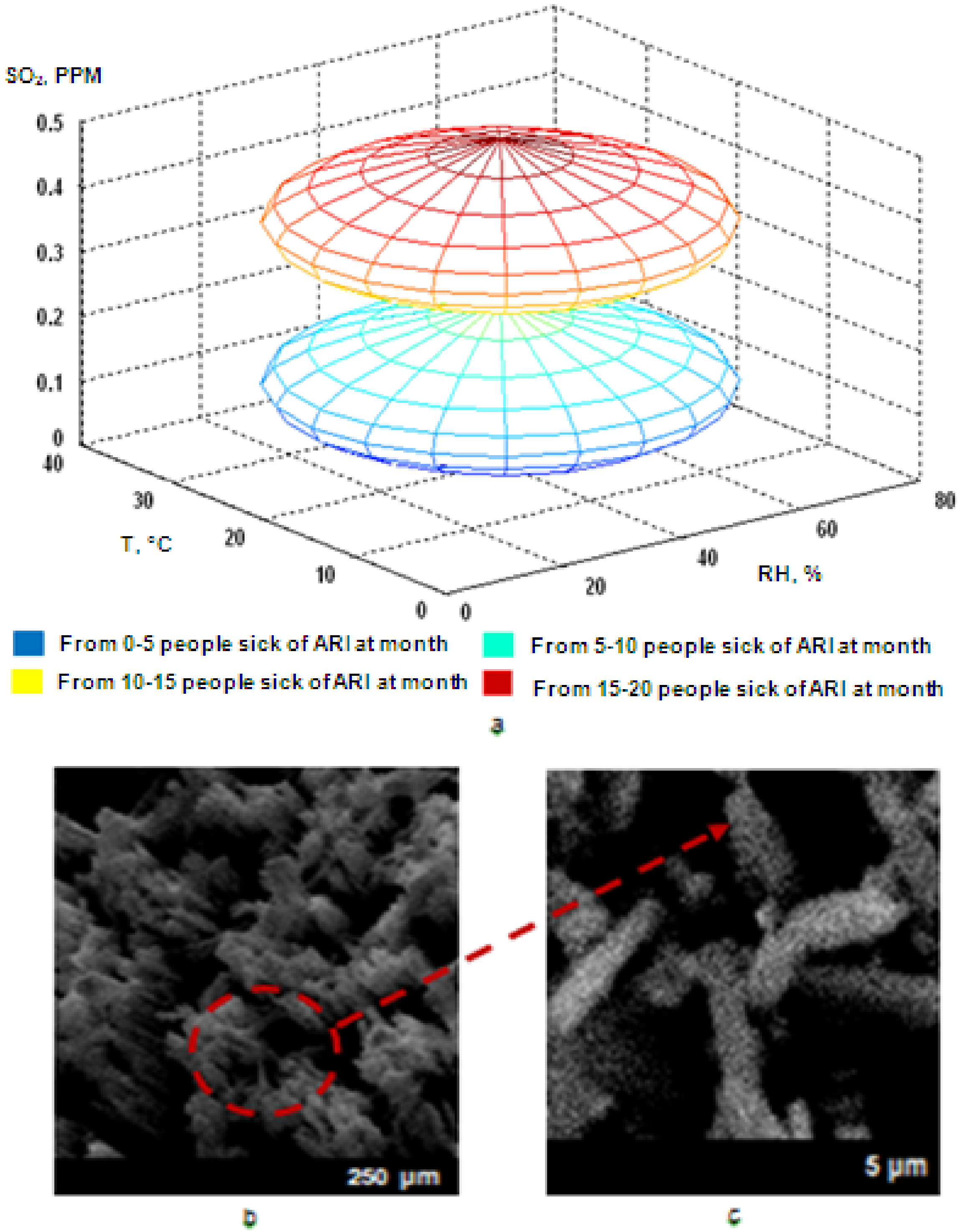


Figure 2 Analysis of (a) climate and contamination factors correlated to ARI, and MO photomicrographs at (b) 250 X and (c) 5X in summer 2011 in company 1.

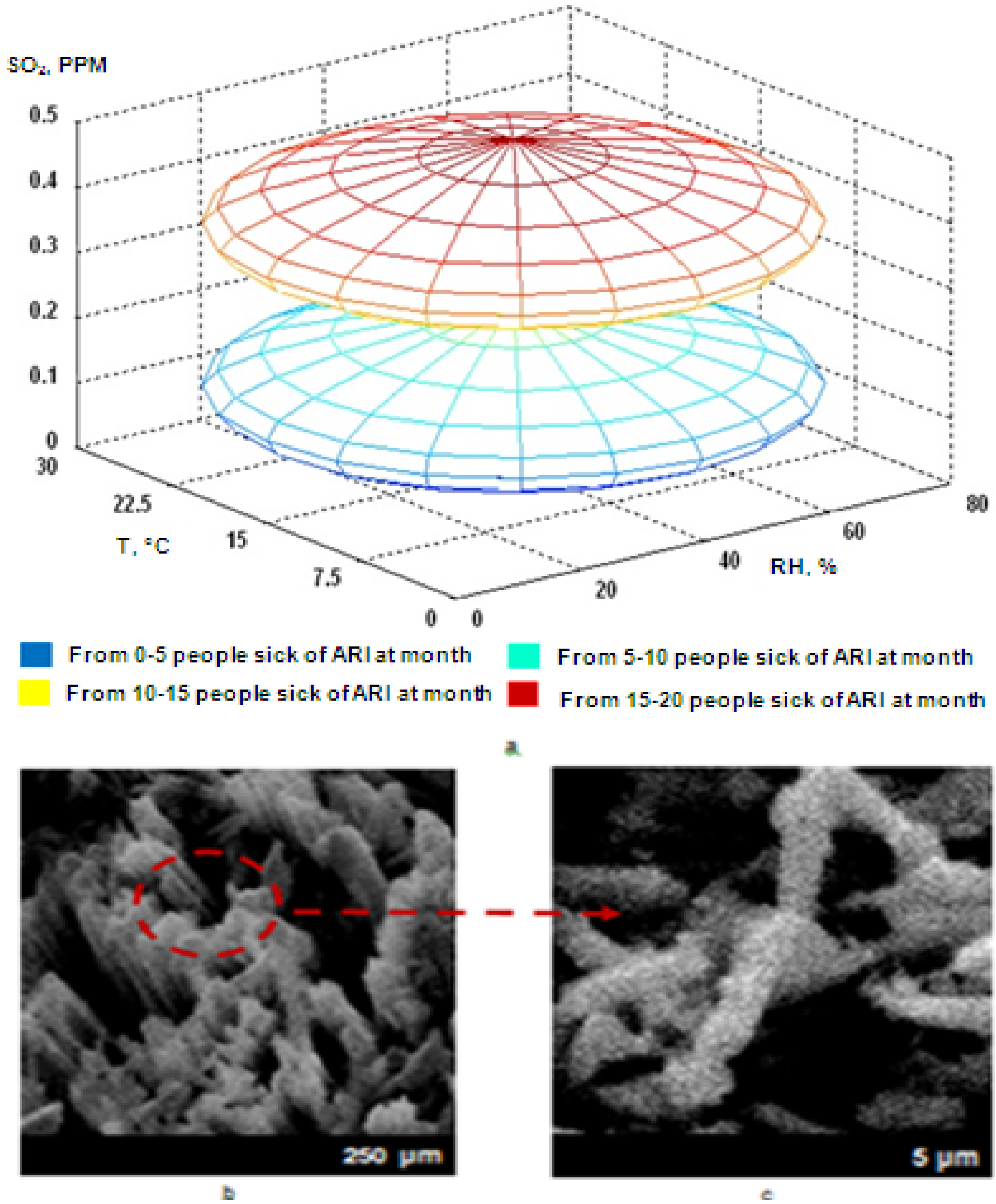
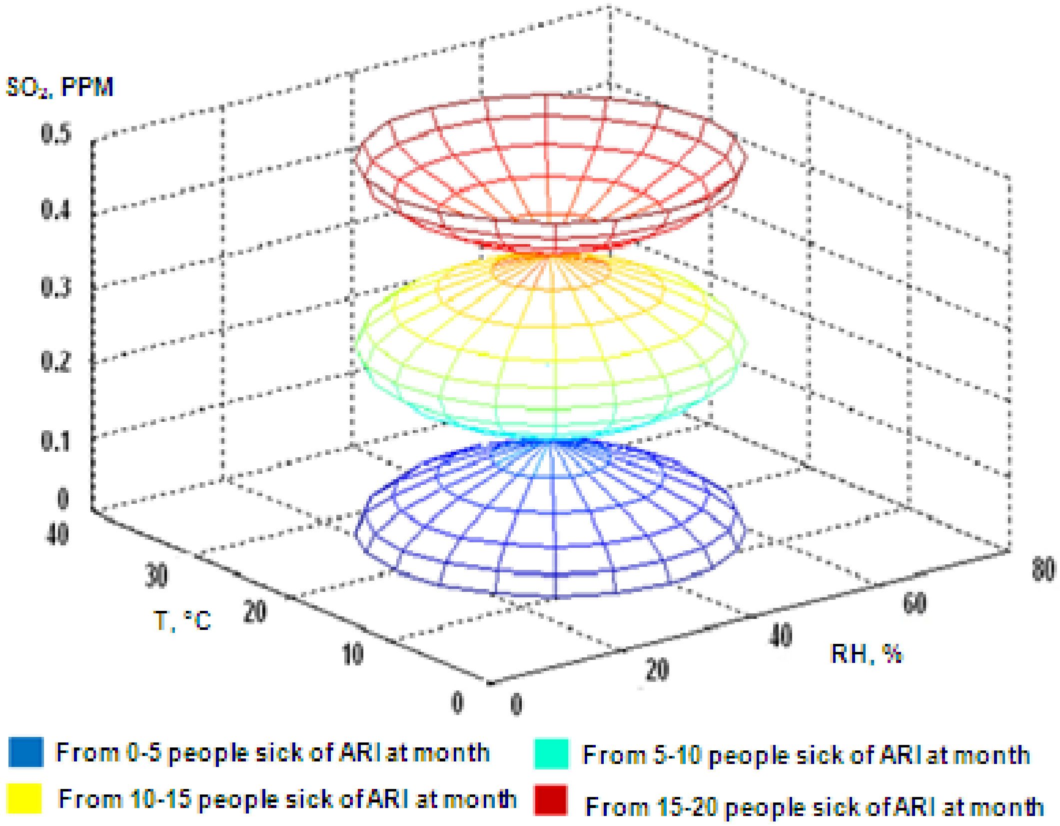
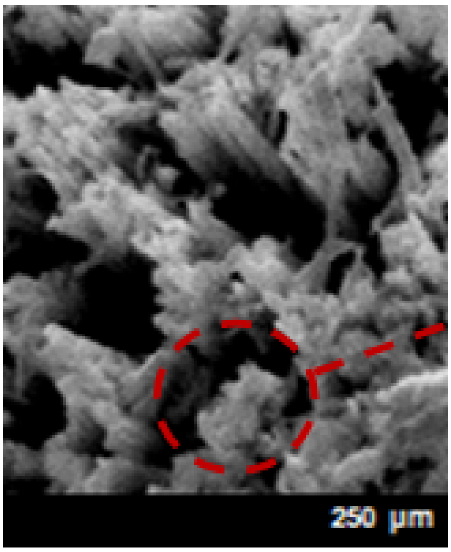
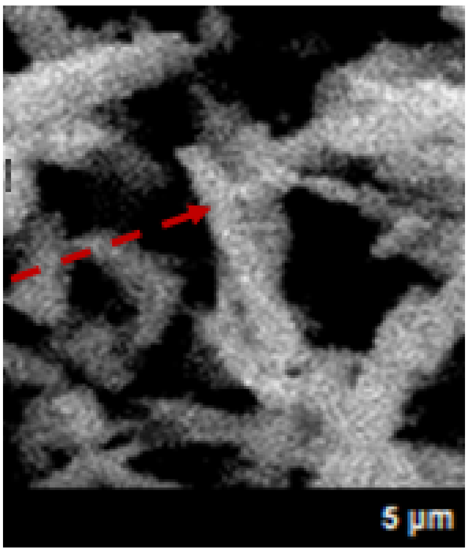


Figure 3 Analysis of (a) climate and contamination factors correlated to ARI, and MO photomicrographs at (b) 250 X and (c) 5X in summer 2012 in company 1.



a.





b.

c.

Figure 4 Analysis of (a) climate and contamination factors correlated to ARI, and MO photomicrographs at (b) 250 X and (c) 5X in winter 2011 in company 1.

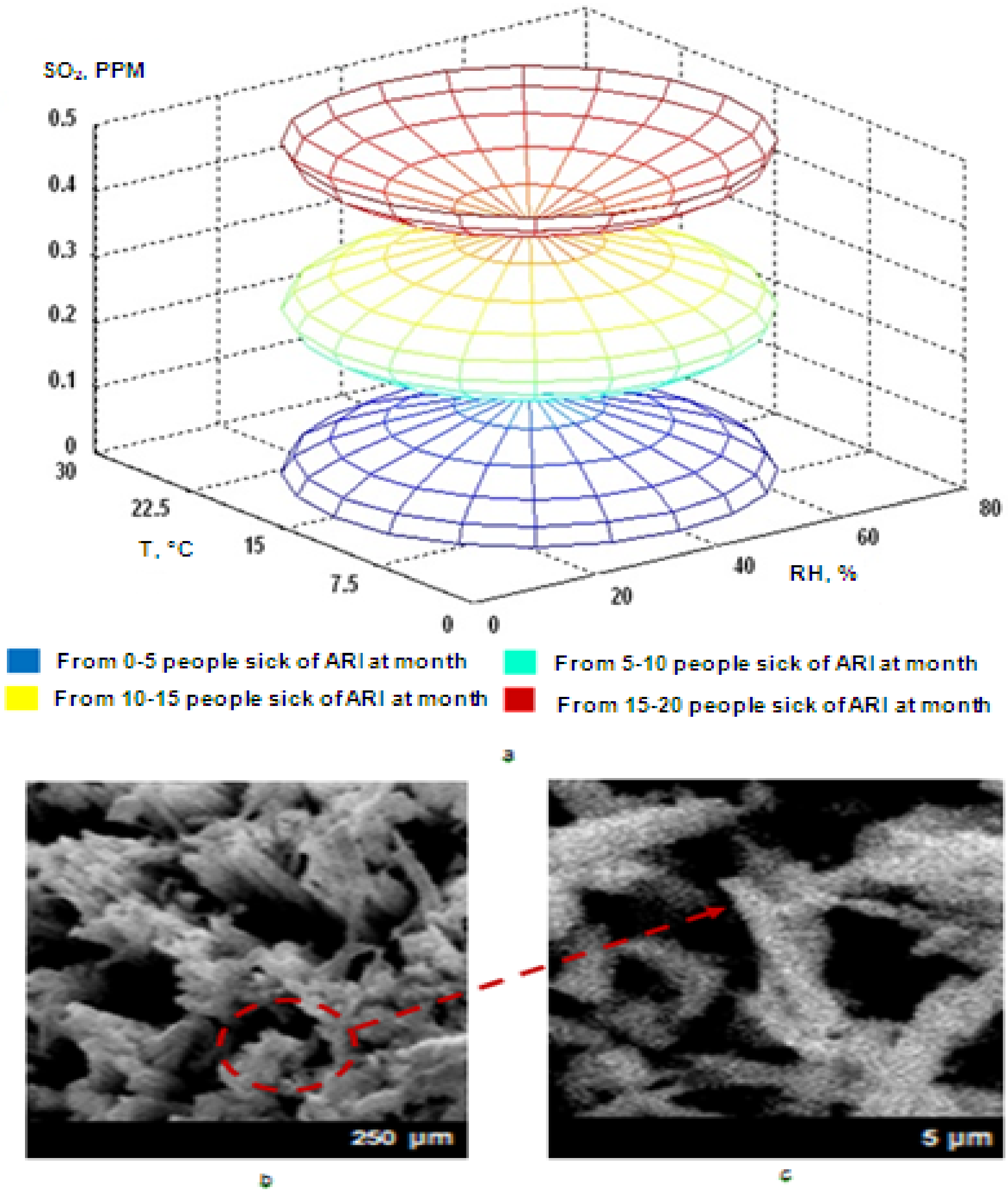


Figure 5 Analysis of (a) climate and contamination factors correlated to ARI, and MO photomicrographs at (b) 250 X and (c) 5X in winter 2012 in company 1.

5.- CONCLUSIONS:

It was considered that the lack of microclimates control at the offices of the five companies evaluated, generated discomfort and respiratory symptoms, as well as headaches and stomach pain in certain personnel that work in these workplaces. The automated system generates air exchange and detects microorganisms and micro particles with a sensor that generates a signal when it detects the presence of these factors, improving the environmental conditions in offices. These microclimates can be controlled by an electronic device that has the ability to automatically to change weather conditions to avoid the generation of MO and MB. In periods where the Relative Humidity and indoor to the outdoor temperature values were similar, was because in certain seasons of the year, it was allowed to keep some windows and doors open. This has resulted in a negative effect since it is more easily that pollutant such as SO2 and other smaller-scale, as well as dust particles to penetrate the offices, causing the ARI. The days mentioned in the table, indicate the average time period in which sick people remained incapacitated to work. This caused an income los for such persons; in addition, the operating performance of departments was decreased. In addition, even if there was personnel to cover the activities of ill persons who were not at work, errors were generated and thus delays in certain operations affecting the companies. This put a lot of stress and tension on managers and office workers, when a person fell sick again with symptoms of disorders in the heart and respiratory system. All the evaluated companies are located in various areas of the city of Mexicali, being all in the periphery. An important factor for the generation of MO and MB is the relative humidity in industrial plants, which have levels of relative humidity a little higher than average levels from abroad.

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APPLICATION OF ERGONOMIC METHODS TO REDUCE THE RISK OF MUSCULO-SKELETAL DISORDERS IN WORKERS OF A CAR PARTS MANUFACTURER INDUSTRY

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Resumen: Este documento constituye un caso práctico aplicado en una empresa fabricante de autopartes. El análisis se realizó en la línea de doblado y formado de tubo, donde se tiene planeada la implantación de manufactura esbelta. Para esto necesario que las operaciones realizadas por los trabajadores presenten el menor riesgo posible de adquirir algún tipo de lesión musculo-esquelética (MSD, por sus siglas en ingles). Las metodologías de evaluación de riesgos que se aplicaron son: Ergopymes[2], Egrme[3], REBA[4]. La comparación de resultados obtenidos con estos métodos, nos permitió identificar de manera puntual los movimientos que representan un riesgo para el trabajador de adquirir un MSD y también proponer medidas de actuación para que estas actividades reduzcan su riesgo.

Palabras claves: Manufactura esbelta, Evaluacion de riesgo, DTA´S

Abstract: This paper is a case study performed at car part manufacturing company. The analysis was performed on the bending tube line where the company plans to implement lean manufacturing. For this it is necessary that the operations carried out by the workers have the lowest possible risk for any type of musculo-skeletal damage (MSD).

The results obtained through the application of three different methods of ergonomic evaluation will allow us to identify in a timely manner the movements that pose a higher risk to the worker to get an MSD. A set of proposal is presented for reducing the identified risks.

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[2]Ergonomía para PYMES
[3]Evaluación grafica de riesgos musculo esqueléticos
[4]Rapid Entire Body Assessment

Keywords: Lean manufacturing, Risk Assessment, MSD
Relevance to ergonomics: Application of ergonomic methods for the implementation of lean manufacturing.

1. INTRODUCTION

To introduce the philosophy of lean manufacturing is highly desirable to promote improved health and well being of workers (Kanawaty, 1996), because these are frequently increase performance (Fabrizio, 2010). Musculo-SkeletalDisorder (MSD) represents a potential cost to the employer both workers' compensation for days not worked because of injury, and training a replacement product that no longer occurs in a given time.

The solution of the following case was required by the directors of the company as a precedent for the implementation of lean manufacturing.

The interventionsneeded were identified by using 3 methods of MSD risk assessment methods, in order to obtain congruity in the diagnosis of the manufacturing operations under analysis.

2. OBJECTIVES

2.1 General Purpose

To set up the bases for the implementation of lean manufacturing in the company through the identification operations at risk of incidence of MSD among workers

2.2 Specific objectives

- To assess the risk factors identified
- To determine interventions required to reducing MSD risks before some workers get injured.
- To seek congruity in the results obtained through different methods

3. METHODOLOGY

An assessment of the human-machine interaction for the activities performed by the workers in this production line was made. For this purpose, the three methods mentioned below were applied. (Figure 1)

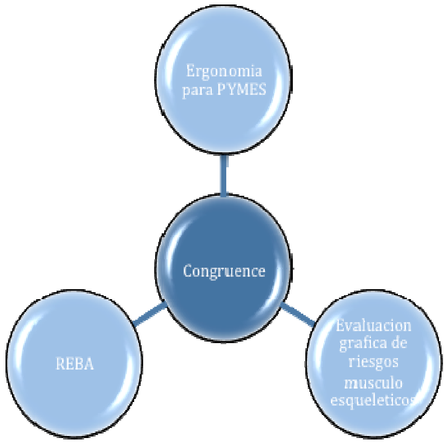


Figure 1: Methods applied to the diagnosis is consistent

The methods shownin Figure 1 are briefly described below:

- ErgonomíaparaPYMES:Evaluates movements and postures that can be carried out on the task being performed,showing some likely causes and suggestions for interventions.
- EGRME(Evaluacióngrafica de riesgosmusculoesquelético):beginswith the application of an ergonomic checklist, and continues with the analysis of body movements .
- REBA: Performs an analysis of the positions taken by the operator to perform physical tasks, giving a rating that represents the level of risk of MSD. (Asensio-cuesta, 2012)

The activities performed in the bending linearedescribed below.

Special bending: This activity is performed with an electricalpipe-bendingmachine, which makes the bendingas the operator presses a button (Figure 2).
Cutting: It is carried out in an electric cutter, which cutsas the operator pulls down a lever (Figure 3).

Figure 2: Special bending

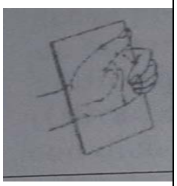
Figure 3: Cutting

4. EVALUATION OF RISKS

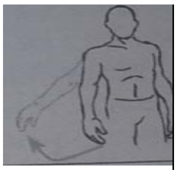
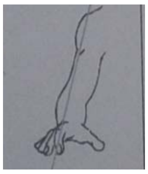
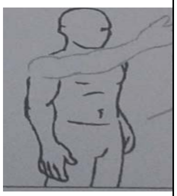
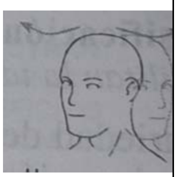
These activities were carried out by applying the methods shown in figure 1.

4.1 ErgonomíaparaPymes

This method was applied in tasks mentioned before. The application is described in the book“ErgonomiaparaPYMES”(Oliva López, 2012). The output of this application is shown in tables 1and 2, below.

Movements analysed	Observed anomalies	
	Special bending	Cutting
M01 	Repeatability	Repeatability and speed
M02 	Repeatability	Repeatability and speed
M05	Repeatability	Repeatability and speed

Positions	Observed anomalies	
	Special bending	Cutting
P02 	N/A	Time
P03	Force exerted	Force exerted

		
M07 	Repeatability	Repeatability and speed
M08 	Repeatability	Repeatability and speed
M09 	N/A	Repeatability and speed
M10 	Repeatability	Repeatability and speed
M13 	Repeatability	Repeatability and speed
M17	N/A	Repeatability

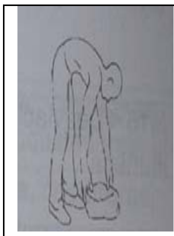
		
P05 	N/A	Time
P08 	Time	N/A

Table 2: Positions

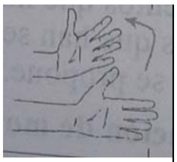
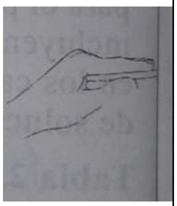
		and speed
M19 	Repeatability	Repeatability and speed

Table 1: Movements

Diagnosis: Potentially hazardous movements to the workers health were found, because of the repetitiveness of theperformed tasks. As well the position taken on the task requires the operator to remain in one position for a long time, which do not have a lumbar support that increases the risk of injury.

4.2 Evaluación grafica de riesgos musculo esqueléticos(EGRME)

The application of this method is described in the book"Evaluacióngrafica de riesgosmusculoesqueléticos" (Oliva López, 2009).

4.2.1 Check list

This list will help us detect occupational ergonomic problems in general. Positive answers in each of the 8 sections of the checklist are an indicator of the attention.When two of three parts of answers,are affirmative immediate attention is required. (Oliva López, 2009)

Table 3 shows the data obtained by applying this tool to the activities.

	Factores	**Special bending**		**Cutting**	
		Yes	**No**	**Yes**	**No**
1	General working conditions	1	7	0	8
2	Physical effort	0	29	2	26
3	Thermal load	0	4	0	4
4	Human Machine Interface	11	28	11	28
5	Space and furnishings	11	14	11	14
6	Noise and vibration	2	7	2	7
7	Lighting	0	8	0	8
8	Work Organization	1	3	1	3

With this check list we are able to realise what factors represents more risk to workers in this case "Human Machine Interface" and "Space and furnishings" are those which represents bigger impact on workers health.

4.2.2 Movement's analysis results

In following charts the results of movements analysis are shown for each activity. (Table 4 and 5) (Same movements that "ErgonomiaparaPYMES")

Ratings (A=high; B=medium; C=Low) help us to detect the level of risk for each movement.

Risk factors	Movements analysed							
	M01	M02	M05	M07	M08	M10	M13	M19
Repetitively	A	A	A	A	A	A	A	A
Straight	C	C	C	C	C	C	C	C
Speed	C	C	C	C	C	C	C	C
Total	**ACC**	**ACC**	**ACC**	**ACC**	**ACC**	**ACC**	**ACC**	**ACC**

Table 4: Special Bending

Risk factors	Movements analysed										
	M01	M02	M05	M07	M08	M09	M10	M11	M13	M17	M19
Repetitively	A	A	A	A	A	A	A	A	A	A	A
Straight	C	C	C	C	C	C	C	C	C	C	C
Speed	A	C	C	C	C	A	C	C	C	C	C
Total	**ACA**	**ACC**	**ACC**	**ACC**	**ACC**	**ACA**	**ACC**	**ACC**	**ACC**	**ACC**	**ACC**

Table 5: Cutting

In movements which got al least one "A" is necessary to act, if the task got more than two "A"s represents more risk to operators and is urgent intervention.

4.3 REBA

Different positions taken by workers as they perform his tasks were analysed with this method as indicated in the publication(Hernández Vico, 2012).

Guidelines were drawn in the illustrative pictures below, to help the assessment of the positions analyzed.

Analysis 1 (Special Bending)

Posture adopted while performing the task, using a bank. (Figure 4 and 5)

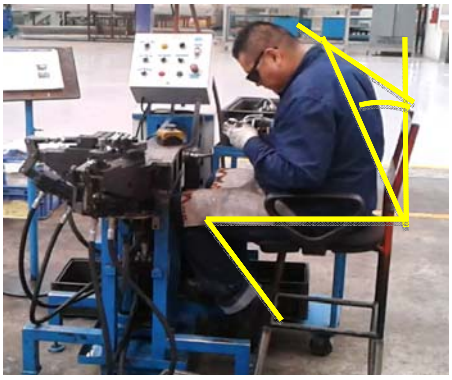


Figure 4: Posture 1

	Group A (Trunk, neck and legs)					Group B (Arm forearm andwrist)					Table C	Activity	Final punctuation and risk level
	Table A			Straight	Final A	Table B			Hold	Final B			
	T	N	L			A	F	W					
Right	2	2	3	0	5	1	1	2	0	2	4	2	6
	5					2							Intermediate
Left	2	2	3	0	5	1	1	2	0	2	4	2	6
	5					2							Intermediate

Table 6: Analysis ofposture 1

Analysis 2 (Special Bending)

Frontal view

Lateral view

Figure5: Posture 2

	Group A (Trunk, neck and legs)					Group B (Arm forearm and wrist)					Table C	Activity	Final punctuation and risk level
	Table A			Straight	Final A	Table B			Hold	Final B			
	T	N	L			A	F	W					
Right	3	2	3	0	6	1	1	1	0	1	6	1	7
	6					1							Intermediate
Left	3	2	3	0	6	2	1	1	0	1	6	1	7
	6					1							Intermediate

Table 7: Analysis of posture 2

<u>Analysis 3 (Special Bending)</u>

Special bending without bank (figure 6)

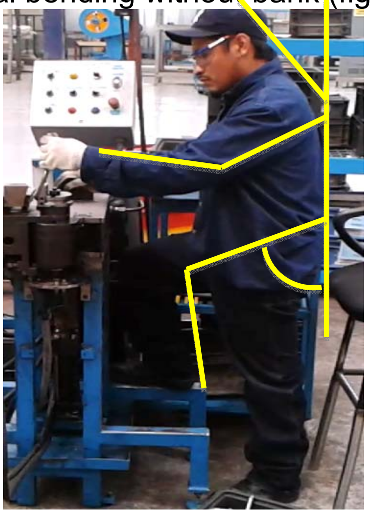


Figure 6:Posture 3

	Group A (Trunk, neck and legs)					Group B (Arm forearm and wrist)					Table C	Activity	Final punctuation and risk level
	Table A			Straight	Final A	Table B			Hold	Final B			
	T	N	L			A	F	W					
Right	1	1	4	0	4	2	1	1	0	1	3	1	4
	4					1							Intermediate
Left	1	1	2	0	2	2	1	1	0	1	1	1	2
	2					1							Intermediate

Table 8: Analysisof posture 3

<u>Analysis 4 (Special Bending)</u>

Throwing the product to the box (figure 7)

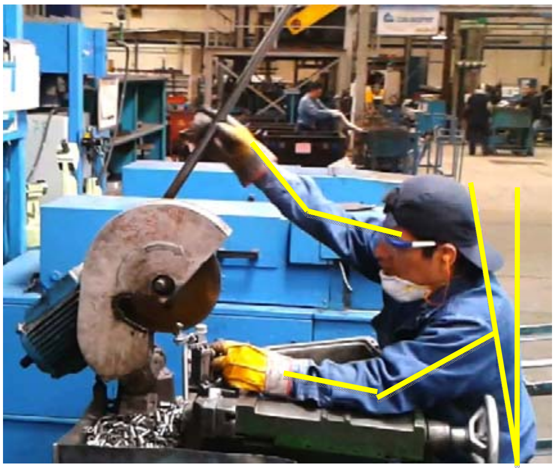
Figure 7:Posture 4

	Group A (Trunk, neck and legs)					Group B (Arm forearm and wrist)					Table C	Activity	Final punctuation and risk level
	Table A			Straight	Final A	Table B			Hold	Final B			
	T	N	L			A	F	W					
Right	2	3	4	0	7	2	1	1	0	1	7	1	8
	7					1							High
Left	2	3	2	0	5	1	2	1	0	1	4	1	5
	5					1							Intermediate

Table 9: Analysisof posture 4

<u>Analysis 5 (Cutting)</u>

Cutting (figure 8)



Lateral view

Full view

Figure 8: Posture 5

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	Group A (Trunk, neck and legs)					Group B (Arm forearm and wrist)					Table C	Activity	Final punctuation and risk level
	Table A			Straight	Final A	Table B			Hold	Final B			
	T	N	L			A	F	W					
Right	2	1	2	0	3	5	2	1	1	8	7	3	10
	3					7							High
Left	2	1	4	0	5	3	2	1	0	5	5	1	6
	5					4							Intermediate

Table 10: Analysisposture 5

<u>Analysis 6 (Cutting)</u>

Pulling the lever down (figure 9)

Lateral view

Full view

Figure 9: Posture 6

<table>
<tr><th rowspan="3"></th><th colspan="5">Group A (Trunk, neck and legs)</th><th colspan="5">Group B (Arm forearm and wrist)</th><th rowspan="3">Table C</th><th rowspan="3">Activity</th><th rowspan="3">Final punctuation and risk level</th></tr>
<tr><th colspan="3">Table A</th><th rowspan="2">Straight</th><th rowspan="2">Final A</th><th colspan="3">Table B</th><th rowspan="2">Hold</th><th rowspan="2">Final B</th></tr>
<tr><th>T</th><th>N</th><th>L</th><th>A</th><th>F</th><th>W</th></tr>
<tr><td rowspan="2">Right</td><td>2</td><td>1</td><td>2</td><td rowspan="2">0</td><td rowspan="2">3</td><td>5</td><td>1</td><td>1</td><td rowspan="2">0</td><td rowspan="2">6</td><td rowspan="2">5</td><td rowspan="2">3</td><td>8</td></tr>
<tr><td colspan="3">3</td><td colspan="3">6</td><td>High</td></tr>
<tr><td rowspan="2">Left</td><td>2</td><td>1</td><td>4</td><td rowspan="2">0</td><td rowspan="2">5</td><td>3</td><td>2</td><td>1</td><td rowspan="2">0</td><td rowspan="2">4</td><td rowspan="2">4</td><td rowspan="2">1</td><td>5</td></tr>
<tr><td colspan="3">5</td><td colspan="3">4</td><td>Intermediate</td></tr>
</table>

Table 11: Analysisof posture 6

Analysis 7 (Special bending and cutting)

Lifting box (figure 10)

Figure 10:Posture 7

	Group A (Trunk, neck and legs)					Group B (Arm forearm and wrist)					Table C	Activity	Final punctuation and risk level
	Table A			Straight	Final A	Table B			Hold	Final B			
	T	N	L			A	F	W					
Right	4	1	2	2	7	2	1	1	0	1	7	1	8
	5					1							High
Left	4	1	2	2	7	2	1	1	0	1	7	1	8
	5					1							High

Table 12: Analysis ofposture 7

Analysis 8 (Special bending and cutting)

Lifting 2 boxes (figure 11)

Figure 11:Posture 8

	Group A (Trunk, neck and legs)					Group B (Arm forearm and wrist)					Table C	Activity	Final punctuation and risk level
	Table A			Straight	Final A	Table B			Hold	Final B			
	T	N	L			A	F	W					
Right	3	1	3	3	8	2	1	2	3	5	10	1	11
	5					2							Very high
Left	3	1	3	3	8	2	1	2	3	5	10	1	11
	5					2							Very high

Table 13: Analysisof posture 8

<u>Analysis 9 (Special bending and cutting)</u>

Carrying two boxes. (Figure 12)

Frontal view Lateral view

Figure 12:posture 9

	Group A (Trunk, neck and legs)					Group B (Arm forearm and wrist)					Table C	Activity	Final punctuation and risk level
	Table A			Straight	Final A	Table B			Hold	Final B			
	T	N	L			A	F	W					
Right	2	1	2	3	6	2	1	3	3	6	8	1	9
	3					3							High
Left	2	1	3	3	7	2	1	3	3	6	9	1	10
	4					3							High

Table 14: Analysis ofposture 9

4.3.1 Recommendations

Thanks to the analysis performed we can easily identify movements that represents risk (Table 15)

Analysis	Cal if.	Recommendations
1 (Special bending)	6	Place a self-adjusting bank so that the operator need not stoop
2 (Special bending)	7	Change hand to push the button
3 (Special bending)	4	Place an ergonomic carpet.
4 (Special bending)	8	Raising the finished product box
5 (Cutting)	10	Slowing down the task
6 (Cutting)	8	Place a platform
7 (Special bending and cutting)	8	Raise by flexing legs and keeping the back straight
8 (Special bending and cutting)	11	Load up just one box
9 (Special bending and cutting)	10	Place enough industrial cars

Table 15: Summary of ratings and advice on the studies analyzed, emphasizing red those needing urgent action.

Were labeled with red scores higher ratings, which represents a risk for the worker acquiring a MSD and recommendations are also shown for these activities to reduce their risk.

5.- COMPARISONS BETWEEN METHODS AND RECOMENDATIONS

To get reliability and consistency in the assessments made, a comparison between the methods and recommendations based on encountered risks by the several methods was made. (Table 16)

Taking into account the highest grade obtained for each position in the case of REBA. In Table 16 the following symbols for the level of congruence used. * = low, ** = Intermediate; *** = High

Task	Evaluated member	Method	Qualification	Risk	Congruence	Recommendations
Special bending	Wrist	PYMES Ergonomics	N/A	Intermediate	***	Reduce frequency and switch a break
		EGRME	ACC	Intermediate		
		REBA	2	Intermediate		

	Arm and shoulder	PYMES Ergonomics	N/A	Intermediate	***	Place an self-adjusting bank in this area
		EGRME	ACC	Intermediate		
		REBA	2	Intermediate		
	Neck	PYMES Ergonomics	N/A	Intermediate	***	Place an ergonomic carpet to reduce fatigue.
		EGRME	ACC	Intermediate		
		REBA	3	Intermediate		
	Column	PYMES Ergonomics	N/A	Intermediate	**	
		EGRME	N/A	N/A		
		REBA	3	Intermediate		
Special bending and cutting	Lower back	PYMES Ergonomics	N/A	High	**	Train the worker to lift with his legs rather instead the trunk. Set weight limits to the worker
		EGRME	CAC	N/A		
		REBA	4	High		
Cutting	Wrist	PYMES Ergonomics	N/A	Intermediate	**	Post a platform with ergonomic carpet so that the worker does not
		EGRME	ACC	Intermediate		
		REBA	1	Low		

Arm and Shoulder	PYMES Ergonomics	N/A	High	***	need to raise his arm to high.
	EGRME	ACA	High		
	REBA	5	High		
Neck	PYMES Ergonomics	N/A	Intermediate	**	Reduce frequency and switch a break
	EGRME	ACC	Intermediate		
	REBA	1	Low		
Column	PYMES Ergonomics	N/A	Intermediate	**	
	EGRME	N/A	N/A		
	REBA	2	Intermediate		

Table 16: comparison ofresults

In this table we can see an acceptable level of congruence for each method so it can be concluded that the risks were properly identified and evaluated and it was possible to propose Interventions to reduce risks in each work task.

6.- CONCLUSIONS

With analysis performed by different methods was possible to identify and assess the levels of risk to which workers are exposed to acquire MSD and propose interventions to reduce them, achieving a contribution to the implementation of lean manufacturing.

Risks factors were identified

With performing of different methods congruence were achieved.

Action is needed especially in the activity of cutting and how to manipulate the filled containers to prevent injury to workers.

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IMPORTANCE OF ERGONOMICS IN THE IMPLEMENTATION OF LEAN MANUFACTURING.

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Resumen: Este trabajo presenta las ventajas potenciales que tiene la ergonomía en la implantación de manufactura esbelta, debido a que estas áreas del conocimiento presentan fines comunes que para este caso se aprovechó la disminución de riesgos musculo- esqueléticos para tener una aportación a la productividad.

Este trabajo fue realizado en una empresa dedicada a la fabricación de autopartes, específicamente en una línea de silenciadores en donde se verificaron las actividades que son más demandantes para los trabajadores, estas actividades fueron verificadas mediante tres métodos de identificación de riesgos musculo esquelético para poder verificar el nivel de riesgo que presenta, una vez que se verifica la existencia de un riesgo se realizan las propuestas necesarias para reducir estos riesgos; estas propuestas se analizan mediante un enfoque de manufactura esbelta para poder determinar la aportación a la productividad que tiene la disminución de riesgos y de esta forma poder afirmar la interrelación entre estas dos áreas del conocimiento.

Palabras clave: Ergonomia, productividas, analisis de riesgo musculoesquelético

Abstract: This paper presents the potential advantages of ergonomics in the implementation of lean manufacturing because these areas of knowledge have common purposes for this case decreasing musculoskeletal risks was used to have a contribution to productivity.

This work was performed in a company dedicated to the manufacture of auto parts , specifically a line of mufflers where activities that are more demanding for workers checked , these activities were verified by three methods of identifying musculoskeletal risks in order to verify the level of risk presented , once the existence of a risk verifies the necessary proposals to reduce these risks are realized , these proposals are analyzed by a lean manufacturing approach to determining the

contribution to productivity has decreased risks and thus to affirm the relationship between these two areas of knowledge

Keywords: Ergonomics, productivity, musculoskeletal risk analysis

Contribution to ergonomics: This work provides an interdisciplinary area that has this knowledge with lean manufacturing technique, based on the similarities of goals they have. In addition to the contributions to the productivity of a company that provides the implementation of ergonomics.

1. Introduction

This work was performed in an industrial company engaged in manufacturing auto parts. Contains several production lines as stamping, welding, bending and forming pipe, mufflers. The study only covers a line of business, line of mufflers.

It also contains the potential benefits of the combined use of ergonomics and lean manufacturing in order to increase productivity. This was done through a study of muscle-skeletal risk factors, to determine the degree of risk that exists in different jobs line mufflers. The most significant work positions were evaluated with different techniques of risk analysis for an integrative characterization of the activities. Once a risk level is obtained, improvements are proposed to avoid the reduction. Finally, the contribution to productivity of proposals where the main point of these two techniques is similar objectives they have, where lean manufacturing is assessed its purpose is to eliminate waste and through ergonomic techniques can eliminate the risks skeletal muscle and can also improve the cycle time.

2. Objectives.

2.1 General Objective:

Suggest a risk reduction of skeletal muscle in workers, focused as part of the implementation of lean manufacturing.

2.2 Specific objectives:

- Identify operations that warrant the risk assessment.
- Assess the risks of the selected operations.
- Suggest solutions to reduce risks skeletal muscle in jobs.
- To assess the contribution to productivity of the proposals submitted.

3. Methodology

First, activities requiring increased demand effort from the worker discussed the activities that were analyzed were:

- Verification of CM-3858 muffler. (Figure 1)
- Seaming muffler´s tops CM-3858. (Figure 2)
- Seaming muffler´s tops 559920. (Figure 3)

Figure 1: Verification of CM-3858 muffler.

Figure 2: Seaming muffler's tops CM-3858

Figure 3: Seaming muffler's tops 559920.

Verification muffler CM-3858 : This activity is to collect from a sideboard to the knee high, jiggle muffler then up to the head and to witness a loose component inside the muffler subsequently placed on a leak tester and eventually placed on another tester pressure.

Seaming muffler´s tops CM-3858: This activity is to collect the body of the muffler and then place a shelf along with the lower and upper tops inside the seaming machine, after seaming the muffler is placed on a leak tester is removed.

Seaming muffler´s tops 559920: This activity is to collect the body of the muffler and then place a shelf along with the lower and upper tops inside the seaming machine, after seaming the muffler is placed on a leak tester is removed.

These activities were tested by 3 methods of risk assessment. These methods are: Method of Ergonomía para PYMES, Método de evaluación grafica de riesgos musculo esqueléticos and finally analysis by REBA method.

The method of Ergonomía para PYMES, is an overall assessment of the postures and movements more commonly adopted by workers , where the purpose of the method is only throwing the presence or absence of musculoskeletal hazards including possible corrective actions are proposed and benefits of adopting them. Here the list of movements (Figure 4) and positions (Figure 5) mentioned in method. For a more advanced knowledge of the method can consult the book Ergonomía para PYMES Dr. Eduardo López Oliva.

Figure 4: List of moves for the PYMES method.

Figure 5: List of positions for PYMES method.

The method evaluación grafica de riesgos musculo esqueléticos first proposed the classification of working conditions through a checklist, this checklist can be found in the book method evaluación grafica de riesgos musculo esqueléticos, Dr. Eduardo

López Oliva. Depending on the degree of responses to be continued for an assessment of the main movements (Figure 4) that can be adopted to perform the job, the actions taken will qualify by speed, repeatability and force exerted. Once the shares are rated a letter A if the movement is the highest in its category, a letter B if the movement has an intermediate magnitude and a letter C if the movement has a low magnitude is added.

Once qualified all the qualification criteria is unified.

The risk of work will be:

• Very high: if one or more columns AAA possess immediate corrective action required to reduce the level of risk factors.

• High: if one or more of the columns have AA, corrective actions planned to reduce levels of risk factors higher required.

• Medium = If one or more of the columns have A, is recommended to track risk factors to prevent their growth.

According to the marks obtained in these movements is the level of risk in the work and actions to propose.

Finally the REBA method, (Rapid Entire Body Assessment) was proposed by Sue Hignett and Lynn McAtamney and published by the journal Applied Ergonomics in 2000. This method is the result of joint work of a team of ergonomists, physiotherapists, occupational therapists and nurses, who identified about 600 positions for its preparation.

The REBA method allows the joint analysis of the positions taken by the upper limbs (arm, forearm, and wrist), trunk, neck and legs. It also defines other factors considered decisive for the final assessment of posture, such as load or run hard , gripping the type or types of muscular activity developed by the worker. It allows evaluating both static and dynamic postures and incorporates as novelty the possibility of reporting the existence of sudden changes in posture or unstable postures.

Note the inclusion in the REBA method of a new factor assesses whether the position of the upper limbs is taken for or against gravity. It is considered that that fact accentuates or attenuates, as a stand for or against gravity, the risk associated with the position.

After applying the data obtained with the 3 methods to ensure that the final grade is consistent work (Figure 6) were compared. This will be reflected congruence with similar results between methods.

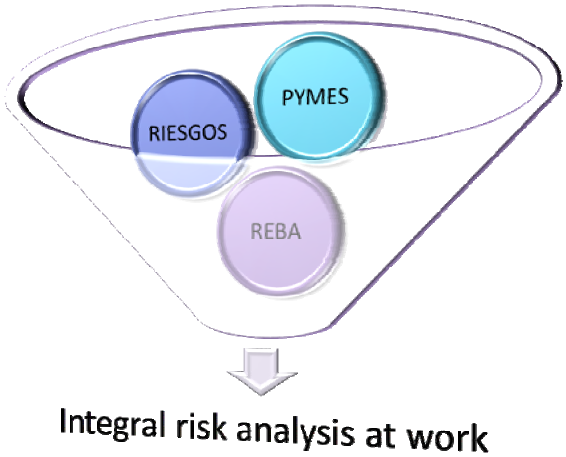

Figure 6: Integral analysis of 3 methods.

4. Results.

For practical purposes only the particular results of a job is exemplified, verification muffler CM-3858, in case you want to inquire into the qualifications of the other jobs you can contact the authors. Significantly, the overall results are shown at work.

4.1 Scoring by Ergonomía para PYMES.

These are the results of this method. Firstly movements (Table 1) carried out and then the positions (Table 2) are shown.

As you can see much of the movement has a risk of work, possible solutions and improvements that could be also added. In the analyzed positions there is a risk for a period of time standing and turning force, so that the solutions and benefits that can be added

4.2 Muscleskeleta risk Assessment chart

The overall result of the checklist throws for an overall score of 35% so you have to perform the second part of the method (Figure 7).

Job title: Inspection muffler			
Operator: Cleotilde López			
Movements analyzed	Abnormalities observed	Corrective Actions	Expected Results
M01	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid hand injuries
M02	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid hand injuries
M03	N/A	N/A	N/A
M04	N/A	N/A	N/A
M05	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid shoulder injuries
M06	Repeatability, lot of weight, sudden moves	Reduce frequency, present breaks, gripper.	Avoid shoulder and elbow injuries
M07	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid wrist and elbow injuries
M08	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid wrist injuries
M09	Repeatability, lot of weight, sudden moves	Reduce frequency, present breaks, gripper.	Avoid neck injuries
M10	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid neck injuries
M11	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid neck injuries
M12	Repeatability	Reduce frequency, present breaks.	Avoid neck injuries
M13	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid neck injuries
M14	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid wrist injuries
M15	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid wrist injuries
M16	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid wrist injuries
M17	Repeatability, lot of weight	Reduce frequency, present breaks.	Avoid wrist injuries
M18	N/A	N/A	N/A
M19	N/A	N/A	N/A

Table 1: Results of the moves for the method ergonomía para PYMES.

Postures analyzed	Abnormalities observed	Corrective Actions	Expected Results
P01	Accumulated time, exerted force, force turning	Combine activities, rest breaks, anti fatigue mats, semi sitting bench, using a gripper	Increase productivity, reduce quality errors, protect workers
P02	Accumulated time, exerted force, force turning	Combine activities, rest breaks, anti fatigue mats, semi sitting bench, using a gripper	Increase productivity, reduce quality errors, protect workers
P03	N/A	N/A	N/A
P04	N/A	N/A	N/A
P05	Accumulated time, exerted force, force turning	Combine activities, rest breaks, anti fatigue mats, semi sitting bench, using a gripper	Increase productivity, reduce quality errors, protect workers
P06	N/A	N/A	N/A
P07	N/A	N/A	N/A
P08	N/A	N/A	N/A
P09	N/A	N/A	N/A
P10	N/A	N/A	N/A
P11	N/A	N/A	N/A
P12	N/A	N/A	N/A
P13	N/A	N/A	N/A

Table 2: Results of the positions for the method ergonomía para PYMES.

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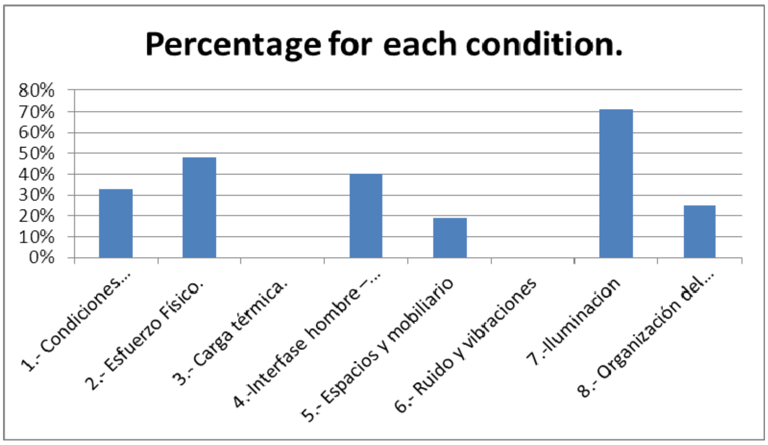

Figure 7: Results for each condition in the checklist.

The second part of the method corresponds to the implementation of a table where the movements are evaluated in three respects, the strength of the movement, speed of movement and repeatability were evaluated. (Table 3)

Table 3: Summary of the movements analyzed in verification activity muffler CM-3858

Risk Factors	Analyzed Moves																		
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19
Repeatability	A	A			A	A	A	A	A	A	A	A	A	A	A	A	A		
Strength	B	C			B	A	B	B	A	C	C	C	C	B	B	B	B		
Speed	B	B			B	B	B	B	B	C	C	C	C	B	B	B	B		
Qualification	ABB	ACB			ABB	AAB	ABB	ABB	AAB	ACC	ACC	ACC	ACC	ABB	ABB	ABB	ABB		

As can be seen in the table, the verification operation has 2 mufflers high risk movements, lifting of the arm and forearm in abduction with flexion.

These two movements should be omitted or be subject to revision.

4.3 REBA.

This method is used to identify risks in the work of skeletal muscle type. Be applied in one of the jobs where more effort is needed in the line of mufflers, this work consists of checking leakage and pressure mufflers finished. To understand the methodology used, the most important actions were chosen. Lift the muffler. (Figure 8)

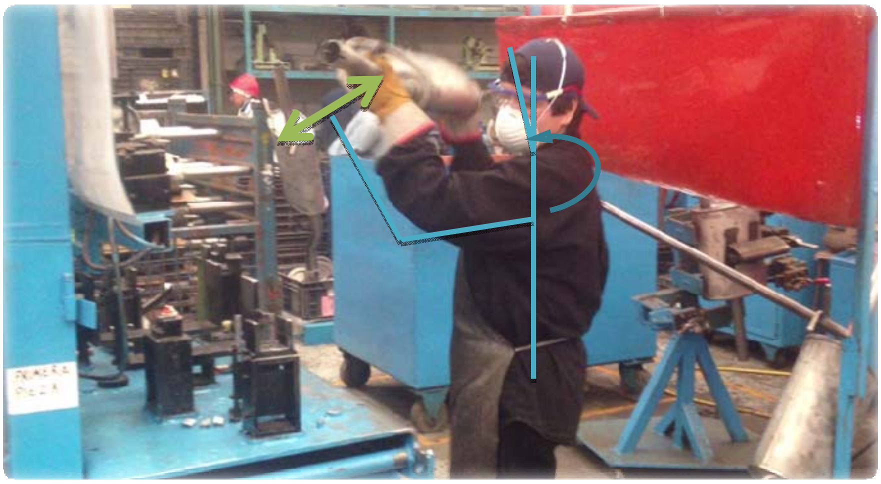

Figure 8: Jiggle the muffler with angle lines.

Once the necessary crosses in the evaluation table conducted a rating of 8 is obtained. This rating falls within the range high risk level and need to make immediate corrections.

Thus all the other two activities within the line of mufflers are rated.

4.3 Comparison of results.

After analyzing the 3 most representative activities line mufflers from 3 methods, the results are outlined. (Table 4)

Table 4: Rating of used methods

Rated Methods.			
Method	Activity		
	Verification	Seaming CM-3858	Seaming CM-559920
PYMES	Risk	Risk	Risk
EGRME	High Risk	High Risk	High Risk
REBA	High Risk	High Risk	High Risk

.

As shown in table 4 thrown congruence in ratings between the two methods is similar due to the same level of risk between methods therefore concluded that the rating for the three activities have a high level of risk and immediate corrective action is required.

4.4.1 Recommendations.

Suggested recommendations are classified for each activity:

Verification muffler CM- 3858.

We recommend removing the muffler jerk. By using a device that is dedicated to performing this movement, positioning activity is recommended muffler closer to the worker platform check, to avoid stretching and finally modify the device dedicated to bringing a muffler previous work station, to prevent the worker bend over to take the muffler.

Seamed muffler CM- 3858.

A change to the platform is recommended for seaming the worker does not have to stretch far to introduce caps and avoid stretching the neck both , so the platform can be designed with a hopper seaming thus would not have to so carefully check the position of the material.

Seamed muffler 559920.

It is recommended to minimize the distance that the worker must travel with the loaded muffler, it is recommended to expand the conveyor nearest worker. Another recommendation is to prevent the worker bend over at the time of inspection of leakage, so it is recommended to raise this platform a few inches.

4.5 Contribution to productivity.

Finally, the contribution to productivity was calculated by the reduction of time in the process , simulating the recommendations made by the system default time activities , the table 5 shows the forecast reduction of time for each activity:

Table 5: Time reduction

Time Reduction			
Activity	TC	Reduction	Percent
Verification	73 Sec.	5.4 Sec.	7.3%
Seaming CM-3858	51 Sec	5.3 Sec.	10.4%
Seaming 559920	63 Sec.	5.8 Sec.	9.2%

Other aspects that contribute to the utility and productivity of the company but cannot be accounted for due to the need for the implementation of the proposals are to improve productivity by decreasing fatigue workstations and all the extra investment you should do if the insurance policy for workers up for work injuries.

5. Conclusions

It was possible to establish the relationship that has ergonomics and lean manufacturing implementation, because similar results can be obtained by applying ergonomics and lean manufacturing goals. Worker security and environmental adaptation is reflected directly to an increase in productivity, where productivity is a common goal of these two techniques.

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ASSESSMENT MUSCULOSKELETAL DISORDERS (MSDS) IN WAITERS

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RESUMEN. El trabajo es una actividad que permite a los seres humanos desarrollarse plenamente e interactuar con sus semejantes, la Organización Internacional del Trabajo (OIT) define este concepto como el conjunto de actividades humanas, remuneradas o no, que producen bienes o servicios en una economía, que cumplen con la necesidades de una comunidad o proveen los medios de subsistencia necesarios para los individuos. El turismo de masas nació en la década de los años 50´s, a partir de esto, la industria del turismo ha transformado la vida de muchos países y sus habitantes , llegando a convertirse en un sector clave de sus economías , crear riqueza, fuerza laboral, y un promotor de su cultura. Siendo el factor más importante en la industria del turismo el factor humano, que no puede ser sustituido por robots o la automatización de todos los servicios, ya sea para la producción y la prestación de servicios; es esencial mantener y cuidar los equipos, maquinaria y herramientas, mucho más lo es el factor humano, que sin duda, debe enfatizar la seguridad y salud en el trabajo. Los trastornos musculo-esqueléticos incluyen un gran número de afecciones de los músculos, tendones, nervios o articulaciones que pueden ocurrir en cualquier parte del cuerpo, aunque las más comunes son las que afectan al cuello, la espalda y las extremidades superiores. **Objetivo**. Determinar la presencia de trastornos musculo-esqueléticos en meseras trabajando a tiempo completo. **Delimitación**. La realización de este proyecto de investigación se centró en las meseras en Guasave, Sin. Dónde trabajan seis días a la semana con un turno de 8 horas, para determinar los trastornos músculo-esqueléticos que se producen con más frecuencia. **Metodología**. Este artículo presenta las principales afectaciones que las personas desarrollan como meseras por las actividades inherentes a esta profesión, se analiza fatiga y los trastornos musculo-esqueléticos. La herramienta de mapeo que se utilizó fué Corlett & Bishop, que muestra el grado de malestar - dolor que se produce en diferentes partes del cuerpo. Así como la escala de 4 puntos de Luke, que muestra un nivel de fatiga experimentada por meseras. **Resultados**. Después de realizar los estudios mencionados y analizar el ámbito de la investigación, se observó que todo el tiempo eran las mismas posiciones de los trabajadores y las actividades se repitieron durante un turno completo. Antes de comenzar con la aplicación de métodos de evaluación se tienen la obligación de informar a las meseras lo que iba a hacer, eso no va a afectar a la forma en la que se realiza el trabajo y del mismo modo no afecta a los resultados del estudio. En cuanto a los cuestionarios para medir la fatiga y los trastornos musculo-esqueléticos, antes de aplicarlo a las camareras se les pidió que contestara lo que sentía al momento de la encuesta. **Conclusiones**. En base a los resultados obtenidos por los estudios realizados se puede concluir que el mayor índice de quejas presentadas por cansancio fué el jueves, viernes y sábado con un resultado de cansado, muy cansado y extremadamente cansado en eso días, ya que son lo días de la semana en que se tiene un incremento en las molestias. También los datos muestran como resultado que se debieron al aumento de la demanda en el restaurante, ya que son días muy ocupados, lo que hace que el peso que se lleva en la bandeja es más alta de lo normal, sin embargo, eso no quiere decir que el peso acostumbrado sea el adecuado para los segmentos del cuerpo de la mesera.

PALABRAS CLAVE: Lesiones musculoesqueléticas, evaluación del riesgo, meseras

ABSTRACT. Work is an activity that allows human beings to fully develop and interact with their peers, the International Labour Organization (ILO) defines this concept as the set of human activities, paid or unpaid, that produce goods or services in an economy, that meet the needs of a community or provide livelihoods necessary for individuals. Mass tourism was born in the decade of the 50s, from this, the tourism industry has transformed the lives of many countries and their inhabitants, reaching to become a key sector in their economies, create wealth, power work, and an enhancer of their culture. Being a major player in the tourism industry talent human factor, which cannot be replaced by robots or automation of all services, whether for production and service provision is essential to maintain and care equipment, machinery and tools, much more so is the human factor which undoubtedly must emphasize safety and health at work. Musculoskeletal disorders include a large number of disorders of muscles, tendons, nerves or joints that can occur anywhere on the body, although the most common are those that affect the neck, back and upper extremities. **Objective**. Determine the presence of musculoskeletal disorders in waitresses working full time. **Delimitation**. The completion of this research project will focus on the waitresses in Guasave, Sin. Where works six days a week with one shift of 8 hours to determine the musculoskeletal disorders that occur most frequently. **Methodology**. This paper presents the main diseases that people develop as waiters can get by the activities inherent in this profession, fatigue analyzes and musculoskeletal disorders are evaluated. The mapping tool is used Corlett &Bishop, which shows the degree of discomfort - pain that occurs in different parts of the body-. Scale of 4 points of Luke, showing a level of fatigue experienced by waitresses. **Results**. After performing the above studies and analyze the area of research, several points are observed such as decreased efficiency of waitresses, and all the time were the same positions of workers and activities were repeated for a full shift . This research also considered the non-work activities of the waitresses, and also influence on fatigue and musculoskeletal disorders. Before starting with the application of assessment methods are required to inform the waitresses what was to be done, that will not affect the way in labor and likewise not affect the study results. Regarding the questionnaires to measure fatigue and musculoskeletal disorders, before applying it to the waitresses asked to answer how he felt at the time of the questionnaire. **Conclusions**. Based on the results obtained by surveys conducted it

can be concluded that the highest rate of complaints presented by tired on Thursday, Friday and Saturday whit a rate of tired, very tired and extremely tired, this because as the days of the week for the inconvenience increase served on the waitresses. Also the data shows as a result, the trouble those days were due to increased demand in the restaurant as they are very busy days, which makes the weight is carried on the tray is higher than usual, however that does not mean that the usual is the right weight for the waitress´s body segments.

KEYWORDS: Musculoskeletal disorder, risk assessment, waiters

CONTRIBUTION TO ERGONOMICS: Waitress is an understudied activity, this investigation is a beginning for a future investigation works for occupations related to this profession, new hand-tools designs to improve the execution of this activity

1. INTRODUCTION.

Although they may have an even staff and labor extra, home, working conditions are an aspect directly related to musculoskeletal disorders. In this regard, efforts, postures or movements performed may be influenced by the design of the place, the type of tasks to be performed and work organization, can appear both in the development of heavy and office work. According to the above, the prevention of musculoskeletal disorders is linked directly with a proper design of the space and the workplace, maintaining adequate lighting, the use of quality tools and good work organization.

2. OBJECTIVE

Determine the presence of musculoskeletal disorders in waitresses working full time

2.1 SPECIFIC OBJECTIVES:

- ✓ Analyzing the subject of research in their work environment.
- ✓ Interviewing research subjects.
- ✓ Assess the activities undertaken by the study subjects and analyze the collected data to propose for improvement

3. DELIMITATION.

The completion of this research project will focus on the service personnel in restaurants (waitress) specifically for businesses that exist in Guasave, Sin. Where works six days a week with one shift of 8 hours to determine the musculoskeletal disorders that occur most frequently.

4. METHODOLOGY.

This paper presents the main diseases that people develop as waiters can get by the activities inherent in this profession, the same as with training and other measures could be eliminated or reduced. We analyze fatigue and musculoskeletal disorders are evaluated. One of the tools used is mapping Corlett & Bishop, which is a study that shows the amount of discomfort-pain that occurs in different parts of the body. Scale of 4 points of Luke, showing a level of fatigue experienced by waiters, this will help us to determine the body segments where pain or discomfort is experienced also applies.

4.1 PROCEDURE.

It begins with designating the sample size, which is 20 people dedicated to the waiter. It took 6 working days, since the servers will distribute their working time during the week. This was repeated for a period of 3 weeks, during which 100% of the servers they work 6 days a week.

4.2 METHOD OF 4 ITEMS OF LUKE AND ET AL.

Used a scale to determine the level of fatigue. On this scale, called the points of Luke, fatigue levels are entered after a normal day of work, where the measurement scale is: "nothing tired" 1 point "tired" 2 points "very tired "3 points and" extremely tired "4 points. Responses to "very tired" and "extremely tired" fatigue are considered.

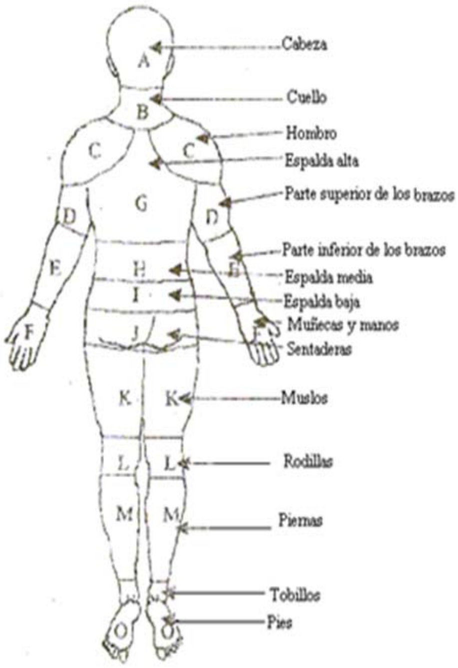
4.3 METHOD CORLETT & BISHOP

The scale of discomfort body segments (Corlett & Bishop, 1976) is a measurement technique that can be used to determine the degree of comfort experienced by a person who uses technical assistance, this can be observed in the image 1, where the hand and shoulder posture are incorrect.

Image 1. Waitress´s bad posture

The technique was developed for evaluating designs of chairs, but the principles could easily be applied to other products as well.

Figure 1. Corlett & Bishop map of the body



The development of such scales requires expert knowledge, but are made by the end user to be applied: also requires some skills and experiences in technical analysis. Such scales are an effective way to obtain information on perceived discomfort, but it should be noted that some of the respondents may not reveal their discomfort in a reliable way.

For this reason, it is not a good idea to rely solely on such subjective measures and should be supplemented with other more objective techniques to gather this information.

In addition, the discomfort of a person can be determined by the degree of change in posture when using a product, the amount of time that is available for use and their preferences for similar products. [7]

The test of pain in body parts (Corlett & Bishop) is another test of comfort (Figure 1) in which questions about the rate of discomfort or pain in any part of the body, at time intervals while the furniture is used for a number 1 to 3 hours. To assist the location of pain, the test is accompanied by a map of the body, with small variations in the areas where it is divided, according to authors. Responses were weighted by the level of discomfort and temporary pain assessment is obtained in each area of the body. [8]

Any change made in the sensations of discomfort or inconvenience (Drury & Coury, 1982), should be solely for the purpose of using that seat. The discomfort should be related to the characteristics of the task and furniture, to obtain design criteria.

5. RESULTS.

After performing the above studies and analyze the area of research, several points are observed such as decreased efficiency in the servers, and all the time were the same positions of workers and activities were repetitive, for a full shift.

This research also took into account the non-work activities of the servers, and also influence on fatigue and musculoskelet al disorders.

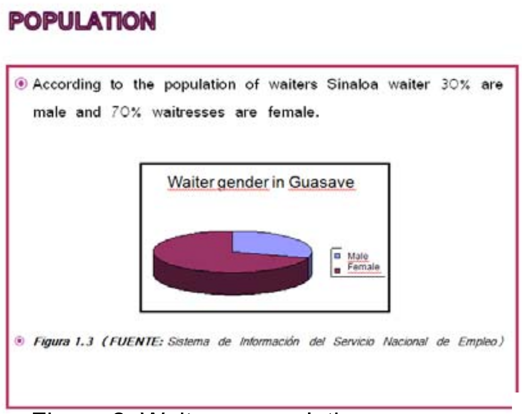
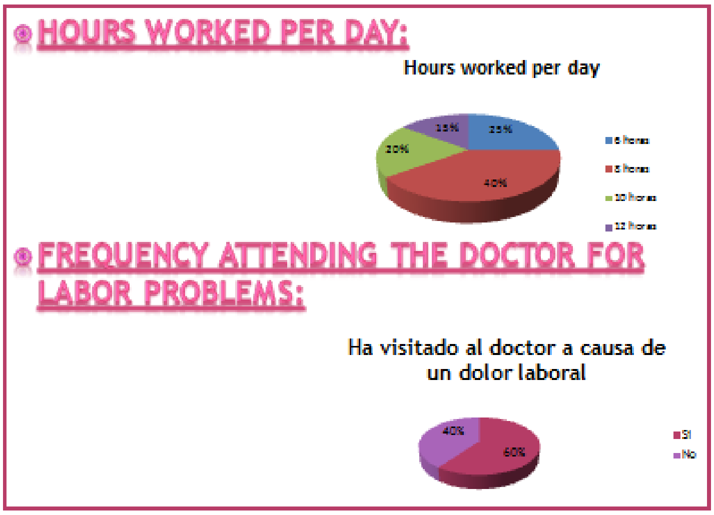


Figure 2. Waitress population

The size of the wasprobing was 20 people –male or female- who are dedicated to working as a waitress (Figure 2). It took 6 working days, since the servers will distribute their working time during the week. This was repeated for a period of 3 weeks, during which 100% of the waitresses are working 6 days a week.

The sounding result show a 40% of interviewed work 8 hours per day and a 60% visited the doctor for labor pains, it shows in the figure 3



Based on the results obtained by surveys the highest rate of complaints presented by tired on Thursday, Friday and Saturday (figure 4) whit a rate of tired, very tired and extremely tired

Before starting with the application of assess-ment methods are required to inform the waitresses what is going to do, so they do not affect in the way of working and likewise not affect the study results.

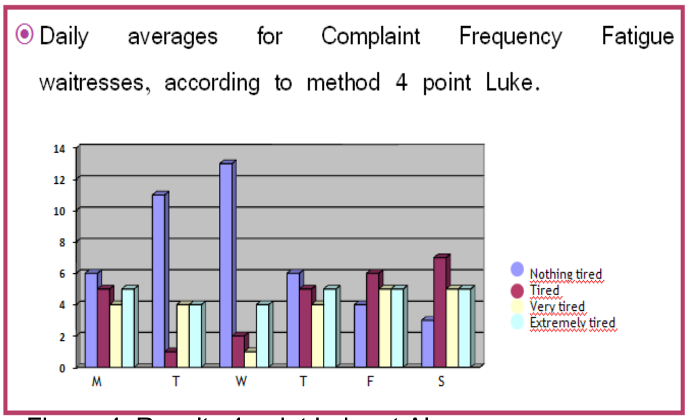


Figure 4. Results 4 point Luke et Al

Regarding the questionnaires to measure fatigue and musculoskeletal disorders, before applying it to the waitresses asked to answer how he felt at the time of the questionnaire. The results for the Corlett & Bishop map analysis are shown in the table 1

Table 1. Results Corlett & Bishop map of the body

Partes del Cuerpo	Día											
	1		2		3		4		5		6	
Molestia/Dolor	M	D	M	D	M	D	M	D	M	D	M	D
Cabeza	2		2	1	4		1	2	1	1	3	3
%	10%		10%	5%	20%		5%	10%	5%	5%	15%	15%
Cuello	1	1	1	2	1	2	2	3	2	1	3	2
%	5%	5%	5%	10%	5%	10%	10%	15%	10%	5%	15%	10%
Hombros	2	2	1	2	2	3	1	1	2	2	1	3
%	10%	10%	5%	10%	10%	15%	5%	5%	10%	10%	5%	15%
Espalda Alta	1		1		2	1	1	2	1	1	1	
%	5%		5%		10%	5%	5%	10%	5%	5%	5%	
Parte Sup. de los Brazos		1	2	2	1	1	2	3	2	2	3	2
%		0.5%	10%	10%	0.5%	0.5%	10%	15%	10%	10%	15%	10%
Parte Inf. de los Brazos	1	2	1	1		1	2			1	2	1
%	5%	10%	5%	5%		5%	10%			5%	10%	5%
Espalda Media	1	1			1	2		2	2	1	2	2
%	5%	5%			5%	10%		10%	10%	5%	10%	10%
Espalda Baja		1	1	2		1	2	2	2	2	2	3
%		5%	5%	10%		5%	10%	10%	10%	10%	10%	15%
Muñeca/Mano	1	1	2	1	2	2	2	3	4	4	4	5
%	5%	5%	10%	5%	10%	10%	10%	15%	20%	20%	20%	25%
Sentaderas			1		1	1	1					
%			5%		5%	5%	5%					
Muslos	1								1		1	
%	5%								5%		5%	
Rodillas			2		2		1				3	
%			10%		10%		5%				15%	
Piernas			1			2		2	1		2	
%			5%			10%		10%	5%		10%	
Tobillos			2		2		3	1		3	2	1
%			10%		10%		15%	5%		15%	10%	5%
Pies					1		2				2	1
%					5%		10%				10%	5%

Mayor disorders are in neck, shoulders, upper arm, wrist and hand. In lower grade are head and lower back.

6. CONCLUSIONS

Based on the results obtained by surveys conducted it can be concluded that the highest rate of complaints presented by on Thursday, Friday and Saturday whit a rate of tired, very tired and extremely tired, this because as the days of the week for the inconvenience increase served on the waitresses.
Also the data shows as a result, the trouble you had those days were due to increased demand in the restaurant as they are very busy days, which makes the weight is carried on the tray is higher than usual, however that does not mean that the usual is the right weight for a waitress.
One of the recommendations made is the redesign of the tray to adapt better to the worker (s). Looking to give comfort to the worker that he can fulfill his duties in the best way, the redesign is that the tray fits in a better way to work and that has a texture and shape so that it can be used without overexertion and in an essential way that suits the neutral body shape.

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WORK PROCESS ANALYSIS OF HYDROPONIC GREENHOUSESFOR DETECTION OF CUMULATIVE TRAUMA DISORDERS

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RESUMEN: Los trabajos del sector agrícola son complejos y diversos, y generalmente se confunde en el trabajador las condiciones de vida y de trabajo; lo que implica que se enfrentan día a día a innumerables riesgos para su salud, es por lo que el propósito de la presente investigación es analizar las condiciones laborales de los trabajadores en invernaderos hidropónicos analizando las operaciones y procesos en el cultivo de tomate orgánico, que pudieran ser las que por provocar malas posturas llegan a generar desordenes de trauma acumulativo a los trabajadores. Como resultados se evidenció que, el método de trabajo requiere ser modificado ya que al menos 3 de las 5 operaciones presentan altos riesgo de lesión para el trabajador ya que al momento de estarlas realizando adopta posturas no neutrales para el cuello, la espalda, los hombros, manos, muñecas y dedos.

Así también las herramientas manuales que se utilizan al momento de ser evaluada la operación de deshojado y recolección, se puede corroborar que no cumplen con la antropometría de la mano del trabajador y por su pobre diseño hace que la mano del mismo se convierta en una extensión de ella, lo que provoca daños que pueden ser permanentes tanto en las muñecas como en las manos, por lo que se concluyó que las condiciones bajo las cuales se laboran en los invernaderos es no son las ideales.

PALABRAS CLAVE: Invernaderos Hidropónicos, Evaluación Ergonómica

ABSTRACT: Jobs in the agricultural sector are complex and diverse, and generally worker'slife and work conditions are confused; this imply that they face daily risks to their health, so the purpose of this research is to analyze the working conditions of

those workers in hydroponic greenhouses for operations and processes in organic tomato crop;Working conditions could be the cause of bad postures leading to cumulative trauma disorders. As results showed, the working method requires to be modified since at least 3 of the 5 operations have high risk of injury to the worker, because of bad postures adoptedthat are non-neutral for neck, back, shoulders, hands, wrists and fingers.

Also, the hand tools used duringdefoliation and harvest operations,were found that do not meet the worker's hand Anthropometry and due to its poor design it becomes and extension to the hand, causing damage that may be permanent on both wrists and hands; It was concluded that working conditions in the greenhouses are not ideal.

KEYWORDS: Hydroponic greenhouses, ergonomic evaluation

CONTRIBUTION TOERGONOMICS: A postural indicator in hydroponic greenhouses for the purposeof contributing to the indicator of national or international media of this typeof greenhouses in order to find more efficient solutions posture.

1.- INTRODUCTION

Agriculture is the most important activity in the State of Sonora; this is recognized nationally for its significant contribution to the PIB (Gross Income Product).For this reason,Sonora is called the National Bran and this has brought great benefits to the State. In order to strengthen agriculture, marketing process and Production and Service systems are constantly innovating through the use of new technologies and more efficient production methods.

One Production method that is fast increasing in the last years is the use of hydroponic greenhouses. Hydroponics is a system of agriculture that utilizes nutrient-laden water rather than soil for plant nourishment (Bridgewood, 2003). Because it does not require natural precipitation or fertile land in order to be effective, it presents people who are living in arid regions with a means to grow food for them and for profithydroponic systems do not require pesticides, require less water and space than traditional agricultural systems, and may be stacked.

This makes them optimal for use in cities where space is particularly limited and populations are high-self-sustaining city-based food systems mean a reduced strain on distant farms, the reduction of habitat intrusions, fewer food miles, and fewer carbon emissions.

Hydroponics allows you to design simple or complex structures favoring the right environmental conditions to produce any type of herbaceous plants taking advantage of its entirety any area. Within the benefits that this provides is to be able to produce 100% organic crops

Due to the above is that it offers great benefits such as: intensification, increase yields, reduced risk of production, more efficient use of supplies and much better control of pests, weeds and diseases;

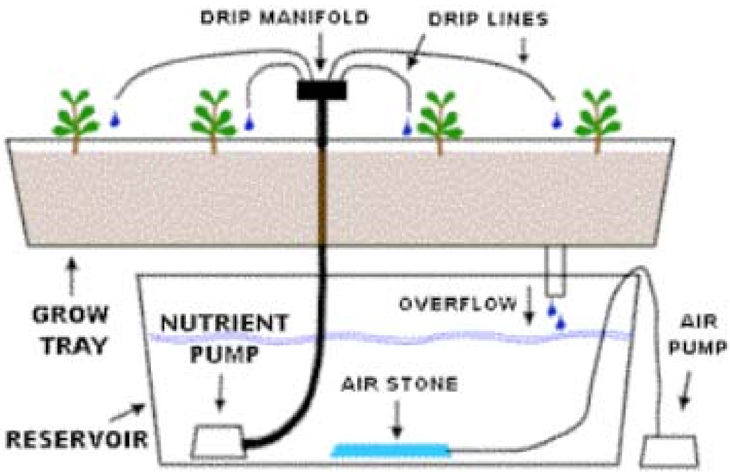

Figure 1 Illustration of a typical drip-style hydroponic system

Also the possibility to farm throughout the year any kind of seasonal product, get products in regions with restrictive conditions, to obtain products of high quality, better work conditions, environment ideal for research, among other factors that add value and increase economic development of the country.

However one of the major weaknesses that exist in this type of greenhouse is that it requires that personnel working at it should have a specialization in the management of its processes.This fact requires senior management to pay greater attention in movements that staff performs during his workday because according to studies made by Meyers, (1997) indicate that theagriculture is one of the hardest jobs and presents a high level of DTA´s (Cumulative Trauma Disorder), so the injury risk factors should receive much more attention and *Ergonomics* should be applied in this field, thing that has not happened in the past. And its use has been nil.

Damage muscles related to farm grow and harvests are an important cause of incapacity of persons in their productive years and it is caused by chronic exposure to physical stresses. On the greenhouse sector it can be found that all the activities carried out have health risk factors mainly due to the type of tasks that are carried out such as working inclined, kneeling, crouching, work with arms raised above the shoulders and lift heavy loads (L., 2006).

Litchfield (1999) indicate that statistic data shows agriculture as one of the sectors with highest levels of accidents and injuries mostly in the back, neck, shoulders and wristand it is highlighted the temporary disability costs incurred; he concludes that it is necessary to improve the work conditions through worker proper training and better accident prevention programs.

It is understood that a work accident is all event that produce an injury on the worker and it can be functional, permanent or temporary, or even death, resulting from an action that was induced in the course of work. In this sense, Rodellar (2002) defines accidents as: "an undesired event that results in loss to persons, property or work processes".

These accidents may not only be caused by the type of work, but also by the poor design of hand tools that are used to accomplish it. According to Rodgers (1983), there are five major factors involved in theprocess design of hand tools taking in consideration those that may affect the health and performance of users: static load of arm muscles and shoulders which result in fatigue and pain; bad position of hand, highpressure on hands palm and finger; vibrations and noise exposure on using electric tools and improper handgrip of tools.

It is reasonable to think that the correct design of tools used in operations, will generate large benefits for the workers, starting from the premise that it would reduce the mechanical demands related to this type of tasks (Shyrle, 2011).

2.- DELIMITATION

The study was conducted in the company Crisp Greenhouse, greenhouse #6 located to the North of the State of Sonora

3.-METHODOLOGY

The large number and variety of tasks often carried out in the agricultural sector, the harsh conditions and lack of knowledge about the risks that imply certain machines, substances or modes of performing certain tasks, makes this activity a very risky owner. This study was conducted in hydroponic greenhouses.

The study was done in hydroponic greenhouses whichmain and onlycrop is organic tomatoes, Sue Redgers method was used for evaluation. This method systematically assesses the functions and identifiestasks with high ergonomic risks.

Three phases were considered during the study: The first consisted of a facility tour to detect, visually, operations and processes which can lead to muscle fatigue, based on theory of the method of evaluation Sue Rodgers. Workers spend approximately 6 days every weekwith 9 hours per day inside the greenhouses.

The second phase focused on making videos of operations and processes identified above, which are:

- Pruning: removal of flowers or fruits not desired to eliminate the probability that the quality decreases.
- Defoliation: remove leaves that prevent the light reaching the tomato.
- Trellising: means to put a support to the plant to guide in its vertical growth and get as much sunlight as possible.
- Harvest: collect the tomato that is in optimal conditions.
- Support placement: place base support to the plant to avoid is damaged with the weight of the tomato.

In the third phase an analysis is carried out by video editing where the evaluation is performed through the ergonomic method chosen, in which injuries or illnesses over joint effort are evaluated highlighting those activities that can impose excessive demands on the muscles, tendons or ligaments of operating personnel;demands are derived from three factors that the method consider:: effort, duration, and frequency.

4.- RESULTS

Once the study was finished, it was found that the operations with elevated risk of inducing DTA involved those with high repetitive movements, such operations were:

1) Defoliationwill generate damage on back and wrists as shown in Figure 2

Figure 2: Process of defoliation

According to the analysis using evaluation method, the results are as shown in table 1:

Table 1: Results of the analysis in the process of defoliation

Part of the Body	Effort	Duration	Effort Frequency	Result	Risk
Shoulders	2	2	2	6	Moderate
Wrist/hand/fingers	3	1	3	8	High
Neck	1	2	3	5	Moderate
Back	1	2	3	5	Moderate

2) In the harvest of the product, that is to be found in the lower part of the plant, injuries in the wrist, hand and fingers are caused while using a hand tool that is not suitable for the type of operation as it is shown in Figure 3. Table 2 showsthe results:

Figure 3: Harvest Process

Table 2:results of the analysis in the process of harvest

Body part	Effort	Duration	Effort Frequency	Result	Risk
Wrist/hand/fingers	3	2	3	10	Very High
Back	2	2	2	6	Moderate

3) In the pruning processbecause it is done in the upper part of the plant (above the shoulders of the worker), causing lesions in shoulder, neck, back and wrist, as shown in Figure 4. Table 3 shows the results:

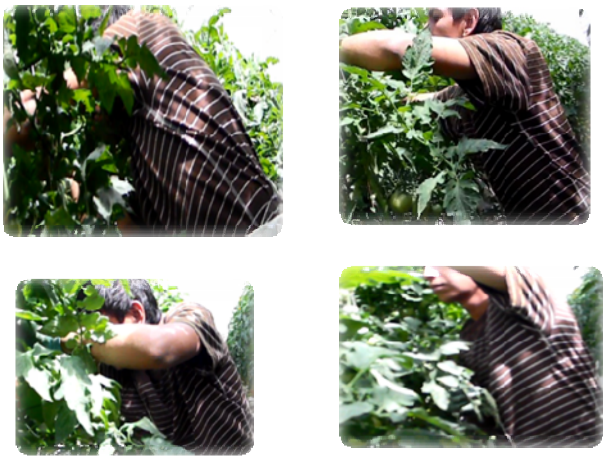

Figure 4: Pruning Process

Table 3: Pruning Process Analysis Result

Body part	Effort	Duration	Effort Frequency	Result	Risk
Shoulders	2	1	3	6	Moderate
Wrist/hand/fingers	3	1	3	8	High
Neck	1	2	3	5	Moderate
Back	2	1	3	6	Moderate

4) Finallyit was detected that the tools used to carry out defoliation is a sickle cutter and the one used for harvestis cutting tweezers, which do not comply with the requirements of the Anthropometry of the worker's hands, this causes injury to the wrist, as you can see in Figure 5 and 6.

Figure 5: Sickle type cutter

Figure 6: Cutting pliers for the harvest process

5.-CONCLUSIONS

The main objective of this study consists in addressing the ergonomic risks in a hydroponic greenhouse process in order to achieve agreements for the improvement of working conditions through the participation of all actors working as entrepreneurs, workers and its regulations, considering that all play a role with the same importance.
Some of the factors to assess and redefine are working tools, skills at the time of hiring, climatic changes, working hours, frequencies in the rotation of activities among others that might improve the performance of production and the quality of life of the people involved.

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APPLICATION OF NASA TLX METHOD FOR ESTIMATING MENTAL LOAD OF STUDENTS OF CALCULUS II AT THE INSTITUTO TECNOLOGICO DE SONORA

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Resumen: Sin lugar a dudas el estudio de las matemáticas ha representado por décadas el principal foco de interés en las universidades al ser de las materias que mayor índice de reprobación presentan. El presente estudio tiene como objetivo estimar el nivel de carga mental presentado en estudiantes de la clase de cálculo II del Instituto Tecnológico de Sonora, para ello se dispone del método propuesto por NASA TLX el cual conlleva a la aplicación de un instrumento donde se consideran factores como la exigencia mental, física, temporal, el rendimiento, el esfuerzo y el nivel de frustración durante la realización de la tarea. Se concluyó que el 83% de los alumnos de la materia de cálculo II presentan carga mental por lo cual se deben tomar medidas encaminadas a lograr el máximo aprovechamiento además de considerar el desarrollo de estudios ambientales en los sitios de estudio.

Palabras Clave: Carga mental, estudiantes, cálculo, reprobación

Abstract: Undoubtedly the study of mathematics has represented for decades the main focus of interest in universities due to it is one of the subjects in where there is presented higher failure rate. The objective of the present study is to estimate the level of mental load which it is presented in Calculus II students at Instituto Tecnologico de Sonora, Guaymas Unit, for this reason it is provided the method proposed by NASA TLX which entails to the application of an instrument where are considered as factors the mental, physical, and temporal demands, performance, effort, and frustration level while performing the task. It was assumed as a conclusion that 83% of students taking the subject of Calculus II generate mental load, therefore it should be taken measures to ensure the maximum study utilization in addition it has to be considered the development of environmental investigations at the study sites.

Keywords: Mental load, students, calculus, failure.

Relevance to Ergonomics: Today the determination of mental load which is presented in individuals is one of the main aspects to consider in taking decisions and / or the generation of actions, as they allow the development of production systems such as the learning of Calculus II at a university level. These actions seek to reduce the level of mental load and, as a consequence they have an important impact on the performance improvement (goal achievement, higher efficiency and other operation indicators), achieving welfare, satisfaction and safety at work, which are goals of ergonomics; is therefore the relevance of creating this kind of investigations.

1. INTRODUCTION

The national education system has undergone several transformations throughout its history especially in the early twenty-first century (Maya, 2011). The World Declaration on Higher Education in the XXI century notes that social change and progress is only feasible if higher education is able to transform itself based on the needs of the society, which has generated that the institutions are at the same level as the increasing technological and industrial revolution (UNESCO, 1998).

As part of this growth there are originated various organizations as the Fund to improve the quality of Higher Education (FECES, 2014) which seeks to ensure that the plans and programs of study are relevant and help students to progress successfully in their educational path; and the Support Program for the Development of Higher Education (PADES, 2014) which drives the implementation of strategic plans to enhance the quality of higher education, to support the professionalization of academic staff in IES and to promote comprehensive education.

In this context the current plan of studies in the Faculty of Engineering at the Universidad Autónoma de México (2011), maintains an ongoing reviewing and updating process, structured by a common trunk for the subjects of Basic Sciences: Physics, Chemistry and Mathematics, being this one of the core subjects in academic education and which is based on the transmission of knowledge as a pattern in the development of algebraic skills.

Mathematics helps students to construct their own knowledge through the process of solving problems and tasks related to student interests (Camarena, 2000). The study of mathematics has been addressed in several studies in which there are shown from theoretical arguments to proposals to improve the quality of learning (Farfan, 1991 & 1994; Artigue, 1995, Dolores, 1999, Salinas et al, 2002). Most studies about this subject have shown a high percentage of college students who fail it (Navarro, 2002).

The Faculty of Engineering of the UNAM year after year applies a diagnostic test to new students resulting in scores below the minimum passing grade in all subjects (Algebra, Trigonometry, Analytic Geometry, Calculus), a situation that appears so similar in the Instituto Tecnologico de Sonora, Guaymas Unit.

Describing, through the technique of brainstorming, among various factors there could be a reason why they fail; it could be the possibility of presenting mental load on students when taking the course, so it is extremely important to make a study of this kind in the academic unit.

Mental load is defined as the number of processes required to complete an activity and according to the time in which a person can find answers in his/her memory (Mondelo, 2000). According to Barraza (2006), this is a real phenomenon immersed in the educational environment, defined as academic stress, in which the student is subjected to a series of demands which, after being valued as stressors cause a systemic imbalance as shown in Figure 1.

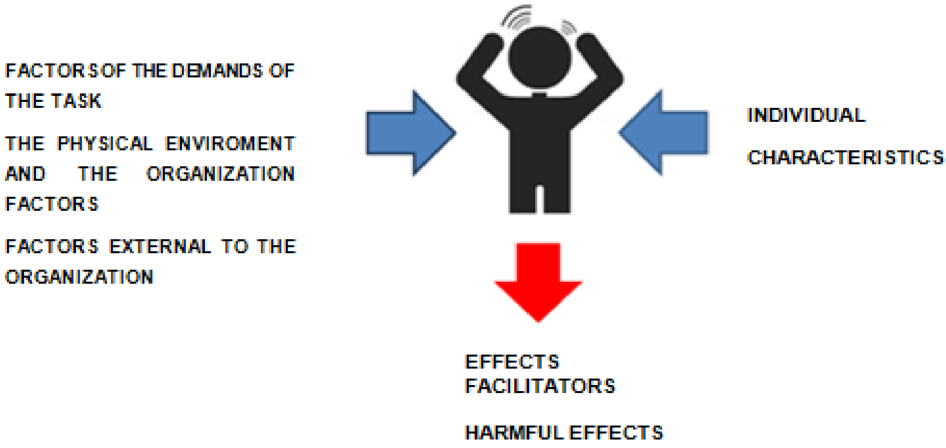

Figure 1. Groups of factors that form the mental workload and its effects.

Factors of the demands of the task

- Maintenance of a high or very high level of attention
- Maintaining a high work-rate
- Perform tasks too repetitive and too short-lived.
- Amount of work
- Feeling of monotony

The physical environment and the Organization factors

- Design tasks
- Design of devices and controls
- Organization of working time

External factors to the Organization

- Stress, depression, anxiety
- Violence and harassment at work

Individual characteristics

- The level of aspiration, self-confidence, motivation, attitudes and reaction styles.
- The capabilities, qualifications/training, knowledge, and experience.
- The age, general health, fitness and nutrition.
- The actual state and the initial level of activation.

In general, these stressors which are conceived by the students are the overhead of homework and schoolwork, sleepiness or increased need for sleep is the most frequent physical reaction among young people. For Arnett (2000), higher education represents the culminating point of the academic stress for high workloads, but also because it coincides with a period of life in which the students must face many changes in their lives.

2. OBJECTIVE

In this context it is aimed to estimate the level of mental load in students in the class of Calculus II at the Instituto Tecnologico de Sonora.

3. METHODOLOGY

To evaluate the mental load of the students who are studying the subject of Calculus II, it was used the procedure of the method NASA TLX (National Aeronauties And Space Administation - Task Load Index), which is a multidimensional assessment which provides global scores to the workload from the weighted average of scores for various factors.

The steps were: 1) determine the population under study; (2) develop the instrument of implementation based on the NASA method; (3) capture information in spreadsheet; (4) describe information obtained; (5) conclusion in relation to the results obtained by identifying the variables to control in order to improve the quality of student´s life.

4. RESULTS

For the study of mental load in university students, it was developed an instrument to collect information based on the NASA TLX method which was applied to 30 students who are studying the subject of Calculus II in the range of ages between 18-22 years. This document is based in six subscales which refer to: mental demands or mental activity and perceptive; Physical demands or degree of physical effort; Temporary requirements; Performance or degree of compliance with the objectives; physical and mental effort; and frustration level during the accomplishment of the task (see Figure 2).

As part of output information the results in the sample are: a) 53% were male and 47% female; (b) 23% have a job; (c) 93% have no children; (d) 42% there are 5 or more members at home; (e) 50% said it has to be considered the noise in medium-scale on the outside to the classroom; (f) 33% considered regular classroom conditions, this information can be seen in Figure 3.

Once applied the survey, the information was captured in a spreadsheet to determine the value of the mental load in each one of the students who are studying the subject and whose results once the information was processed are indicated in Figure 4.

Folio: _____

NASA TLX METHOD

Name: ______________________________ Age: ______ Sex: F M Semester: _____ Do you work?: Yes No

Number of subjects: _____ Number of times taken de subject: _____ Marital status: __________

Number of children: ______ Number of people who lives in your house: _____

Noise outside the classroom: Loud Moderate Low

Instructions: According to the scale of 1 to 20, where 1 is the lowest and 20 is the highest, indicates a reply to each of the following questions:

Mental Demand — How much mental and perceptual activity was required?

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

Low High

Physical Demand — How much physical activity was required?

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

Low High

Temporal demand — How much time pressure felt because of the pace that happened tasks?

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

Low High

Effort — To what extent has had to work to achieve your level of performance?

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

Low High

Performance — To what extent do you think that has had success with the objectives established?

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

Low High

Frustration level — To what extent have you felt discouraged, angry, tense or worried?

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

Low High

Instructions: Place the blank in which of the following do you identify.

M: Mental demand

P: Physical demand

T: Temporal demand

E: Effort

Pr: Performance

Fr: Frustration level

P-M		T-P		T-Fr	
T-M		Pr-P		T-E	
Pr-M		Fr-P		Pr-Fr	
Fr-M		E-P		Pr-E	
E-M		T-Pr		E-Fr	

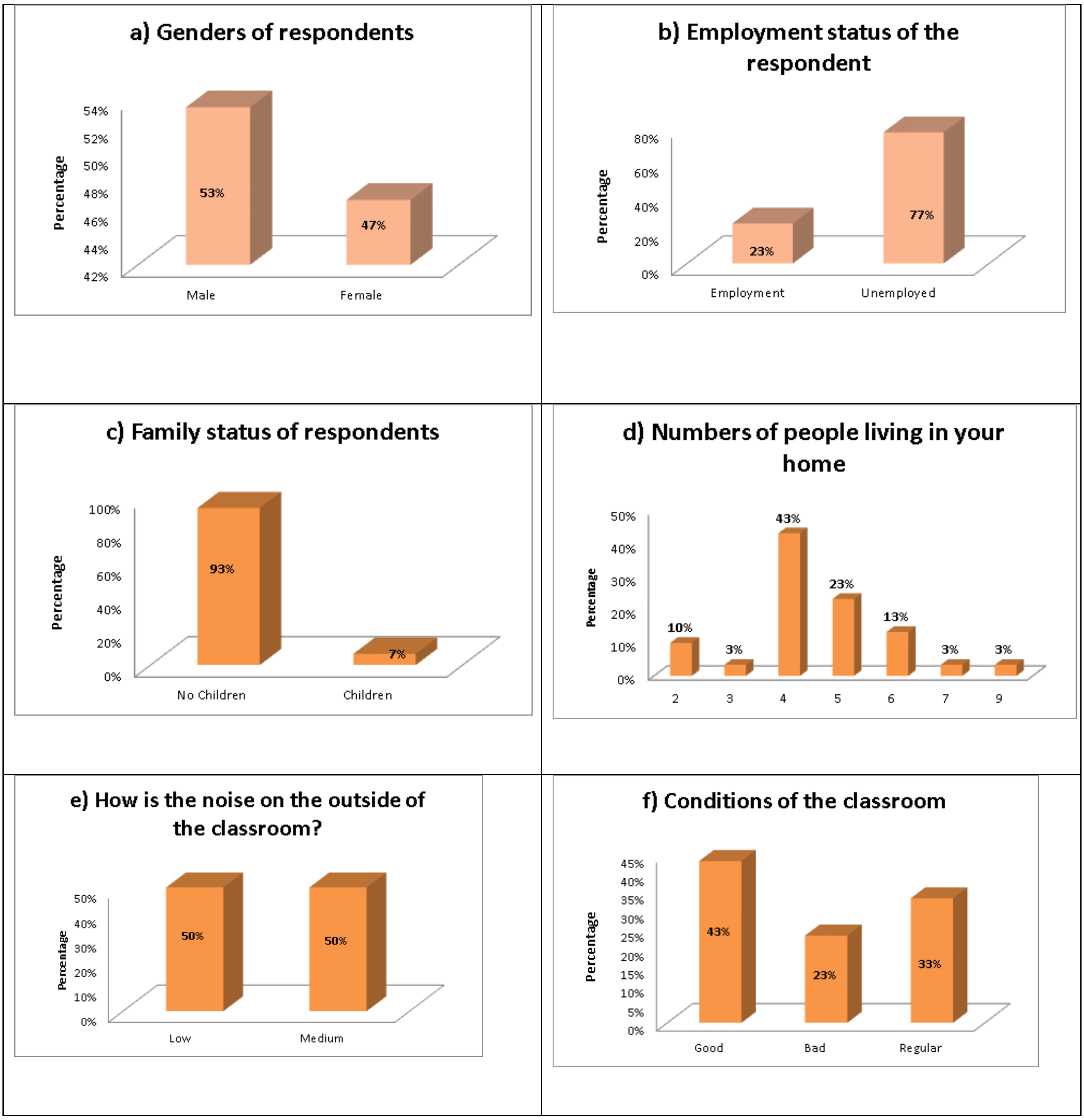

Figure 3. Characterization of respondents

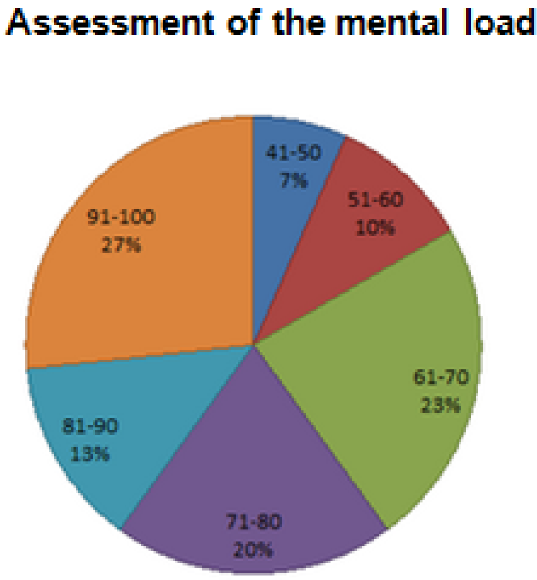

Figure 4. Results of the NASA TLX method

In the figure above you can see that 7% of pupils have a range estimated between 41-50% of mental load, 10% have a range estimated between 51-60, 23% of them have a range estimated between 61-70, 20% have a range between 71-80%, 13% have a range between 81-90% and finally the highest concentration (27%) of the students is located in the range of 91-100% mental load, determining with these results that the students are suffering from physical, mental, temporal demand and efforts in the subject of Calculus II.

Although the method NASA does not specifies from what range it is considered mental load the results obtained reflect enough evidence to assert that the majority of the students (83%) %) suffer from mental load, so several steps should be followed in relation to the type of responses issued in the instrument such as:

- Generate exercises whose degree of difficulty will increase as the course progresses, so that they serve in increasing student awareness and allow him /her to be mentally prepared.
- It is identified that Calculus II is taught along with Algebra linear at any given time causing temporary, physical and mental demand; as a result, it would be necessary to seek a proper load-balancing of activities both of the content of the subject as of the curriculum to help to minimize the possibility of physical wear.
- In order to achieve a greater degree of compliance with the objectives, and qualifications, the best conditions should be generated both internal (tutoring, counseling, supplementary courses program) and external (job, family, economic, health situation and others).
- About the level of frustration during the performance of the task it must be disappearing as the results are becoming favorable for the student.
- It should be paid main attention to the physical environmental conditions such as lighting, noise and climate through formal study

5. CONCLUSIONS

Through the development of this study it was concluded that the subject of Calculus II affects considerably to the students, since most of the time they generate mental load. Generating perhaps, in small scale, little interest in the subject and a low performance; or on a large scale, problems in some of the students, this may be related to depression or anxiety disorders.

Conducting out such studies demonstrate in a concrete and sustainable way the effects that reloaded activities may have in the students. Ergonomic analysis are very important, as its development generates information needed to promote changes that could be possible in the subject planning to not go so fast or not so loaded, generating satisfaction among students and teachers.

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ERGONOMIC EVALUATION AND ANALYSIS OF INDUSTRIAL MECHANICAL METAL WORKSHOP

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Resumen: Proyecto desarrollado en empresa que tiene 8 operadores que laboran directamente en tornos y fresadoras para fabricar herramientas y piezas de ensamble para empresas aeroespaciales, automotrices y semiconductores.

Para realizar un diagnostico previo de la empresa se aplicaron encuestas y entrevistas a los operadores para determinar las condiciones físicas de las instalaciones, evaluación de las condiciones de operación de los puestos de trabajo así como una evaluación del entorno de trabajo.

Para evaluar el confort de los operadores se aplicó una matriz de riesgo y listas de verificación para comprobar los riesgos ergonómicos, la cual cubre muchos factores de los lugares de trabajo, como un apoyo en la supervisión.

Se realizaron mediciones antropométricas para obtener indicadores de percentiles así como mediciones de iluminación, ruido y temperatura en estaciones de trabajo. Se analizó por último la evaluación ergonómica en las estaciones con el método RULA (Rapid Upper Limb Assessment).

Al final se aplicó el método LEST (Laboratorio de economía y sociología del trabajo) para valorar aspectos de carga física, entorno físico, carga mental, aspectos psicosociales y tiempos de trabajo.

Palabras Clave: Matriz de Riesgo, RULA, LEST

Abstract: Project developed in a company that has 8 operators working directly in lathes and milling machines to manufacture tools and assembly parts. for aerospace, automotive and semiconductor companies.

To perform a prior diagnosis of the company applied surveys and interviews with operators to determine the physical condition of the facilities, assessment of the conditions of operation of workstations as well as an assessment of the working environment.

To evaluate the comfort of the operator was applied to a risk matrix and checklist to check the ergonomic risks, which covers many factors of workplaces, as an aid in monitoring.

Anthropometric measurements were performed to obtain indicators of percentiles, as well as measurements of lighting, noise and temperature on workstations. Ergonomic evaluation in stations with the RULA (Rapid Upper Limb Assessment) method was finally analyzed.

At the end, the LEST (laboratory of economy and sociology of work) method was applied to assess aspects of physical load, physical environment, mental load aspects psychosocial and work times.

Key words: Risk matrix, RULA, LEST

Relevance to Ergonomics: To evaluate a work center, you must use altogether, appropriate tools of ergonomic analysis and matrix of risk in combination with LEST. In addition it is important to consider the opinion and needs of operators through surveys and/or interviews to allowing validate the results.

1.- INTRODUCTION

Project developed in a company that has 8 operators working directly in lathes and milling machines to manufacture tools and assembly parts. for aerospace, automotive and semiconductor companies.

To perform a prior diagnosis of the company applied surveys and interviews with operators to determine the physical condition of the facilities, assessment of the conditions of operation of workstations as well as an assessment of the working environment.

To evaluate the comfort of the operator was applied to a risk matrix and checklist to check the ergonomic risks, which covers many factors of workplaces, as an aid in monitoring.

Anthropometric measurements were performed to obtain indicators of percentiles, as well as measurements of lighting, noise and temperature on workstations. Ergonomic evaluation in stations with the RULA (Rapid Upper Limb Assessment) method was finally analyzed.

At the end, the LEST (laboratory of economy and sociology of work) method was applied to assess aspects of physical load, physical environment, mental load aspects psychosocial and work times.

2.- OBJECTIVE

Evaluate the ergonomic operating and environmental conditions of workstations through surveys, tables and checklists of risks in industrial workshop station, as well as the operations of work based on international recommendations

3.- METHODOLOGY

Were applied in the following order surveys and interviews, risk matrix, lists of verification of ergonomic hazards, anthropometry, measurements of lighting, operation conditions, environmental and refraction of color on machines, measurement of temperature and noise, as well as the application of the method RULA and LEST

1.Implementation of surveys and interview

The results that are shown in Table 1 correspond to the operating personnel of the process survey

Table 1. Results from survey to operating personnel.

Description of evaluation	Results	Observation
Number of people polled	6	men
Age	20-45 years	20, 23, 30,38(2) y 45
Experience	2-24 years	2,5,6,12,10,24
Evaluation of environment		
1. Illumination	Very good	Improve illumination
2. Noise	Acceptable	
3. Temperature	Regular	
4.Ventilation	Regular	Improve ventilation
5. Physical condition that influence the job	50%	Excess heat and moisture
Assessment of condition of work station		
6.Equipment and tool	Acceptable	Everyone with their proper tools
7. Height of table	Very good	Acquirer more tables
8. Distance of components to be assembled	Acceptable	

9. Consider regular place of work	50%	Does not require physical exertion, multitasking
10.Nuisance attributable to working conditions	0%	2 years the oldest

2. Matrix of risks in work stations and equipment

Instrument to determine any alteration in the comfort of your workstation users, in table 2 displays only significant conditions to analyze of the workstations in the process. (García, 2008)

Table 2. Matrix of risks in workstations and equipment with significant priority

Activity (Work station)	Milling machine(1,4,5,6,7 y 8) Leathe (2,3 y 9) Numerical Control Machine (10 y 11)	
Type and class of danger	Ergonomic design of work station	Noise
Cause of danger	Height of the place of work, location of controls, tables, equipment, surfaces, etc.	Motor
Risk	Alterations of the health (muscle bone injury, fatigue, vascular alteration, accident at work)	There are ear plugs, however, the danger would be presented in case of not using it. Health alterations (low hearing effect, acoustic trauma, alterations of sleep and rest, stress, etc.)
Exposed	Tool fabricant	Tool fabricant
Number of exposed	6	6
Hour of exposition	8	8
Probability	500	200
Consequence	200	500
Legal requisite	10	10
Grade of importance	710	710
Priority	Significant	Significant

3.List of verification of ergonomic hazards

Checklist of ergonomic hazards (LCE) table 3. offer practical and low-cost solutions to ergonomic problems, particularly for the small and medium enterprises. The list covers all the main factors ergonomic workplaces, which will help to monitor them in an organized manner.(Ministerio del trabajo e inmigracion de españa, 2006).

Table 3. Ergonomic hazards checklist

No.	Subject	Valuation
1	**Subject.** Adjust the working height to each worker, placing his elbows level or slightly more down	**Valuation.** Proposed action
	Observation: **Preventive action:** For accuracy work, the elbow height can be the best. In light of Assembly or packaging work, hand height should be approximately 10-15 cm below the elbows. When you need to make a very important force, even that can be used the weight of the body, the height must be even lower. **Recommendations:** Buy adjustable work tables; they facilitate the use of the same by several people. **Not to forget.** The correct height of the hand in foot work or sitting must be applied the "elbow rule".	
2	**Subject.** Make sure that younger workers can reach the controls and materials in a natural posture	**Valuation.** Proposed action
	Observation: **Preventive action:** Surface working of the machines and equipment must power adjusted in height to adjust the lower and higher workers. **Recommendations:** A mobile control panel do that job is adjustable. **Remember:** Smaller workers must be comfortable.	
3	**Subject.** Make sure that the larger workers have enough space to comfortably move of legs and body	**Valuation.** Proposed action
	Observation: **Preventive action:** Check the total free space for workers in all positions and passage ways, and should be increased where necessary. **Recommendations:** In every place of work, should make sure that both workers smaller as the larger ones feel safe and comfortable with the existing space. We must also consider gloves, protective clothing, helmets, etc. **Don't forget: The larger workers must feel secure and comfortable with the existing space.**	
4	**Subject.** Locate the materials, tools and controls most frequently used in an area of comfortable reach	**Valuation.** Proposed action
	Observation: **Preventive action:** Tools and controls frequently used must be located in the preferred area for the movement of the hand (at the height of the elbows, between 15 and 40 cm ahead of the body, and not more than 40 cm to the sides). It is important to have the opinion of the workers. **Recommendations:** Allow workers to fit the job to your needs. The Visual presentation of information devices and instructions may be placed beyond this area to make them easy to read. Provide adjustments for adaptation to left-handed workers. **Don't forget:** should the materials, tools and controls with greater frequency of use in an area of comfortable reach.	
	Subject. Provide a stable, multipurpose work in every workplace surface	**Valuation.** No action

5	**Observation:** **Preventive action:** Different jobs must have an area of stable work of an appropriate size so that you can perform a variety of tasks. The thickness of the work surface should not be greater than 5 cm, in order to make space for the knees. **Recommendations:** Take into account also the places for small tools, for material of desks and other personal items. If necessary, use a side table, a flat on a shelf, or stands for work next to the worker. **Remember:** for every job there is to provide a stable surface for carrying out both the main tasks, as the secondary or preparation.	
6	**Subject.** Provide sites for working seated workers carrying out tasks requiring precision or a detailed inspection of items, and sites where work standing to those who perform tasks that require movements of the body and a stronger	**Valuation.** Proposed action
	Observation: Preventive action: for a job that requires a high accuracy, the repetition of detail manipulation, or a continuous inspection is assigned a sitting position. On the other hand, for a job that requires many movements of the body and greater strength, a foot post. Ensure, if provided enough space for the knees, legs and feet. Make the post, in particular, its working height. **Recommendations:** It is recommended to assign the tasks so that the worker can toggle to be standing with sitting while working.	
7	**Subject.** Make sure that the worker may be standing naturally, supported on both feet, and doing the work around and in front of the body	**Valuation.** Proposed action
	Observation: **Preventive action:** Important and frequent operations should be about and in front of the body, and to the height of the elbows or slightly more down, without having tilts or turns of the body. Jobs must also be adjustable when they will be occupied by different workers, or different operations are carried out. **Recommendations:** Detect forced positions ask workers if they feel pain or discomfort during the work. **Not to forget:** natural postures should be sought in the workplace, support on both feet and without tilt or twist, in this way fatigue is lower and higher productivity.	
8	**Subject.** Allow workers to alternate sitting with be standing during the work, as much as possible	**Valuation.** No action
	Observation: **Preventive action:** The worker must perform work tasks alternating foot positions and sitting. If possible, have to organize the job rotation so that the same worker can go through different works, alternating the positions of standing and sitting. **Recommendations:** Place chairs so that workers who stand feel occasionally, and providing, which are sit, additional space where to perform secondary tasks while standing. **Not to forget:** Alternate being foot with being seated, and thus obtain a greater efficiency and greater comfort.	
9	**Subject.** Provide chairs or benches for workers who are standing feel sometimes	**Valuation.** Proposed action
	Observation:	

<table>
<tr><td></td><td colspan="2">Preventive action: It is important to place a Chair or a stool near each of the workers who are standing.
Recommendations: Chairs or stools should not occupy too much space, or hinder the work. Remember: to give chairs or benches close to the job so that the foot work is not so hard</td></tr>
<tr><td>10</td><td>Subject. Provide good adjustable chairs with backrest seated workers</td><td>Valuation. No Action</td></tr>
<tr><td rowspan="2">11</td><td>Subject. Provide adjustable work surfaces to workers who alternate working with large and small objects</td><td>Valuation. Proposed action</td></tr>
<tr><td colspan="2">Observation:
Preventive action: Foot workers must possess a work surface adjustable which allows actions of the hand between the waist and the heart (or between the elbows and the heart, in the case of seated workers) for handling objects of different sizes.
Recommendations: You have to remove work above the shoulders or below the knees.
Not to forget: work surfaces should be adjustable so that those working with different sizes of objects can make it around the level of the elbows.</td></tr>
<tr><td>12</td><td>Subject. Make posts with screens and keyboards, such as jobs with displays of data (PVD), may be regulated by the workers</td><td>Valuation. No Action</td></tr>
<tr><td rowspan="2">13</td><td>Subject. Provide recognition of the eyes and glasses appropriate to workers who normally used a computer with a display of data (PVD)</td><td>Valuation. Proposed action</td></tr>
<tr><td colspan="2">Observation:
Preventive action: Introduce this recognition of the view as part of the periodic medical examination program, introduce at least once every two years.
Recommendations: A display screen requires a greater viewing distance (over 50 cm) and a viewing angle that can not be attained by bifocal lenses.
Remember: avoid the fatigue of the eye and the postural discomfort, derived from working with PVD, through the use of appropriate glasses where necessary.</td></tr>
<tr><td rowspan="2">14</td><td>Subject. Provide training to start the day of workers with displays of data (PVD)</td><td>Valuation. Proposed action</td></tr>
<tr><td colspan="2">Observation:
Preventive action: All PVD operator must receive an initial basic training, depending on the individual skills on the objectives and main features of the system.
Recommendations: When new programs, procedures or equipment are introduced, training sessions should be organized for operators of PVD. Furthermore, for new employees can be arranged a separate course, ensuring that they receive training of update.
Not to forget: the updating training is the most effective way of quickly using technologies in development.</td></tr>
<tr><td rowspan="2">15</td><td>Subject. Involve workers in the improvement of the design of your own workstation.</td><td>Valuation. Proposed action</td></tr>
<tr><td colspan="2">Observation:
Preventive action: ask workers about problems causing them job and collect their ideas about how to fix those problems. It is also important and we must not forget to express appreciation to people for ideas for the improvement of the workstation for future enhancements.</td></tr>
</table>

Recommendations: Should create specific opportunities for workers to propose their ideas for the improvement of their job. It must not forget that: workers are the best tool to improve workplaces, good use of your suggestions should be.

4. Anthropometry

Table 4. Anthropometric measurements of the center of machining

Medida operador	1	2	3	4	5	6	prom	desv	P_{95}
Edad (Años)	20	23	30	38	38	45			
Peso (Kg)	80	110	75	69	95	98			
1.Cabeza	16	17	16	15	17	17	16.30	0.82	17.64
2. Estatura completa	184	179	169	166	176	178	175.12	6.68	186.11
3.Cintura al piso	108	101	97	94	102	104	100.79	4.98	108.99
4. Ojo al piso	169	168	158	153	166	167	163.28	6.47	173.93
5. Codo al piso	121	120	113	109	116	116	115.69	4.45	123.00
6.Anchura de acromión	38	44	36	37	41	41	39.31	3.02	44.27
7.Muñeca al piso	95	90	87	84	89	90	89.04	3.66	95.06
8.Acromión al piso	156	152	143	141	148	150	148.16	5.61	157.38
9.Dedo medio al piso	75	75	69	67	69	73	71.19	3.44	76.86
10. Máxima amplitud de brazos	185	187	165	166	181	178	176.57	9.44	192.11
11. Máxima extensión de codos	98	99	92	83	93	97	93.33	5.92	103.08
12. Cabeza al piso	131	128	131	127	128	133	129.63	2.34	133.48
13. Rodilla al piso	62	61	54	53	59	61	58.11	3.88	64.50
14. Tibia a piso	51	49	45	43	48	48	47.18	2.88	51.91
15. Pie	30	32	28	28	31	32	30.07	1.83	33.09
16. Acromión al glúteo	60	59	62	61	60	61	60.48	1.05	62.21
17. Ancho de cadera	39	46	38	42	43	42	41.50	2.88	46.23
18. Anchura de hombros levantados	43	50	42	42	49	44	44.77	3.58	50.66

5. Measurements of environmental conditions of operation

5.1 Illumination

Table 5. Weighting factors to be considered when selecting specific levels of lighting within each category

Características de la tarea y el trabajador	Ponderación o Peso		
	-1	0	+1
Edad	< 40	40-55	>55
Reflejo del fondo de tarea/superficie	>70%	30-70%	<30%
Velocidad y exactitud (sólo para las categorías D a I)	No importante	Importante	Crítico

Lighting levels recommended for use in the design of interior lighting, with the respective weighting factor and the reflection of colors are shown in Table 6 and Table 7 in machines for lathes, mills and numeric control machines. Finally table 8 shows the resulting values compared with the recommended values

Table 6. Operation qualification according to lighting for lathes and milling machines (recommendation)

Operación/Intervalo de iluminación	Edad	Reflejo de superficie	Velocidad y exactitud	Total	Ilumina
Ajuste de controles superiores Categoría D 20-30–50	20-38 años (-1) 45 años (0)	Gris claro 75% (-1)	Importa (0)	-2 -1	20 30
Fabricar e inspeccionar piezas y herramientas sobre mesas de trabajo de fresadoras y tornos. Categoría G 200-300-500	20-38 años (-1) 45 años (0)	Gris oscuro 30% (0)	Crítico (+1)	0 1	300 300
Ajuste de controles numéricos en pantallas de visualización. Categoría D 20-30–50	20-38 años (-1) 45 años (0)	Gris oscuro 30% (0)	Importa (0)	-1 0	30 30
Desplazamiento de extremidades inferiores en estación de trabajo. Categoría C 10-15-20	20-38 años (-1) 45 años (0)	Crema claro 75% (-1)	No aplica	-2 -1	10 30

Table 7. Qualification of operating according to lighting for machines of numerical control (recommendation)

Operación/Intervalo de iluminación	Edad	Reflejo de superficie	Velocidad y exactitud	Total	Ilumina
Ajuste de controles superiores Categoría D 20-30–50	20-38 años (-1) 45 años (0)	Gris claro 75% (-1)	Importa (0)	-2 -1	20 30
Fabricar e inspeccionar piezas y herramientas sobre mesas de máquinas de control numérico. Categoría G 200-300-500	20-38 años (-1) 45 años (0)	Gris oscuro 30% (0)	Crítico (+1)	0 1	300 300
Ajuste de controles numéricos en pantallas de visualización. Categoría D 20-30–50	20-38 años (-1) 45 años (0)	Gris oscuro 30% (0)	Crítico (+1)	0 1	30 30
Desplazamiento de extremidades inferiores en estación de trabajo Categoría C 10-15-20	20-38 años (-1) 45 años (0)	Crema claro 75% (-1)	No aplica	-2 -1	10 30

Table 8. Registration of measurements of lighting

Estación	Maquinaria	Nivel superior		Mesa de trabajo		Nivel Control		Nivel Inferior	
		Medido	Requier	Medido	Requier	Medido	Requier	Medido	Requier
1	Fresadora 1	417	30	90	300	150	30	60	30
2	Torno 1	238	30	228	300	121	30	65	30
3	Torno 2	392	30	289	300	385	30	204	30

4	Fresadora 2	414	30	152	300	172	30	156	30
5	Fresadora 3	205	30	118	300	251	30	76	30
6	Fresadora 4	536	30	65	300	230	30	90	30
7	Fresadora 5	457	30	180	300	272	30	110	30
8	Fresadora 6	384	30	107	300	62	30	102	30
9	Torno 3	288	30	273	300	220	30	79	30
10	Máquina de control numérico CNC 1	378	30	163	300	315	30	111	30
11	Máquina de control numérico CNC 2	405	30	119	300	185	30	40	30

5.2 Noise

Table 9 noise levels do not represent risk of working in any of the stations from the Centre of machining since they are low according to the provisions of the Occupational Safety and Health Administration (OSHA).(Niebel 2004)

As noise control, we have implemented a dispenser of earplugs that reduce 33 decibels of noise. The measurements were made by working four milling machines, one lathe and one machine of numerical control CNC 1.

Table 9. Measurements of levels of noise and reduction with plugs.

Estación	Maquinaria	**Escala A (db)**	**Escala C (db)**	**Protección para oídos (33 decibel)**
1	Fresadora 1	75.6	76.3	43.3
2	Torno 1	80.7	82	49
3	Torno 2	75.4	84	51
4	Fresadora 2	77.2	82.7	49.7
5	Fresadora 3	75	81.6	48.6
6	Fresadora 4	75.1	85.4	52.4
7	Fresadora 5	74	80.6	47.6
8	Fresadora 6	73.2	80.9	47.9
9	Torno 3	78.9	81.4	48.4
10	Máquina de control numérico CNC 1	79.3	85.6	52.6
11	Máquina de control numérico CNC 2	80.1	84.1	51.1

5.3 Temperature

Table 10. Registration of measurements of temperature (degrees centigrade)

Equipo	Día 1:9 am	Día 1:2pm	Día 2: 9 am	Día 2:2 pm.
Fresadora 1	26.8	28.8	26.5	28.8
Torno 1	27.4	29.4	27.5	29.4
Torno 2	27.9	29.4	28.1	30.1
Fresadora 2	27.9	29.5	28.1	30.1
Fresadora 3	27.9	29.5	28.1	30.1
Fresadora 4	27.9	29.5	28.7	30.2
Fresadora 5	27.9	29.5	28.7	30.2
Fresadora 6	28.1	29.5	28.7	30.2
Torno 3	28.2	30.2	28.7	30.2
Máquina de control numérico CNC 1	28.2	30.2	28.1	30.2
Máquina de control numérico CNC 2	28.2	30.2	28.1	30.9
Promedio	**27.9**	**29.6**	**28.1**	**30**

Table 11. Measurements of field in the workspace.

Equipo	Día 1:9 am	Día 1:2pm	Día 2: 9 am	Día 2:2 pm.
Temperatura media (^{o}C)	27.9	29.6	28.1	30
Velocidad del aire (m/s)	0.5	0.5	0.5	0.5
Humedad relativa (%)	20%	20%	23%	21%
Voto medio estimado	1.25	1.32	1.29	1.34
Situación	Inadecuada	Inadecuada	Inadecuada	Inadecuada

To evaluate the temperature will be used the FANGER method proposed by the Universidad Politécnica de Valencia. (Ministerio del trabajo e inmigración de España, 2006)

Is recommended that the estimated average vote is between - 0.5 and 0.5 so the situations are inadequate, from 0 to 1 is slightly warm, 1.5 to 2 is hot, situation that directly contributes to the fatigue and employee productivity. (Ministerio del trabajo e inmigración de España, 2006)(ministerio de empleo y seguridad Social de España, 1997)(www.ergoprojects.com-articulo26, 2013)

6. Method RULA (Rapid Upper Limb Assessment)

Table 12. Ratings and recommendations of the RULA method for milling machine.

Operación o preparación de trabajo	Indice Final	Recomendación	
Maquinado	7	se requieren cambios urgentes en el puesto o tarea.	
Movimiento de ejes con manivelas	5	se requiere el rediseño de la tarea; es necesario realizar actividades de investigación.	
Manejo de Controles superiores	6	se requiere el rediseño de la tarea; es necesario realizar actividades de investigación.	
Cambio de bandas para velocidad	7	se requieren cambios urgentes en el puesto o tarea.	

Table 13. Ratings and recommendations of the RULA method for lathes

Operación o preparación de trabajo	Indice Final	Recomendación	
Colocacion de Buril	7	se requieren cambios urgentes en el puesto o tarea.	
Colocar pieza en Chuck	6	se requiere el rediseño de la tarea; es necesario realizar actividades de investigación.	
Maquinado axial	5	se requiere el rediseño de la tarea; es necesario realizar actividades de investigación.	
Colocar contrapunto	3	pueden requerirse cambios en la tarea; es conveniente profundizar en el estudio.	
Maquinado Radial	6	se requiere el rediseño de la tarea; es necesario realizar actividades de investigación.	

As shown in table 12 and table 13 RULA method results, rates are high so it is necessary to make proposals for change in the operations and preparation of milling and turning. (RiesgoLab Consulting Grup S.R.L., 2013)

7. Method LEST (Economics and labour sociology laboratory)

LEST method makes it possible to obtain quantitative indicators to reduce. Seeks to improve in stages of prototyping of workstation. (Lianeza, 2009)(LEST, www.ergonautas.com, 2013)

Table 14. Results of the LEST method in 5 dimensions, variables, and overall results

Carga Física	5	Débiles molestias. Mejoras para comodidad	
	Carga Estática	8	
	Carga Dinámica	2	
		Esfuerzo Realizado en el puesto de trabajo	2
		Esfuerzo de aprovisionamiento	0
Entorno Físico	**10**	**Nocividad**	
	Ambiente Térmico	9	
		Valoración del Ambiente	9
		Variaciones en la Jornada	0
	Ruido	2	
		Valoración del ruido	0
		Indice compuesto de exposición al ruido	-
		Nivel de intensidad sonora equivalente dB	<60
		Ruidos impulsivos	2
	Ambiente Iluminado	12	
		Niveles de iluminación y contraste	10
		Existencia de iluminación natural	2
		Existencia de deslumbrameintos	0
		Diferencias de iluminación puesto/entorno	0
	Vibraciones	0	
Carga Mental	**1**	**Situación Satisfactoria**	
	Presion de tiempo	1	
	Atención	2	
	Complejidad	0	
Aspecto Psicosocial	4,5	Débiles molestias. Mejoras para comodidad	
	Iniciativa	3	
	Comunicación	3	
	Relación mando	8	
	Status social	4	
Tiempo de trabajo	**5,5**	**Molestia medias existe riesgo de fatiga**	
	Cantidad de tiempo	8	
	Organizar tiempo	3	

8.- RESULTS

- High heat and humidity with little ventilation
- Lighting levels were below in work tables, Table 8
- Noise levels do not represent risk of working in any of the stations from the center of machining, Table 9
- Inadequate temperature, Table 11
- workstations with bad height for controls and speed gearbox, Table 12
- Need for ergonomic workstations with high rates changes, so it is necessary to make proposals for change in the operations and preparation of milling and turning. Table 12 and Table 13
- Harmful physical environment lighting and contrast and valuation of the environment, Table 14

- Discomfort fatigue due to time of day with 5 to 12 hours average extras (survey), Table 14

9.- CONCLUSION

- Acquisition of adjustable tables
- Purchase basis for height adjustable controls
- Redesign workstations with ergonomics to neutral positions
- Improve temperature to decrease fatigue and increase productivity
- Regular workstations in lathes and milling machines there is also high lighting controls so it is necessary to place solarpur
- Where does lack lighting insert auxiliary lamps adapted to Workbench
- The acquisition of ear plugs reduce 33 decibels.
- Surveys were used to identify latent and tangible needs, but it was necessary to apply measurement tools that we use in the methodology to realize the possibilities for improvement are in the workshop.
- The proposals were delivered and are still rating on workshop and by the graduate Committee of the Facultad de ingenieria of the Universidad Autónoma de Baja California and be feedback in Ergonomia SEMAC Congress

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DETERMINATION OF BURNOUT SYNDROME AMONG MIDDLE AND SENIOR MANAGEMENT PERSONNEL IN AUTOMOTIVE INDUSTRY IN JUAREZ CITY MEXICO

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Resumen Este artículo presenta un estudio descriptivo del Burnout en mandos medios y superiores de la industria automotriz en Ciudad Juárez, México como parte de una investigación sobre ergonomía ocupacional. Para ello, se encuestó a 103 personas, incluyendo sólo a gerentes y supervisores de los diferentes departamentos donde 72 fueron hombres y 31 mujeres. El propósito es aportar conocimiento sobre un tema cuyos estudios en México son escasos, así como en el sector industrial. Adicionalmente, mencionar las consecuencias organizacionales, sociales e individuales que conlleva el padecer este síndrome y las técnicas que existen para prevenirlo. Todo ello, considerando que la calidad en el servicio que se ofrece, es un factor determinante para el éxito.

La metodología consistió en medir la consistencia interna del Maslach Burnout Inventory- General Survey (MBI-GS) a través del Alfa de Cronbach usando el Software SPSS 20.0. Después, obtener las puntuaciones de las dimensiones que lo conforman sumando los ítems de cada una: agotamiento emocional con cinco ítems, cinismo con cinco ítems y eficacia profesional con seis ítems. Posteriormente, se hizo una agrupación visual de cada dimensión utilizando como puntos de corte el percentil 33.3 y 66.6 para distribuir las puntaciones en grado bajo, medio y alto respectivamente. De esta manera se obtienen 27 combinaciones, que se distribuyen en una variable categórica de cinco niveles: nada, poco, medio, bastante y extremo para comprender el burnout de manera general.

Los resultados arrojan que, un 30.1% está en el nivel extremo, 18.4% en bastante, 16.5% en medio, 10.7% en poco y 24.3% están exentos de burnout. Por otra parte, la consistencia interna del MBI-GS resultó satisfactoria en todas las dimensiones con valores superiores de 0.7 considerado como el límite mínimo de aceptabilidad.

Palabras clave: Burnout, Mandos medios y superiores, Industria automotriz, Maslach Burnout Inventory (MBI-GS), Niveles Burnout.

Abstract This article presents a descriptive study of Burnout among middle and senior management personnel in the automotive industry in Juarez City, Mexico as part of a research in the section of occupational health. To this end, samples of 103 people were surveyed, including only managers and supervisors from different departments where 72 were men and 31 were women. The purpose is to provide knowledge on a subject whose studies are scarce in Mexico, as well as in the industrial sector. Additionally, mention the organizational, social and individual consequences that involve this syndrome and the techniques that exist to prevent it. All this, considering that the quality of service offered, is a determining factor to its success.

The methodology consisted in measure the internal consistency of the Maslach Burnout Inventory-General Survey (MBI-GS) through Cronbach's alpha using SPSS 20.0. The next step was to get the scores for each dimension by summing the items of each: emotional exhaustion with five items, cynicism with five items and professional efficacy with six items. Later, a visual grouping of each dimension was made to distribute the scores in low, medium and high grade respectively, using the percentile 33.3 and 66.6 as cutoffs. In this way, 27 combinations are obtained that are distributed in a categorical variable with five levels: none, low, middle, fairly, extreme. So, describe the burnout in a general mode.

The results show that 30.1% is in the extreme level, 18.4% is in a fairly level of burnout, 16.5% is in a middle level, 10.7% in low level and 24.3% is exempt from burnout. While, the internal consistency of the MBI is satisfactory because all dimensions have values greater than 0.70 which is considered as the lower limit of acceptability.

Keywords: Burnout, Middle and Senior Management, Automotive Industry, Maslach Burnout Inventory (MBI-GS), Burnout levels.

Relevance to Ergonomics: The study of stressful psychosocial factors affecting workers' performance and work environment is relevant for Ergonomics and has becoming an object of study of it recently. A lack of studies of Burnout in automotive industry has been found in literature review so this research contributes to knowledge of this syndrome under this context

1. INTRODUCTION

According to Llaneza (2002), the appearances of job stress associated with diseases are on the rise in developed countries. This as a result of the demands of jobs, factors from new technologies and especially relationships among workers. This has caused in them psychological, physiological and behavioral responses.

In the aspect of organizations, the consequences are reflected in economic and labor climate impacts due to low efficiency and exhaustion in workers. According to Gil-Monte and Peiró (1999) some of the consequences include: increased absenteeism, turnover, reduced productivity and quality because workers cease to be thorough in their work. All these aspects have aroused interest in learning and take action to prevent and reduce the Burnout, especially with more momentum if it is present in the administrative levels of the organization.

However, in spite of it, studies in Mexico according to Gonzales and Guillermo (2009) on this syndrome have started from the year two thousand. But, most of them focused on medical or faculty matters. This is why the need of provide knowledge in other areas, such as the industrial sector, specifically the automotive which represents the highest percentage of established industries according to the Association of Maquiladoras in Juarez City (AMAC, 2013) with a 29% and where the 63% of labor force works in the transformation industry.

1.1 Objectives

The general objective, the specific objectives as well as the scope and delimitation of this research are as follow:

1.1.1 General Objective

Determination of Burnout Syndrome among middle and senior management personnel in automotive industry in Juarez City using Burnout Levels according to (Guerrero and Vicente,2001).

1.1.2 Specific Objectives

- Validate the instrument of measurement: Maslach Burnout Inventory-General Survey (MBI-GS)
- Quantify the presence of Burnout Syndrome among middle and senior management personnel in automotive industry in general trough levels
- Recommend strategies and prevention programs to detect the Burnout based on the collection of literature

1.2 Scope and Delimitations

In terms of scope, this research includes the study of the three dimensions of Burnout grouping them generally in levels according to Guerrero y Vicente (2001).

The descriptive analysis is limited to only managers and middle managers within which were included supervisors from different departments such as: Quality, Engineering, Human Resources, Safety and Environment among others; also, group leaders, administrative staff, trainees and technicians in one automotive industry of Juarez City, Mexico.

2. LITERATURE REVIEW

The Burnout is a clinical syndrome described in 1974 by Freudenberguer who developed his career in a clinic for drug addicts in New York. He noticed that after a year of work, most of the volunteers suffered an aggressive energy loss, until exhaustion, to have symptoms of anxiety and depression as well as lack of motivation in their work, calling this group of manifestations such as "Burnout Syndrome ".

Since then, different perspectives have emerged attempting to study this syndrome. Although initially was conceived from a clinical perspective which described it as a state that is reached as a result of suffered work stress Subsequently, Maslach and Jackson proposed a wider point of view by including more factors in its definition considering as a process instead of a status. From this perspective, it is understood that the Burnout arises in a number of stages as a result of the interaction of the working environment and personal characteristics of the individual (Tonon, 2003). According to Apiquian (2007), there are four stages of evolution of the syndrome although these are not always well defined:

- Mild form: Includes physical, vague and nonspecific symptoms (headaches, backaches, lumbago), the affected is little bit operative.
- Moderate form: Appears insomnia, attention deficit and concentration and tendency to self-medication.
- Severe form: Increased absenteeism, aversion to the task, cynicism. Abuse of alcohol and psychotropic drugs.
- Extreme form: isolation, existential crisis, chronic depression and suicide risk.

In the consequent years, researchers as Dale (1979) and Cherniss (1980) proposed other definitions for this syndrome highlighting the work as an important precedent in the development of the Burnout. They mention that their stay varied depending on the intensity and duration of work stress caused by "negative personal changes that occurred along the time with workers exposed to frustrating tasks or excessive demands" (Llaneza, 2002: 488).

According to Buzzetti (2005), today there is a more refined concept of Burnout, which is having a good acceptance in the academic and scientific community. This concept is derived from factor analysis of the results obtained by Maslach and Jackson, through the wide application in different samples of the instrument called MBI. In this way is defined as a psychological syndrome trifactorial which is due to an interpersonal stressor that appear in the employment context, where these factors are: emotional exhaustion, cynicism behaviors towards people who attends the individual and a sensation of ineffectiveness or lack professional effectiveness.

2.1 Dimensions

The dimensions and items of the questionnaire that compose each are as described below:

2.1.1 Emotional exhaustion

There is a tiredness and fatigue that can manifest physically, mentally or a combination of both. There is a decline and loss of emotional resources that correspond to the measure of feeling overwhelmed emotionally. Their items are five (1, 2, 3, 4 and 6).

2.1.2 Cynicism

It is understood as the development of feelings, cold and distant attitudes and negative responses, to other people, especially related to the beneficiaries of their work. It is accompanied by irritability and a loss of motivation to work. This dimension also include five items (8, 9, 13, 14 and 15).

2.1.3 Professional Effectiveness

This third dimension refers to feelings of competence and successful completion of the labor task performed daily. In the case of Burnout corresponds to assess negatively own work with the reproach of not having reached the objectives, with experiences of personal inadequacy and low professional self-esteem (Tonon, 2003:40). This dimension is evaluated by six items (5, 7, 10, 11, 12, and 16).

2.2 Effects of Burnout

To understand the magnitude of this syndrome, it is necessary to emphasize the effects produced at the organizational, social and individual levels.

2.2.1 Burnout Effects in organizations

The effects of having workers affected by the syndrome will be manifested in the objectives and results of the organization (Llaneza, 2002). According to Bosqued (2008) and Maslach (2011) the consequences of having workers with Burnout , will be reflected in increased absenteeism, rotation, the abandonment of the workplace earlier, the declining performance which will cause more likely to make mistakes in professional practice. This as a consequence that the effort on the tasks is not the same, it ceases to be careful and less creativity to solve problems.

All these factors contribute to there being a decrease in the quality of service, lower productivity and therefore increased the economic costs to keep workers who are not being competitive, just as if new recruitment is required, which take them time to get the rhythm of work required.

In addition, according to Maslach (2011), it is very common for organizations reduce importance to the fact that their employees feel stressed or are suffering Burnout. Because it is believed that if the worker is having a bad day, actually that is not relevant to the organization. Even goes down on the idea that if there is no tolerance in the pressure of work, this is beneficial to them, because in this way, weak or incompetent workers are eliminated. However, these ideas are lacking of investigative foundation.

2.2.2 Burnout Social Effects

Are all those described as attitudinal. It is considered that there is a development of negative attitudes toward people with that relates daily (Tonon, 2003). Note that although individual chooses to leave his job, the consequences of the syndrome did not end there, because the cynic attitudes and irritability affects his private life , sometimes even lead to a separation of couples because is very difficult for people with this syndrome set aside professional problems when they get home (Llaneza, 2002).

2.2.3 Effects on individuals

Since this syndrome was described clinically, researchers have tried to describe in terms of the appearance of their overall symptoms relating their effects with all organism systems which are described by Guerrero y Vicente (2001:46) in Table 1.

Table 1. Symptoms associated with Burnout

Psychosomatic	Frequent headaches, chronic fatigue, ulcers or gastrointestinal disorders, muscle pain in the back and neck, hypertension and loss in women menstrual cycles.
Behavioral	Absenteeism, increased violent behavior, drug abuse, inability to relax and high-risk behaviors (suicidal conduction and dangerous random games).
Emotionals	Emotional distance, impatience, desire to leave work, irritability, difficulty concentrating, decreased performance at work, concerns about his/her own professional competence and low self esteem.
Defensives	Denial of emotions, irony, selective attention and displacement of feelings.

3. METHODOLOGY

3.1 Internal consistency of MBI-GS

To measure internal consistency of MBI-GS the Cronbach's alpha test was applied using SPSS 20.0 to assess equality or similarity in nature of the 16 items. Generally, an index of 0.60 to 0.70 is considered the lower limit of acceptability, and an index of 0.80 is considered satisfactory, while an index of 0.90 is defined as very satisfactory and thus the measuring instrument is deemed reliable if each of the dimensions has satisfactory ranges. A significance level of 0.05 was used for this test.

3.2 Evaluation by levels

Once validated the questionnaire, is important to mention how the scores for each dimension were distributed by grade, considering that the cutoff points for 33.3 and 66.6 percentiles were applied. The results are shown in Table 2.

Once assigned a value to each grade of Burnout is possible to get the 27 combinations that allow obtaining five levels. The method according to Guerrero and Vicente (2001) is as shown in Table 3. EE belongs to Emotional Exhaustion, CC represents the dimension of Cynicism and PE to Professional Effectiveness.

Table 2. Distribution of scores by dimension

Grade of Burnout	Assigned value	Emotional exhaustion	Cynicism	Professional Effectiveness
Low	1	< 7 points	<2 points	>32 points
Middle	2	7-11 points	2-4 points	27-31 points
High	3	>12 points	>5 points	<27 points

Table 3. Distribution of combinations

Distribution of combinations				
Grade of Burnout			Categorical level	
Low Grade (1)	Middle Grade (2)	High Grade (3)		
EE, CC, PE			1	None
EE, CC	PE			
EE, PE	CC			
PE, CC	EE			
EE, CC		PE	2	Low
EE, PE		CC		
PE, CC		EE		
PE		EE, CC		
CC		EE, PE		
EE		PE, CC		
	EE, CC, PE		3	Middle
EE	CC	PE		
EE	PE	CC		
CC	EE	PE		
CC	PE	EE		
PE	EE	CC		
PE	CC	EE		
	EE, CC	PE	4	Fairly
PE	EE, CC			
	EE, PE	CC		
CC	EE, PE			
	CC, PE	EE		
EE	CC, PE			
		EE, CC, PE	5	Extreme
	PE	EE, CC		
	CC	EE, PE		
	EE	CC, PE		

4. RESULTS

The results of Cronbach's alpha test for each dimensions is shown in Table 4. The Table 5 and Figure 1 show the information obtained by levels.

Table 4. Cronbach`s alpha

Dimension	Items number	Result
Emotional exhaustion	5	0.917
Cynicism	5	0.843
Professional Effectiveness	6	0.854

The information obtained for each dimension, shows that the internal consistency of the MBI is good and therefore the evaluation instrument is suitable for measuring the Burnout among middle and senior management personnel. According to the parameters established before, all dimensions are greater than 0.70 which is considered as the lower limit of acceptability. The dimension of emotional exhaustion has a very satisfactory value with 0.917, cynicism with 0.843 and professional efficacy with 0.854.

Table 5. Descriptive by levels

Level of Burnout	Frequency	Percentage	Valid percentage	Cumulative Percentage
None	25	24.30%	24.30%	24.30%
Low	11	10.70%	10.70%	35.00%
Middle	17	16.50%	16.50%	51.50%
Fairly	19	18.40%	18.40%	69.90%
Extreme	31	30.10%	30.10%	100.00%
Total	103	100.00%	100.00%	

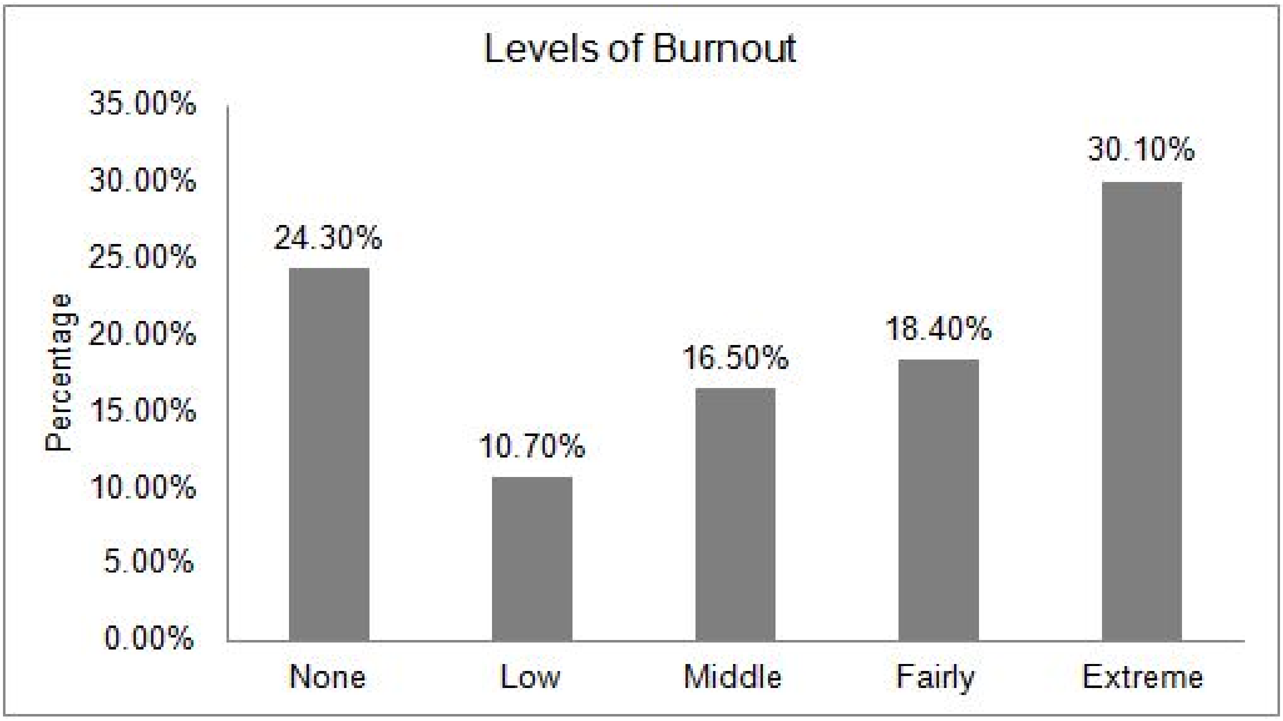

Figure 1. Levels of Burnout

The graph shows that actually burnout levels in middle and senior management personnel are worrisome, because 48.5% is located at levels above middle level and only 35.0% at levels below this. A 16.5% of them are located at a medium level. Therefore, the application of reduction techniques burnout is considered necessary.

5. CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions based on the objectives of prevention and intervention techniques that can be applied in industry.

5.1 Specific objectives

5.1.1 Validate the instrument of measurement: Maslach Burnout Inventory-General Survey (MBI-GS)

All dimensions show a range satisfactory. Upper to 0.70 which is considered as the lower limit of acceptability. The dimension of emotional exhaustion has a very satisfactory value with 0.917, cynicism with 0.843 and professional efficacy with 0.854

5.1.2 To quantify the presence of Burnout in the middle and senior management in the automotive industry in general through levels.

Through the analysis of levels of Burnout is achieved confirm that 30.1% of managers and middle managers are at the maximum level of Burnout and 24.3% at the minimum. The results indicate that approximately 35% is almost free, and 48.5% have worrying levels that exceed the average, and only 16.5% have a middle level of Burnout.

5.1.3 To recommend strategies and prevention programs to detect the Burnout based on the collection of literature.

According to Martinez (2010), the strategies and intervention techniques currently available consist of methods and knowledge developed to cope and manage stress. Where most of these are focused on spreading among workers the importance of preventing the risk factors of Burnout and training in specific areas such as coping, behavior restructuring, time management and lifestyle.

5.2 Recommendations

Peiró, Ramos and Gonzalez-Roma (1994) cited by Martinez (2010), classify and describe intervention programs at the following levels.

5.2.1 Organizational strategies

In this aspect, Llaneza (2002) recommends the following:

- Programs prior to the real: To avoid discrepancies between the real and expected. Through simulation programs no real role to adapt the high expectations and develop strategies to prevent burnout.
- Increasing the opening lateral, vertical and diagonal communication.
- Increase the level of excitement and personal satisfaction in the organization.
- Increase the level of personal and group responsibility in the planning and execution.
- Solve common problems through creative solutions through the cooperation of the team.
- Retro inform employees about their job performance to lessen symptoms of burnout. To do this, you can apply questionnaires to customers their degree of satisfaction with the service provided.

5.2.2 Social Strategies

It is recommended to promote social support from social groups with which the subject has a relationship so that you feel supported even in the workplace. Pines (1983) cited by Llaneza (2002) distinguishes the following forms of social support at work:

- Listen actively, but without giving advice or judging his actions
- Give support in the sense that a colleague or boss confirm you are doing things right.
- Create needs and thoughts of challenge, creativity and involvement of labor.
- Emotional support, thought-provoking on the subject if you have exhausted all possible solutions.
- Participate in the social reality of the subject, confirming or questioning the beliefs about you.

5.2.3 Individual Strategies

The recommended strategies from this perspective are: increasing professional competence (continuing education), redesign of the execution, personal organization, planning leisure time (extra work distraction, physical exercises for their calming effect and anxiolytic effect, techniques of muscle relaxation which induces mental relaxation, sports, hobbies), taking breaks at work, effective use of time, propose real and achievable goals, communication skills management humor to control the thoughts and emotions, biofeedback for self control certain bodily functions (heart rate, brain waves, blood pressure and muscle tension) and the application of cognitive techniques to control reactions to stressors.

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ERGONOMIC STUDY ON POTENTIAL RISK OF INJURY IN WORKSTATIONS IN METAL COATINGS.

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Resumen: En el presente trabajo se realizó una evaluación ergonómica en las estaciones de trabajo del proceso de galvanizado en una empresa metalmecánica para identificar la existencia de desórdenes por trauma acumulativos (DTAs). Se evaluaron los principales factores de riesgo en cada estación de trabajo, considerando factores como: entorno laboral, métodos de trabajo y factores individuales, Los métodos aplicados fueron Plebe, Fuerza de Compresión al Disco (FCD) y Ergotice. Los resultados indicaron la existencia de riesgo potencial en dos estaciones de trabajo. Se hace una propuesta con la finalidad de disminuir las lesiones musculo-esqueléticas.

Palabras claves:Ergotec Riesgo, Lesiones, Estación de trabajo.

Abstrac: In this paper an ergonomic evaluation of workstations in a galvanizing process engineering company was performed to identify the existence of cumulative traumadisorders (CTD`s). The main risk factors were evaluated at each workstation, considering factors such as work environment, work methods and individual factors, methods applied were Plibel, the Disk Compression force (DCF) and Ergotice. The results indicatedthe existence of potential risk in two workstations. It was made a proposal in order to reduce musculoskeletal injuries.

Key words: Ergotec, Risk, Injury, Workstation.

Relevance to Ergonomics: In the results we can see the importance of considering ergonomic factors for the selection of personnel to avoid risksin the executionof the work, to the presence ofDTA's, and costs accordingly. Based on the above,the contribution to theErgonomics is the versatility ofits application in the management of Human Capital.

1.- INTRODUCTION.

The company subject of this study is dedicated to the coating of metal parts, which has different areas to make their production processes , one of which is the area of galvanized , where it began to have low productivity , health problems in several workers and incidents motivated by inadequate working conditions , because they are not have the signs , or the equipment of hygiene and adequate security as well as both men and women perform the same tasks without even considering the age or particular gender characteristics.

2. OBJETIVE

General: Evaluate workstations and activities to identify whether there is risk of CTD'S (cumulative trauma disorder) in the operators.

Specífic: Assess environmental conditions
.

3. METHODOLOGY

Plibel Method: A method of risk analysis designed muscleskeletal injury as Checklist, with relevance in five regions of the body. Kemmlert conducted the study of muscleskeletal lesions in 200 jobs evaluating ergonomic conditions and possible changes to method validation.

The Checklist is formatted questions with answers YES and NO detection areas most likely to risk of injury (Das) Sum of YES responses are considered increased risk of injury in the dominant muscle group.

DCF " Disc Compressive Force": The biomechanical model presented by Chaffin and Anderson (1984) may be used only to determine the compression force of L5/S1 disc during a lifting task , but does not predict the force during a survey with pan or tilt . The L5/S1 lumbosacral junction disc is the point of calculation for disk compression force, because disk is the most stressed in the uprising. According to the authors.

Ergotice Method: Dr. Enrique De la Vega created ERGOTEC basis of a method performed by The Joyce Design Team Training Institute (1992). It is a method for ergonomic evaluation of jobs, which aims to eliminate or minimize the causes of DTA 'S work-related

Ergonomic evaluation of this method is done with a checklist for data collection and evaluation. The list contains only meaningful questions. The possible results of this evaluation are jobs classifieds as low, medium or high risk. According to the authors (Ascencia , Pretty et al , and Diego, 2012).

Production Process

The property customer product is received by the production area and boarding assigning Enumerated Rack and according to the product type is determined according to the inclination or the respective hook and start the production process. To ensure that the product delivered by the customer does not present any grease or oil impregnated in its manufacturing, the parts are subjected to degreasing in hot alkaline solutions. After degreasing the product is rinsed in a water bath to prevent entrainment of degreasing solutions to the next stage the etching used to remove rust and mill scale, which are the most common contaminants of surface and ferrous products thereby obtaining a chemically clean steel surface. Is carried out with dilute hydrochloric acid at room temperature. The pickling time depends on the degree of surface oxidation of the product and the concentration of the acid solution

After pickling the goods are rinsed in a water bath to prevent entrainment of acid residues at the following stages of the process. Treatment with salts (mixtures of chlorides), aims to remove any remaining residue of impurities and produce intense cleaning of the metal surface. These salts are applied by dipping the product in an aqueous solution thereof, and favors the impregnation of the molten zinc with the steel surface. The galvanizing operation itself is performed by immersing the parts in a bath of molten zinc at a temperature between 440°C and 460°C. When products are removed from the galvanizing bath, they are coated with an outer layer of the zinc bath Once out of the galvanizing bath products in water can be cooled or allowed to cool in air. They then pass the finishing area to remove burrs, sharp drops and surface adhesion of ashes or remains of salts and finally undergo inspection. Galvanized coatings on various items must meet a number of requirements on surface appearance; adhesion and thickness are specified in the standards. Finally the products are weighed to determine its price.

Evaluation

Metrixx Vr , is software that applies the technology of virtual reality for the ergonomic evaluation of different workstations, which can be assessed by different methodologies risk of occurrence of damage cumulative trauma or fatigue, just as it is a virtual guide for anyone interested in learning and deepen on evaluations of working conditions in any business or industry . Vr Metrix also helps for Decision issues in any aspect regarding ergonomics. This program covers different genres, ie, can be evaluated simple activities, such as performing a secretary to more complicated activities such as those performed on an assembly line. The Plebe method Ergotice FCD and were applied by considering the physical aspects involved in the activities.

4. RESULTS

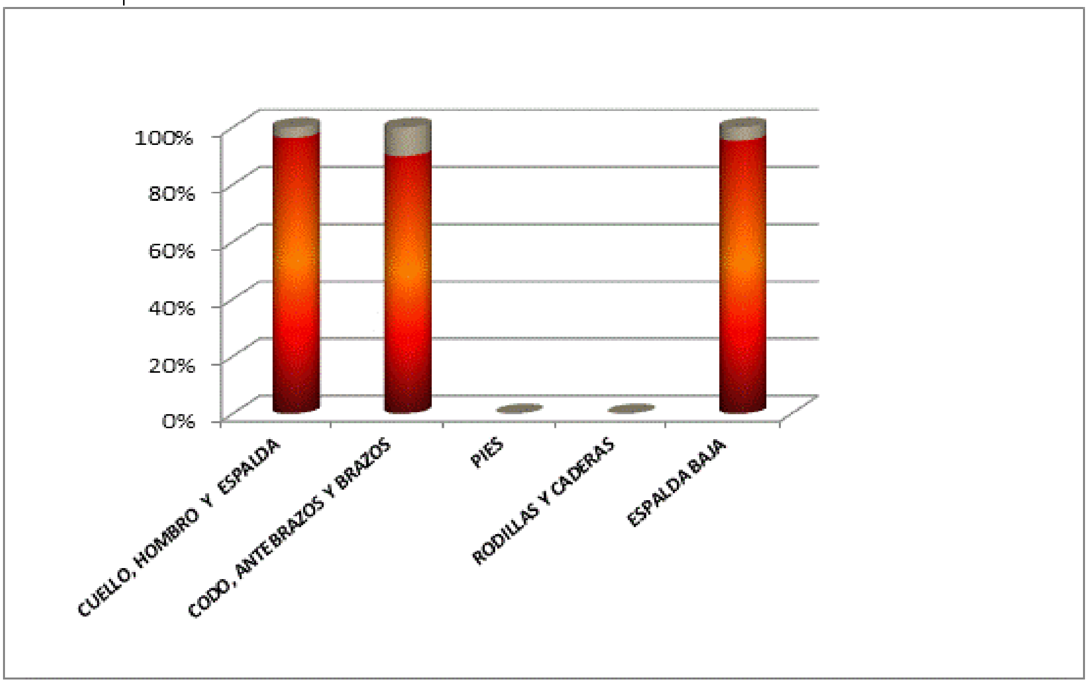
Results obtained with the method Plibel.

Was performedto measureeach of theworkersand questionnairesthat specifiesthe method isapplied; resulting77% has pain in neck, back and hand, 78% inforearmsand arms elbow and 48% lower back.

Operators say that not only prevents twisting of the trunk. If the time destined to that activity and processes will be more efficient and more easily reach the standard and reduce fatigue and tiredness not eliminated. The results are shownin the table of Figure 1.

Figure 1. The results PLIBEL.

	CUELLO, HOMBRO Y ESPA.DA	CODO, ANTEBRAZOS Y	PIES	RODILLAS Y CADERAS	ESPALDA BAJA
TOTAL	20	7	0	0	10
PORCENTAJE	0.77	0.78	%	%	0.48

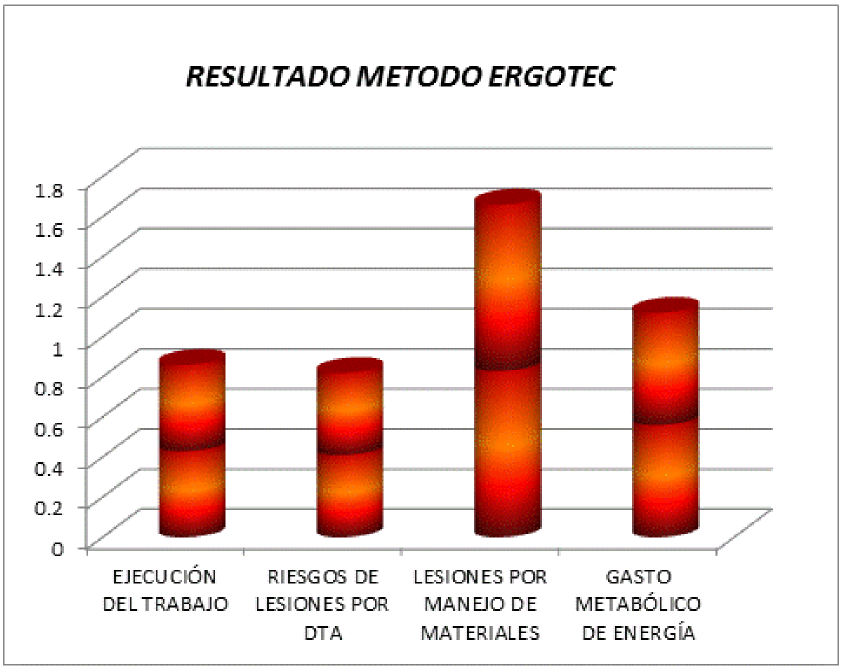


Results obtained with the method ERGOTEC.

It was conducted the evaluation of workers; resulting in execution of work(43%), Risk of injury by DTA (41%), and metabolic energy expenditure (56%), a range of 40% -60% have medium intensity. In material handling injuries (83%), has a high intensity. As shown in Table 2 and in Figure 2.

Figure 2. The results ERGOTEC

CONCEPTO	ESCALA	INTENSIDAD
EJECUCIÓN DEL TRABAJO	0.43	MEDIANA
RIESGOS DE LESIONES POR DTA	0.41	MEDIANA
LESIONES POR MANEJO DE MATERIALE	0.83	ALTA
GASTO METABÓLICO DE ENERGÍA	0.56	MEDIANA



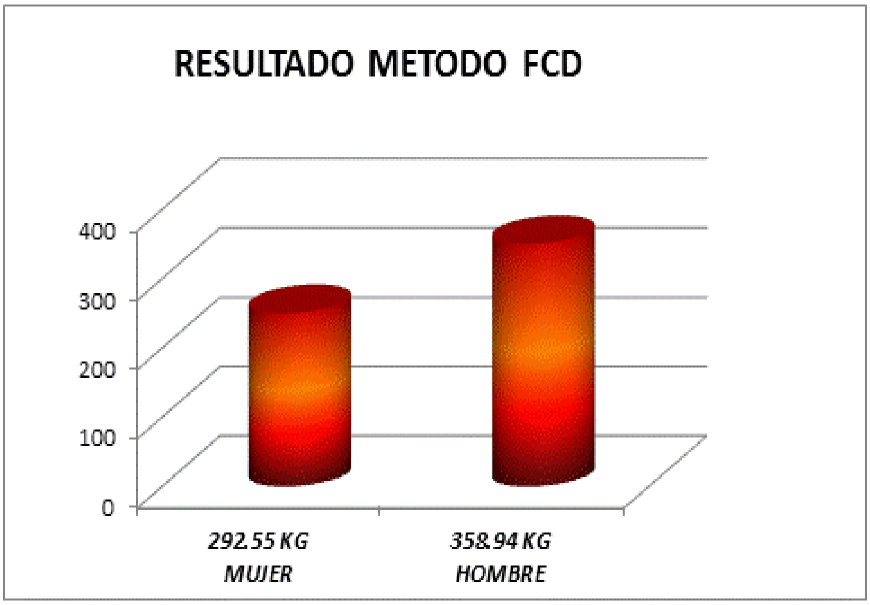
Results obtained with the DCF method.

In DCFimpact assess method the fifth lumbar vertebra was found 292.5Kg. Women and Men are up to 250 kg and 350 kg respectively established byNIOSH.The results are shownin Table 3andin Figure 3.

Table 3. Results DCF.

PERSONA	CALCULO METRIX	RANGO	DESCRIPCIÓN DE RIESGO
MUJER	292.55 KG	250	LEVANTAMIENTO RIESGOSO
HOMBRE	358.94 KG	350	LEVANTAMIENTO RIESGOSO

Figure 3. The results DCF



5. CONCLUSIONS.

The results were: In implementation of the activity the worker experiences a 43 % fatigue, 41 % in lesions with an average risk, material handling 83 % with the highest risk being its main activity heavy lifting, which is confirmed by the FCD study, which shows that they are exceeding the limits set by the standard set by NIOSH. Finally the metabolic energy expenditure with 58 %.

Based on the results it is concluded that workers have a high risk for injury of lumbar spine by lifting excessive loads, damaging the health of workers impacting their performance and therefore the productivity of the company.

Recommendations.

It is suggested to create a process in which major mechanical factors that help the employee in the performance of their work, specifically the heavy lifting included .

Also create an environment where the worker is opening comment how they perceive and how they affect the conditions in your workstation.

In particular, note that you can not suffer prophylaxis of lumbar spine injuries in the workplace, it is worth considering:

* Admission Test

* Stations of suitable work and continuous training of workers in mechanisms and proper lifting techniques and portering.

* Beside the implementation work areas , fitness ten minutes prior to the start of the working day for reinforcement, elasticity and strength of the musculo-ligamentous system back.

* Visual supports the features and / or more detailed specifications of how to do their job and run position.

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VALIDATION OF PROLONGED STANDING STRAIN INDEX. AN ERGONOMIC STUDY OF A WORKSTATION IN MEXICO

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Resumen: El objetivo de la presente investigación es la validación del INDICE DE ESFUERZO PROLONGADO DE PIE (IEPP) elaborado por Isa Halim de la Universidad Técnica de Malasia y publicado por la revista INTERNATIONAL JOURNAL OF OCUPATIONAL SAFETY AND ERGONOMICS en el 2012, por lo que se realizó un estudio ergonómico al puesto de Troquelador en una empresa en Monterrey NL, México, valorándose el tiempo de exposición a la postura de pie, la postura de trabajo, la actividad muscular, el tiempo de carga, la vibración a cuerpo completo y la calidad del aire interior. El IEPP es un excelente Índice que nos permitió relacionar el tiempo al estar de pie y la fatiga muscular en piernas, así como la presencia de dolor lumbar bajo por la exposición a las vibraciones generalizadas. Los investigadores sugieren agregar un parámetro más para medir la intensidad del esfuerzo con el uso del Método Strain Índex (JSI).

Palabras Clave: Esfuerzo, Postura de Pie, Índice

Abstract: The aim of this research is the validation of the Prolonged Standing Strain index (PSSI) prepared by Isa Halim of the Technical University of Malaysia and published in the“International Journal of Safety and Ergonomics” in 2012. The ergonomic research was held at a company in Monterrey, Mexico at the job position of a Punching worker. The study assesses the exposure time to the standing posture, work posture, muscle activity, load time, whole-body vibration and indoor air quality. The PSSI is an excellent qualifier which allowed us to relate the amount of time in a standing position and muscle fatigue in the legs, and the presence of low back pain by exposure to whole-body vibration. Researchers suggest adding another parameter to measure the intensity of effort with the use of the Job Strain Index (JSI).

Keywords: Strain, Standing Posture, Index.

Relevance to Ergonomics: In Mexico many of the jobs we have in the companies are long standing posture , and do not have a tool that allows us to see the actual risk to which workers are exposed to this task. The intent of this research is to validate a tool that was used in Malaysia, which brings together some assessment methods along with ergonomic assessment of physical stressors in the work area giving an equal weighting to each major , which allows you to view more specific risk to which workers are exposed.

The use of these tools within our jobs will allow us to see beyond what we have now identified being more strict on risk assessment, and in turn implementing preventive activities risk ,ie ergonomics must currently have a focus preventive within companies , not corrective , because if we identify the areas of opportunity in the workplace before it starts working we will prevent presenting further musculoskeletal injuries of occupational origin.

1. INTRODUCTION

Occupational injuries are causing enormous suffering and deaths in the work force. Furthermore, the natures of the diseases themselves are changing rapidly. The technological and social changes, along with the economic conditions, are increasing health hazards as well as creating new ones, such as musculoskeletal disorders.

In order to diagnose occupational diseases accurately it is necessary to have experience and specific skills that are not easily acquired in many developing countries around the world.

The Mexican Social Security Institute (MSSI) reported a total of 4,853 work-related diseases in 2012, of which 24 % were musculoskeletal disorders. In the State of Nuevo Leon, Mexico, 119 occupational diseases were diagnosed, of which almost 50% were cases of MSDs (1).

Many musculoskeletal diseases that occur in Mexico are related to poor posture, such as the standing posture, which workers take when performing a heavy work cycle.

Individuals who are required to stand for long periods of time adopt an asymmetrical position to reduce fatigue along with an antalgic posture where they shift weight from one foot to another in an effort to relieve the pain (2).

In 2012, Isa Halim developed an index to quantify the level risk in standing poses (PSSI). It was developed at the Faculty of Engineering and Manufacturing at the Technical University of Malaysia based on factors in the work place such as work done standing up, work postures, muscle activity, length of time spent standing, loading time, whole-body vibration, and indoor air quality. All these factors were assigned a multiplier in order to obtain the Prolonged Standing Strain Index (3). In Mexico, there are companies where employees work in a standing position for several hours of their shift

2. OBJECTIVE

The objective of this research is the validation of the Prolonged Standing Strain Index with all the factors that the author has suggested in order to determine the value of the Index as an Ergonomic Method. This may allow us to get a clear idea of what is happening in companies across Mexico with respect to the standing posture during long hours of work

3. DELIMITATION

The study consisted of the collection of information concerning risk factors existing in the job position of a punch-cutter, taking into consideration the features that meet the parameters proposed by PSSI regarding the position and surrounding environment.

4. METHODOLOGY

The job position of a punch-cutter requires 8 hour shifts, 6 days of the week. The job requires the worker to manually load a galvanized sheet, each weighing approximately 2.5 kg, in the following: using both hands the worker must first load the sheet into the punch-cutter. The worker activates a bimanual device, lowering the press that cuts, folds, and punches the sheet, applying 150 tonnes of pressure. After 6 sheets accumulate, the worker uses both hands to pick them up and place them in a container located 1.5 m from him. In this way, the worker produces a total of 2500 sheets per work day.

In addition to open interviews and direct observation of the work process under normal conditions, the workers were filmed continuously in real time as they performed their tasks. The following filming technique was used: the workers remained within the visual field throughout the filming in order to observe the movements the workers made. A variety of photographs were taken to observe the position of the body segments involved in the conduct of operations as well as to determine the angles formed between the body segments.

Those positions taken by the worker which assumed higher postural loading, a static physical load, as well as dynamic and repetitive movements that may cause musculoskeletal disorders, were evaluated. Work tasks were observed during several cycles, and from these observations the most significant work postures adopted during the work shift were selected, particularly those representing greater postural load. The evaluation was developed using the Rapid Entire Body Assessment (REBA) **(4),** which allowed us to determine the conditions of different tasks at the work station, evaluating the stress positions and the level of risk associated with the tasks (see Fig. 1).

The Rodgers Method **(5)** was also applied (see Fig. 2) to assess muscle activity according to the PSSI. The amount of time the worker stands in front of the punch-cutter was also taken into account according to the PSSI and the Method of Hand Position **(6).**

As part of the validation of the PSSI, whole-body vibration was performed using a vibrometer model VI-400 PRO brand 3M for a two and a half hour work cycle. To measure the air quality, a MF-420 gas detector was used which allowed us to measure the carbon dioxide and air temperature in the surrounding environment.

The researchers also applied the Strain Index (JSI) method, complimenting those applied by PSSI to measure the intensity of work done by the worker **(7).**

Figure. 1 - REBA Posture

Figure 2. - Rodgers Posture

5. RESULTS

From the methodology used for the detection of ergonomic hazards in the present study, We obtained the following results.

In the interview with the punch-cutter operator, the main discomforts were muscle fatigue in the lower limbs and lumbago, which occur almost at the end of the shift. These are mostly attributed to prolonged standing postures and manual handling of loads.

The aim of our study is to validate the Prolonged Standing Strain Index; therefore, the results of the indicators are as follows.

The results of applying the method REBA was 6, which represents a medium risk in the evaluation of the full body posture (see Table 1).

Table 1. Classification of Posture Rick Levels

Table 1. - Classification of Posture Rick Levels

RATING CRITERION	REBA SCORE	POSTURE RISK
Very Safe	1	Action level 0 (negligible)
Safe	2-3	Action level 1 (low)
Slightly unsafe	4-7	Action level 2 (medium)
Unsafe	8-10	Action level 3 (high)
Very unsafe	11-15	Action level 4 (very high)

REBA. - Rapid entire body assessment.

The next indicator that gives us the PSSI is the Rodgers Method. The use of this method resulted in a criteria rating of moderate fatigue which signifies a medium level risk (see Table 2).

Table 2. Rating Criteria for Muscle Fatigue Risk Level

Table 2. - Rating Criteria for Muscle Fatigue and Fatigue Risk Level

Rating Criteria	Fatigue Risk Level
Slight Fatigue	Low
Moderate Fatigue	Moderate
Fatigue	High
Extreme Fatigue	Very high

In relation to the third indicator, the Length of Time Spent in a Standing Posture, we took into account a shift in which the worker stands for a total of over four hours plus an additional hour of continuous standing. This signifies a high level of risk and rating criteria of unsafe (see Table 3)

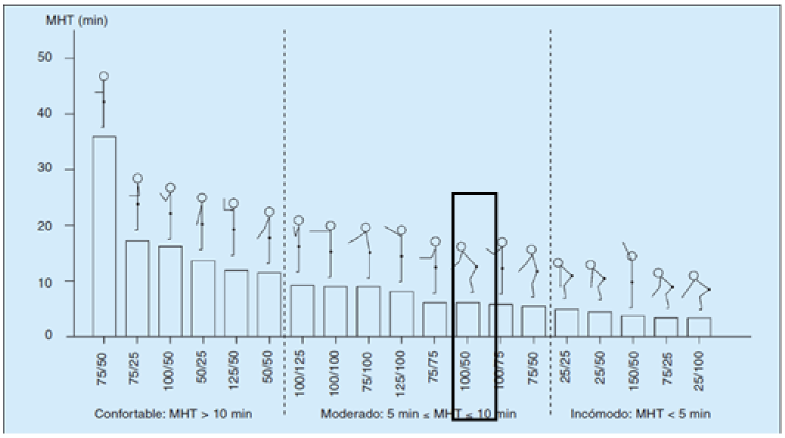
Table 3. Risk Levels with respect to Standing Duration

Table 3. - Risk Levels With Respect to Standing Duration

RATING CRITERION	LEVEL OF RISK	DESCRIPTION
Safe	Low	< 1 h of continuous standing, and < 4 h total
Slightly unsafe	Moderate	> 1 h of continuous standing, and > 4 h total
Safe	High	> 1 h of continuous standing, and > 4 h total

Applying the method of hand position results in a moderate risk of 100/50 (see Graph 1).

Graph 1. - Method of Hand Position



Graph 1. Method of Hand Positio

The most interesting results were the ones after exposure to a Whole Body Vibration risk factor, since the measurements of the three longitudinal axes show an acceleration of 1.2 to 1.5 m/s^2 which is equivalent to a rating criteria of considerable discomfort (see Table 4).

Table 4. Comfort Criteria Corresponding to Acceleration of Vibration

Table 4. - Comfort Criteria Corresponding to Acceleration of Vibration

RATING CRITERIA	ACCELERATION (m/s^2)
Comfort	<0.32
Slight discomfort	0.32-0.63
Moderate discomfort	0.50-1.00
Discomfort	0.80-1.60
Considerable Discomfort	1.25-2.50

As for measuring the air quality, we found that the measured parameters were within a safe range.

Table 5. Lists the multipliers according to the results obtained in this study.

Table 5. - Rating Criteria for Each Risk Factor

RISK FACTOR MULTIPLIER

RATING	WP	MA	SD	HT	WBV	IAQ
1	very safe (1)	slight fatigue (1)	safe (1)	comfort (1)	comfort(1)	safe (1)
2	safe (2)	moderate fatigue (3)	slightly unsafe (3)	moderate discomfort (3)	slight discomfort (3)	unsafe (244)
3	Slightly Unsafe (3)	fatigue (244)	Unsafe (244)	considerable discomfort (244)	moderate discomfort (244)	
4	Unsafe (244)	Extreme Fatigue (244)				
5	Very unsafe (244)					

When applying the PSSI multipliers found on Table 5, we obtained results well above 244 which signifies that the work done together is UNSAFE, due primarily to the Whole Body Vibrations and the length of time the worker remains standing up during their work shift.

Table 6 lists the multipliers of the PSSI.

Table 6. - Risk Levels of Standing Jobs

	Multiplier						
Risk of Standing	**WP**	**MA**	**HT**	**SD**	**WBV**	**IAQ**	**PSSI**
Safe	1	1	1	1	1	1	1
	2	1	1	1	1	1	2
Slightly Unsafe							3
	3	3	3	3	3	1	243
Unsafe						1	244
	244	244			244		>244

Therefore, the results obtained during our study allow us to validate the work done in Malaysia and the multipliers are consistent with the symptomatology presented by the worker. With the intention of elaborating on the Prolonged Standing Strain Index, the authors applied the values of the PSSI through the Job Strain Index (JSI) and the value was greater than 244 shown on the PSSI.

5. CONCLUSIONS

We found it significant to validate the Prolonged Standing Strain Index proposed because currently there are no specific ergonomic assessments for this type of risk. This index allows for the prevention of injuries to workers who must remain standing for most or part of their work shift.

When applying this Index on a work position where a prolonged standing posture is required, we observed that the index is replicable so long as the work position fulfills the following requirements of being exposed to Whole Body Vibration while standing and in an enclosed area. The Index, which was developed in Malaysia, was validated by applying it to a company in Mexico. Even while acknowledging that there are anthropometric differences between Mexico and Malaysia along with differences in labour, standards, and technologies, we found that the model was easily replicated and we obtained excellent results.

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EVALUATION OF ERGONOMIC RISKS IN AGRICULTURAL WORK RELATED MUSCULOSKELETAL DISCOMFORT. THEORETICAL REVIEW.

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Resumen: Existe un sub-registro en México de los problemas de salud que pueden padecer los agricultores. En otros países las estadísticas indican que en este sector son frecuentes los problemas musculo-esqueléticos tales como molestias en la espalda baja, en el cuello y hombros, en los brazos y las muñecas.

El empleo de la ergonomía en el trabajo agrícola enfrenta algunos problemas, sobre todo en la selección de herramientas y técnicas adecuadas para la evaluación, porque cada uno de los productos sembrados presenta un proceso diferente.
Los objetivos de la revisión fueron: 1) Conocer cuáles son los factores ergonómicos que otros autores han identificado en el trabajo agrícola; 2) Identificar las condiciones de trabajo agrícola que han sido estudiadas por otros autores y 3). Analizar los casos reportados en la literatura, en que se relacionan las condiciones de trabajo con problemas musculo-esqueléticos.

Como resultado de la revisión se propone elaborar un método que permita evaluar las condiciones de trabajo existentes a fin de eliminar los posibles problemas musculo-esqueléticos entre los trabajadores agrícolas y detectar necesidades de diseño para mejorar sus implementos de trabajo. Esta propuesta surge de que la revisión evidencio la carencia de un método para la detección y evaluación de los factores de riesgo ergonómicos presentes en el trabajo agrícola, así como de los posibles daños a la salud del trabajador.

Los resultados esperados son que este método pueda aplicarse en zonas agrícolas mejorando la calidad de vida de los trabajadores y aumentando la productividad. Otro resultado importante es que sirva como auxiliar para concientizar a los trabajadores agrícolas de las ventajas de adoptar mejores condiciones de trabajo y que sean capaces de detectar las molestias que indican la probabilidad de un daño a su salud, por la presencia de problemas musculo-esqueléticos principalmente.

Como conclusión se señala que en México un área de oportunidad para la aplicación de la ergonomía es el área agrícola, la cual está totalmente desatendida tanto por la ergonomía ocupacional, como por la ergonomía de diseño, perdiendo la oportunidad de ser una herramienta generadora de beneficios, tanto para el sector productivo, como para el bienestar de los trabajadores.

Palabras clave: Trabajo agricola, lesiones musculoesqueléticas, evaluación ergonómica.

Abstract: In Mexico, there is underreporting of health problems that may develop farmers. Sites statistics indicates that in this sector are common musculoskeletal problems such as pain in the lower back, neck and shoulders, arms and wrists. One of the possible causes of these health problems is the design of the tools used and the way in which it works, ie lifting techniques and handling of products, so it is likely that there are many workers with problems that have not been detected.

The use of ergonomics in agriculture faces some problems, especially in the selection of appropriate tools and techniques for assessment, especially since each of the seeded products has a different process. The contribution of this project is that the features detected conditions serve as a basis for proposing guidelines for the development of tools and instruments used by farmers as well as suggestions for health care. The objectives of this report are: 1) Know what the ergonomic factors that other authors have identified in agriculture, 2) Identify the conditions of agricultural labor have been studied by other authors and 3). Analyze the cases reported in the literature, where working conditions with musculoskeletal problems are related.

Keywords: Agricultural work, musculoskeletal diseases, ergonomics evaluation.

Relevance to Ergonomics: The theoretical review opens the implementation to incorporate occupational ergonomics to the agricultural sector, which has remained in backlog, thus exposing workers to inadequate conditions and the possibility of permanent damage to their health. It is a new job for the ergonomist in our country.

1. INTRODUCTION

Worldwide, 50% of the total labour force is engaged in agriculture. Of them, 3% is in Latin America. (ILO, 2000). In Latin America, 56% of workers are laborers. Statistics indicates that 15% of the economically active agricultural population in Mexico is dedicated to agriculture (ILO, 2005) agricultural work is considered together in the construction and mining as one of the most dangerous sectors, since it has high rates of fatal accidents. In Mexico a large percentage of agricultural workers, lack social security coverage. The interest in the subject arises because of the following:

a) The high mass of studies of occupational ergonomics are concentrated in industrial production, this trend is global, and the same happens with few reported works in Mexico.
b) At the global level is emerging interest in the application of ergonomics in the agricultural sector. Around the world, there are research reported in Colombia, Brazil, California and Europe mainly regarding the use of the ergonomics for the improvement of agricultural production and the Elimination of the risk to the health of workers. These studies are focused on the most important agricultural products for each zone reported.
c) According to the NIOSH, preliminary data from agriculture in California, show that the annual costs per workers compensation because of the more than 3,000 back injuries that occur each year can exceed $22 million US.

d) Before the recognition at the national level of importance which has agricultural production to the development of our country, it is elementary for the sustainability of agriculture that the living conditions of the workers they are appropriate.
e) It is necessary to recognize that there is a wide variety of agricultural production methods, however, these are not designed considering the characteristics of workers and some elements of the same productive work, ignorance of this leads to the presence of musculoskeletal problems.
f) It is necessary to recognize that there is a wide variety of agricultural production methods, however, these are not designed considering the characteristics of workers and some elements of the same productive job, ignorance of this leads to the presence of musculoskeletal problems.
g) The lack of information in Mexico, in relation to the effects on the health of agricultural workers as a result of ergonomic hazards involved in its activity.
h) Although the main journals of ergonomics make reference to different techniques used for ergonomic evaluation, is no reference to any procedure that is applicable to the characteristics of agricultural work.

2. METHODS

Identification and Selection of the Literature.
The available literature in the English, language, was identified by means of a computerized search of several bibliographical databases, including Medline; PsycINFO; EBSCO; ScienceDirect & Scopus. The following key words were used: Agricultural work, musculoskeletal diseases, and ergonomics evaluation. The abstracts of all the citations were retrieved and examined. The selection was made from the identified articles.
Considering that the issue has been little reported in the literature is decided to review all of the found items.
The publication had to be a full report. Letters and abstracts were excluded.

3. RESULTS OF THE REVIEW

3.1 Literature review.
We found some research in which is a review of the literature tracking elements of ergonomics is employed in the agricultural sector. The results of this search provided few details in relation to the application, as a generality is found that there is high interest in the presence of musculoskeletal disorders and that the use of checklists for the accomplishment of research has been common.

Table 1. Summary of literature review

Reference	Results
De Assis, M. A. A., Dutra, D. A. R. A., Eng, M., Da Costa Proença, R. P., & Dos Santos, N. (1997).	It is concluded Ergonomics can have a decisive influence upon the adaptation process to changes expected to occur in the coming century, mainly in what says respect to behavioral alterations. In this future, the use of ergonomics in agriculture is a prioritized group.
Gallagher, S. (2005).	Research needs in this area, include improved exposure assessment tools, research of intervention effectiveness; adaptations of the body in response of work in unusual postures, like as kneeling, stooping, squatting, or lying down.and elucidation of relevant injury pathways. The conclusion is that if awkward postures cannot be eliminated in the workplace, jobs should be designed in accordance with the reduced strength and lifting capabilities observed in these postures.
Kogi, K., Yoshikawa, T., Sakai, K., & Ito, A. (2006). 5	It is useful to create checklists by adjusting the check items to good practices in different work settings and using them in teamwork involving local people. In this kinds of jobs must be considered materials handling, workstation design and physical as well as psychosocial environments; enterprises, agriculture, ergonomic interventions, needle stick injury prevention, mental stress reduction and various training workshops
Kogi, K. (2008).	In this paper, practical means of facilitating participatory steps taken in workplace improvement programs in small workplaces were reviewed. The reviewed programs included those organized by partners of our Asian inter-country network for small enterprises, construction sites, home workplaces and agricultural farms. Trainers who usually acted as facilitators were found to play multiple roles in helping managers, workers and farmers take the initiative and achieve immediate improvements. The participatory steps were more successfully facilitated when the trainers supported (a) building on local good practice, (b) focusing on a range of basic ergonomics principles, and (c) stepwise progress through feedback of achievements. The use of action-oriented toolkits comprising low-cost action checklists and group work guides was generally helpful. The locally adjusted nature of the toolkits seemed essential. Trainers

Reference	Results
	could thus help people build local initiative, plan and implement low-cost ideas through serial group work steps and confirm benefits in a stepwise manner. A report of the results suggested that a local network of trainers trained in the use of locally adjusted toolkits was vital for facilitating effective improvements in different small workplaces.
Fathallah, F. A. (2010).	This paper gives an overview of the extent of musculoskeletal disorders (MSDs) in agriculture, and a historical perspective on how ergonomics has been used to reduce the health effects of labor-intensive agriculture. A summary of exposure to MSD physical risk factors within different classes of crops, along with various administrative and engineering controls for abating MSDs in agriculture is given. These controls range from programmed rest breaks to mechanized or partially-mechanized operations. Including the worker as an integral contributor to all aspects of developing and implementing an intervention, and considering the psychosocial and sociocultural aspects of the work environment are crucial elements of effective interventions for reducing MSDs. Despite the advent development in new technologies in agricultural practices, reliance on labor, especially in fresh market fruits and vegetables, will always be a major cornerstone of agriculture for at least the foreseen future.

3.2 Anthropometric study

Among the items recovered only two refer to study to obtain anthropometric dimensions of farm workers in Indian population. Both studies had the focus to form the basis for the design of machinery and tools.

Table 2. Summary of anthropometric study.

Reference	Population	Variables	Objetive
Victor, V. M., Nath, S., & Verma, A. (2002).	Three hundred agricultural male farm labourers in India. The age of the selected subjects varied from 21 to 48 years.	Bodyweight, stature, chest circumference, bi-deltoids breadth, arm length, sitting height, popliteal height (sitting), buttock popliteal length, hip breadth (standing).	Machinery design
Dewangan, K. N., Owary, C., & Datta, R. K. (2010).	Eight hundred one male agricultural workers from four major and fourteen minor tribes of north-eastern (NE) region of India	A set of 76 body dimensions including Age and body weight was measured.	Design of hand tools and equipment from ergonomic considerations.

3.3 Cohort studies

The four)cohort studies have some shortcomings, which do not allow a deeper analysis of the same. Some are made with dozens of workers and others with hundreds, however, do not provide comparable statistics data between the research.. Most of the studies do not report the instruments used in the collection of the data.

Table 3. Cohort Studies of ergonomics in agricultural work.

Reference	Instruments	Results
Gangopadhyay, S., Das, B., Das, T., & Ghoshal, G. (2005).	OWAS	The results of this study with fifty male and 50 female preadolescent agricultural workers showed that the workers suffered from discomfort in different parts of their body. Even though they were very young, they were likely to suffer from serious musculoskeletal disorders in the future
Mehta, C. R., Tiwari, P. S., Rokade, S., Pandey, M. M., Pharade, S. C., Gite, L. P., & Yadav, S. B. (2007).		In 20 male tractor operators Indian, found that the maximum leg strength values of 655 and 613N for right and left legs, respectively was observed when the pedal was located at 55% stature It was also observed that the actuating force limits as given in IS: 10703 [1992. stature in front and 19% stature below the SRP based on strength limits and postural comfort of operators. It may be recommended that the limits for maximum actuating force for brake and clutch pedals should be 330 and 280 N, respectively.
Agrawal, K. N., Singh, R. K. P., & Satapathy, K. K. (2009).		One hundred subjects of Indian agricultural workers, female and male, was included in the study, Mean leg strength (right) and foot strength (right) of female agricultural workers were found to be significantly lower than their male counterparts. Similarly, leg and foot strength of female workers in the preferred leg was found to be 63.6 and 58.1% that of male workers. Steering strength is an important design criterion on the basis of which the steering systems of tractors and other self-propelled devices are designed, and the mean steering torque was found to be 65.3 8.0 and 49.2 10.7 N m for male and female agricultural workers, respectively. The steering force capability of female agricultural workers was seen to be 75.3% that of male agricultural workers.
Dey, A. K., & Mann, D. D. (2010).	questionnaire and observation	The conclusions is that the operators who used a lightbar navigation device experienced more mental workload than operators who used an auto-steer navigation device
Montoya-García, M. E., Callejón-Ferre, A. J., Pérez-Alonso, J., & Sánchez-Hermosilla, J.	Mini Psychosocial Factor (MPF) method; prevalidated questionnaire containing 15	The results showed psychosocial risks existing for the agricultural workers in the greenhouses of Almería. (n = 310). Multiple correspondence analysis, however, showed that moderate risks can be offset by new prevention programmes that improve the health. Study the variables Rhythm, Mobbing, Relationships, Health, Recognition, Autonomy, Emotional Involvement,

Reference	Instruments	Results
(2013).	questions.	Support, Compensation, Control, Demands, and Mental Load.

3.4 Comparative study

One the majority kind of research found (six) are comparative, mainly with populations of workers. The emphasis on this type of research is on musculoskeletal discomfort, and their relation to the conditions of work affecting the Biomechanics of the worker and their environmental working conditions, such as noise and vibration.

Table 4. Comparative Studies of ergonomics in agricultural work.

Reference	Results
Mohan, D., & Patel, R. (1992).	This paper describes the critical factors associated with traumatic agricultural injuries in Northern India. Participate farmers in nine villages in the state of Haryana in Northern India. Safer designs of fodder-cutting and threshing machines have been developed. These designs are such that the rural machine manufacturers can incorporate them very easily.
Yisa, M. G. (2002).	They include (a) provision of footstep for Steyr and hand supports for Fiat, (b) reduction of steering wheel size and thickness for Steyr and (c) provision of a well-ventilated cabin and rollover protective structure (ROPS) for both Fiat and Steyr. The subject was from Nigerian.
Mehta, C. R., Tiwari, P. S., Rokade, S., Pandey, M. M., Pharade, S. C., Gite, L. P., & Yadav, S. B. (2007).	Twenty male tractor operators in India. The optimum location of clutch and brake pedals on Indian tractors should be at 40% stature in front and 19% stature below the SRP based on strength limits and postural comfort of operators. It may be recommended that the limits for maximum actuating force for brake and clutch pedals should be 330 and 280 N, respectively.
Meyer, R. H., & Radwin, R. G. (2007).	Fifteen male subjects worked on the prone workstation without rest during the 15 min work simulations with less discomfort; no localized fatigue in the back or leg muscles tested, and lower working heart rates than subjects working in a stooped posture.
Milosavljevic, S., Bergman, F., Rehn, B., & Carman, A. B. (2010).	In twelve, New Zealand farmers low back pain was the most commonly reported complaint for both 7 day (50%) and 12 month prevalence (67%), followed by the neck (17% and 42%) and the upper back (17% and 25%) respectively. The results demonstrate high levels of vibration exposure within New Zealand farmers and practical recommendations are needed to reduce their exposure

Reference	Results
	to WBV.
Aybek, A., Kamer, H. A., & Arslan, S. (2010).	An original cabin is recommended to reduce machine induced noise below the danger limit during agricultural machine operations. Personal protection devices should be used when tractors are operated without cabins, which could reduce A-weighted equivalent sound pressure levels by 10–45 dB(A).

3.5 Correlational studies

One of the most evident signs of insufficient research to depth that has been done on ergonomics in the agricultural sector is the existence in the revised material of a single studio of the correlation type, as shown in the table 5.

Table 5. Correlational Studies of ergonomics in agricultural work.

Reference	Population	Variables	Instruments	Results
Tiwari, P. S., Gite, L. P., Majumder, J., Pharade, S. C., & Singh, V. V. (2010).	920 subjects male as well as female agricultural workers, in India	Push/pull strength	A strength measurement setup developed at CIAE, Bhopa	These conditions can be used to set limits in the design of manually operated farm tools and equipment as well as for manual materials handling activities involving pushing/pulling, depending on the frequency of movement.

3.6 Case study / Intervention

The case studies and interventions are the most reported in the literature. Mostly they report the work carried out, or the conditions encountered, but no reported changes accomplished both on the health of agricultural workers or in the modification of processes and the permanence of this change. As in other types of research it places great emphasis in the management of musculoskeletal disease.

Table 6. Case studies and ergonomics intervention in agricultural work.

Reference	Population	Variables	Hand tools, equipment or Product	Instruments	Results
Stoop, J. (1990).			Pneumatic pruning shears, power chain saws and power-take-off shaft	Use-scenarios and hazard patterns	Valid accident data for use in the method are scarce; the technique for the translation of safety requirements into design specifications is still not fully developed, and the first projects are only now being carried through to the implementation stage.
Hogliiltd, S. (1991).	Sweden farmers and agricultural workers.	Statistics about fatal accidents			It has been shown that about 20 percent of the fatal accidents in Swedish work life occur in agriculture and forestry. Only about 3 percent of the total workforce are occupied within this field. Recent research in our organization has shown that the real incidence of work accidents is about twice what is reported from official statistics. Moreover, work-related diseases have been shown

Reference	Population	Variables	Hand tools, equipment or Product	Instruments	Results
					to be caution among farmers.

Table 6. Case studies and ergonomics intervention in agricultural work..Cont.

Reference	Population	Variables	Hand tools, equipment or Product	Instruments	Results
Chapman, L. J., Newenhouse, A. C., Meyer, R. H., Taveira, A. D., Karsh, B. T., Ehlers, J. J., & Palermo, T. (2004).	Vegetable growers (n = 243 and 207) Strawberry growers were used as a comparison group and also received questionnaires (n = 50 and 35).	Improve labor efficiency and reduce exposures to musculoskeletal injury hazards.	Strawberry and vegetable	Mail questionnaire	Better information flow to growers may be able to increase the speed with which agricultural practices with ergonomics are adopted, especially when the practices are more profitable.
O'Neill, D. (2005).				The IAC approach	The contributions that ergonomics can make to the Development Aid industry, particularly in the areas of sustainable livelihoods, and technology transfer are not being realized.. A closer involvement by ergonomists in occupational health care services, even where this is the responsibility of primary health care providers, might be more

Reference	Population	Variables	Hand tools, equipment or Product	Instruments	Results
					appropriate.
Orduño, C. Z., Arellano, J. L. H., & Zuñiga, J. M. (2006).		Discomfort musculoskeletal (MME); postures and movements	Broccoli	RULA,	They were found to be the body regions with high risk of MME arm, forearm and trunk. The recommendation suggested by the method is to immediately make changes to the design of the task,

Table 6. Case studies and ergonomics intervention in agricultural work.Cont.

Reference	Population	Variables	Hand tools, equipment or Product	Instruments	Results
Chapman, L. J., Chapman, L. J., Newenhouse, A. C., Pereira, K. M., Karsh, B. T., Meyer, R. M., Brunette, C. M., & Ehlers, J. J. (2008).	Fresh market berry production workers (USA) and New Zealand berry farm manager		Berry	Mail evaluation questionnaires	
Chapman, L. J., Newenhouse, A. C., &	Rolling, independent, probability samples (n =	Adoption of eight more profitable nursery crop	Nursery crop production	Mail questionnaires and disseminated	The intervention was associated with increased awareness of four

Karsh, B. T. (2010).	1200) USA and (n = 250) from a comparison group of New Zealand nursery managers.	production practices that reduced certain traumatic and musculoskel etal injury hazards.		information	of the eight practices among US managers after year 3 compared to their baseline: zippers (20 vs. 32%, p 0.000), stools (11 vs. 22%, p 0.001), pruners (29 vs. 40%, p 0.014), and tarps (24 vs. 33%, p 0.009). There were no changes in adoption. New Zealand manager awareness was increased for its after year 2 compared to their baseline (35 vs. 52%, p 0.010).

4. CONCLUSIONS

Around the world, in the last ten years has been little research that has been made in this area, this is due to multiple problems of logistics and technical resources. The vast majority of studies have focused in greenhouses and vineyards, authorized areas coffee-producing areas. Emphasis has been placed on data that allow the development of machinery and tools for the sector. However in developing countries, such as Mexico, few studies. It should be noted that a country with similar conditions, such as India, stands by the publication of some articles in this area.
In Mexico, an area of opportunity for the application of ergonomics is the agricultural area, which is totally neglected by both occupational ergonomics and ergonomics for design, losing the opportunity to be a tool to generate benefits for both the industry productive, and to the wellbeing of workers.

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THE INFLUENCE OF TYPOGRAPHY IN READING SPEED. A THEORETICAL REVIEW

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RESUMEN: En la presente revisión teórica se abordó el impacto que tiene la tipografía en la rapidez de lectura y como el estilo tipográfico Serif o Sans Serif en combinación con el puntaje del carácter creó una ventaja para el lector y ayudó a mejorar la velocidad de lectura. Se revisaron artículos con investigaciones referentes a la tipografía y las variables que la hacen más legible, donde se encontraron resultados que muestran cómo la tipografía en combinación con variables como el estilo tipográfico y el puntaje utilizado influyen en la legibilidad.

KEY WORDS: Tipografia, Legibilidad, Serif, Sans Serif.

ABSTRACT: In this theoretical review was addressed the impact of typography in speed reading and as the typographic style Serif or Sans Serif in combination with the size character created an advantage for the reader and helped improve reading speed. Research articles relating to typography and the variables that make it more legible, where results that show how typography combined with variables such as the type style and the size in the character used influence the legibility were found were reviewed.

KEY WORDS: Typography, Legibility, readability, Serif, Sans Serif.

RELEVANCE TO ERGONOMICS: Applying a font with specific characteristics such as the type style and character size given permit an improvement in the speed with which it is read, thus avoiding fatigue and readability makes it easier for the user.

1. - INTRODUCTION

There are several typographic styles, two of them are used to make textbooks: Serif and Sans Serif. Regularly the font that is used to make textbooks is Sans Serif, this typographic style was used for advertising posters, magazines and flyers because of its simple features (McLean, 1993). Additionally, it was observed that the use of typography in free text books in public and private primary schools are made with Sans

Serif typography. However, some authors mention that the characters Serif help to spin reading (Bringhurst, 2008) and legibility of words, since the small line finishing at the end of each stroke help to give continuity in reading the word and allow characters differ, and thus make it faster reading (McLean, 1993).

The factors involved in the rapid reading of the text are not only the style of font used, but the size of the font, the colors used, the type of composition in the text and even if these come with reference images (Bringhurst, 2008), however, this paper will focus on the typographic style.

The use of appropriate typography, along with the color on the background of the page can help create ergonomic teaching materials.

2.- OBJECTIVES

Set the findings that studies report regarding the advantages and disadvantages of Serif and Sans Serif typography, as well as the character size to contribute to an improvement in reading.

3.- METHODOLOGY

A bibliographic search of articles was performed in online databases using keywords like: typography, legibility and reading speed. The summaries of documents obtained were read and reviewed. The most useful documents were fully read.

4.- RESULTS

Below are presented the main findings, ranked by typography and font size.

Typography and font size

Ariditi (2005) evaluated readability in the use of lowercase Serif fonts, different just in size (0%, 5% y 10% the height of the uppercase) by thresholds of size and reading speed.

Serif Typefaces by 5 percentage points were slightly more legible than the Sans Serif, but increased letter spacing that the finishing lines impose, predicted an improvement that could be observed.

RSVP (Reading Speed Visual Presentation) and continuous reading speeds did not show any effect in finishing lines.

When the text is small or far away, Serif letters produce a small increase in legibility due to the increase of the concomitant in spacing.

However, the data showed no difference in legibility between typefaces that differ only in the presence or absence of serifs.

The author of the research indicated that the results obtained could have changed if they had used an ergonomically designed typography.

Rubin (2006) published a study where the objective was to evaluate the effects of print size, font, and line width in the reading speed with readers that have mild to moderate vision problems.

Four fonts were included in the study: Helvetica (HV), Times New Roman (TNR), Foundry Form Sans (FFS), and Tiresias PC (TPC). Thirty passages of text were developed from the materials used to test reading comprehension in school-age children.

This study demostrated that the most significant determinant of reading speed and reading fluency for people with mild to moderate visual impairment is letter size. Line width is not a significant factor, at least over the range from 35 to 90 characters. While typeface may appear to influence reading speed, it is the difference in actual letter size of fonts with similar nominal point sizes that determines reading speed and fluency. Therefore, a publisher who is constrained by the amount of available page space, will not notice a significant difference in legibility for different fonts.

However sources in the same nominal point size were not equivalent in actual size. When adjusted for the actual horizontal and vertical space occupied, the advantage of TPC was removed. There was no effect of the line width ($p > 0.3$). The data of this study were extrapolated to the general population over 65 years. This extrapolation indicated that raising the minimum print size of 10 points to 16 points would increase the proportion of the population able to read fluently (> 85 words per min) of 88,0% to 94,4%.

Russell-Minda (2007) did some research on the actual characteristics of typefaces for readers with low vision, which will determine the existence of any standards or guidelines related to legibility, and deal with the characteristics of the fonts of the French language for readers with low vision.

Between typefaces with Serif an improvement was found in reading the Courier font to Times New Roman in print media. Outcome Two: there is an improvement in reading of readers with low vision using Sans Serif over Serif clarifying that for the existence of this advantage is necessary that the size of the font will not be less than 12 points.

Wilkins (2009) compared with which font size the child has greater speed in reading. The Arial typeface was used in two test versions. Sentences were presented on a larger size than usual were answered faster than that retained the lowest size. The difference in point sizes was approximately 19% and the increase in reading speed was 9%.

In the same study, but another experiment, Wilkins compared the reading speed between Primary Sassoon and Verdana fonts. The average number of words read correctly was 87.2 for printed passages with Sassoon, and 92.1 for those printed in Verdana. The difference was highly significant. There was no effect of test order. There was no significant difference in accuracy between the two fonts. Sixty percent of the children expressed preference for Verdana. Their preference was not significantly related to performance.

Serif and Sans Serif Typography

Bernard (2002) explore how fonts affect common online reading of children of primary school age by examining the real and perceived reading of the four fonts displayed on the computer in 12 and 14 points. In addition, this study investigated which types were most desirable for computer use in schools, perceived as more attractive, and generally more preferred.

Analyzing the percentage of detected substituted words for each combination of size / font revealed no significant difference in the precision of point size, or any interactions between them. One possible explanation for this result is that participants had, in fact, their reading rate for combinations of text, more difficult to achieve roughly the same accuracy level. To test this, the effective reading speed of the participants was examined. Using the fastest reading speed measure, a significant effect was found in a typeface. Pairwise comparisons revealed that Courier had a significantly higher score indicating less effective reading than other typefaces through both text sizes. It is believed that the poor performance of Courier was primarily due to its character width and wide spacing between letters. That is, each character is given the same amount of horizontal space regardless of their actual width, which could make it more difficult for children of primary school age to solve individual characters into words. Indeed, fixed-width text has been found to be less legible than the text of varying width for adults. This is likely to apply to children as well. The large spacing between letters can also make it more difficult for children to distinguish the words, making them less visible and consistent.

Moret-Tatay (2011) developed a study that examines whether the uses of Serif (small finishing lines at the end of a stroke) play a supporting role in lexical access. In this study the results showed that there was minimal disadvantage in reading with Serif typography.

Akhmadeeva (2012) conducted a study aimed at testing whether there was a difference in reading comprehension using Serif or Sans Serif typography, found as a result that there is minimal difference in favor of serifed typography, the research emphasizes mentioning that it could improve the test using a specialized typeface. The experiment showed that the performance difference between Serif and Sans Serif fonts for reading was small, which could be seen as a confirmation of the widespread ecological hypothesis. Note that the number of correct answers on their tests measured the effects of short-term memory: the tests were administered immediately after the reading. It would be interesting to study the dependence of the long-term memory in the choice of the source. This could be of practical value to publishers of textbooks, both print and electronic.

5.- CONCLUSION

The previous studies yielded clear results of how typography combined with variables such as the type style and the point size used influence the legibility.

According to the studies reviewed, it showed that most of the articles suggest that the Sans Serif typography has had better results in reading speed and reducing errors in it, however the authors state that these results could be modified to use an ergonomically designed typography.

It would be important to conduct experimental studies that help establish more clearly the effect on the reading of typography in children who are learning to read.

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IDENTIFYING MUSCULOSKELETAL DISORDERS (MSDs) RELATED TO REPETITIVE MOVEMENTS AND INADEQUATE POSTURE IN THE WORKERS OF A RESTAURANT CHAIN, BOGOTÁ, 2013

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Resumen: Los desórdenes músculo esqueléticos (DME) relacionados con el trabajo son entidades comunes y potencialmente discapacitantes, pero aun así prevenibles que comprenden un amplio número de entidades clínicas específicas que incluyen enfermedades de los músculos, tendones, vainas tendinosas, síndromes de atrapamiento nerviosos, alteraciones articulares y neurovasculares. Estas patologías músculo esquelético aunque no son causadas exclusivamente por el trabajo si impactan de manera importante la calidad de vida de los trabajadores y contribuyen con la mayor proporción en el conjunto de enfermedades reclamadas como el origen laboral en muchos países, en Colombia se confirma este hallazgo.

En Colombia, cuando se agrupan los diagnósticos por sistemas se hace evidente que los desórdenes músculo esqueléticos son la primera causa de morbilidad profesional en el régimen contributivo del Sistema General de Seguridad Social, además con una tendencia continua a incrementarse, pasando de representar el 65% durante el año 2.001 a representar el 82% de todos los diagnósticos realizados durante el año 2.004. (Ministerio de la Protección Social, 2006).

Según la segunda encuesta nacional de condiciones de seguridad y salud en el trabajo en el Sistema General de Riesgos Laborales publicada en el 2013 se puede analizar que los movimientos repetitivos de manos y/o brazos realizados la mayoría del tiempo ocupan un 18,69% y realizados todo el tiempo con un 31,40% y las posiciones que pueden producir cansancio o dolor en algún segmento corporal que ocupan la mayoría del tiempo con un 17,24% y que son realizados todo el tiempo el 25,48%. Además, en el periodo 2009 – 2012 incremento en el reconocimiento de enfermedades de origen laboral del 42% con un componente principal derivado de los trastornos musculo-esqueléticos con un 88%. (Ministerio del Trabajo, 2013)

Para el desarrollo de esta investigación se hizo contacto con una de las empresas del sector de restaurantes ubicada en la ciudad Bogotá dedicada a esta actividad económica desde el año de 2008, Benavides Amaya LTDA, compuesta por 6 puntos, en los cuales se presta el servicio de comida a la mesa; ejecutado tareas de

cortado, pelado, rallado, para el procesamiento de alimentos y adicionalmente la adopción de la postura bípeda en la mayor parte de la jornada laboral. Es por esto que se formula el problema base de la investigación enfocado a la identificación de los desórdenes musculo esqueléticos asociados al movimiento repetitivo y posturas inadecuadas, la investigación se realizó durante del año 2013 fundamentado en la literatura concerniente a la disciplina, proyectos investigativos que desarrollaron una línea similar de investigación, necesidades observadas dentro de la empresa, conocimiento previo, justificado en la alta incidencia de desórdenes de origen musculo esquelético en el país y en este sector económico, como también la gran cantidad de dinero pagado en indemnizaciones por incapacidades permanentes parciales por enfermedades de origen laboral que pertenecen a este grupo de patologías de origen osteo muscular.

PALABRAS CLAVES: Posturas inadecuadas, Movimientos repetitivos.

Abstract: Work-related musculoskeletal disorders (WMSDs) are common entities, potentially disabling, but still preventable. WMSDs comprise a wide range of particular clinic entities that include muscle, tendon and tendon sheath diseases, nerve entrapment syndrome as well as joint and neurovascular alterations. Although these musculoskeletal pathologies are not exclusively work-related, they do affect workers´ quality of life, thus contributing to the highest percentages of alleged workplace related diseases. This finding has been proven in Colombia.

In Colombia, it is evident that musculoskeletal disorders (MSDs) are the first cause of professional morbidity under the contributory scheme of the General Social Security System when grouping diagnosis per system. Also, this trend continues to increase – from 65% in 2001 to 82% of all diagnoses performed in 2004. (Ministry of Social Protection, 2006)

According to the second national survey of work safety and health conditions (Workplace Hazard Prevention System) published in 2013, it can be observed that repetitive hand and/or arm movements *made most of the time* and those *made all the time* correspond to 18.69% and 31.40% respectively. Also, it can be observed that those positions that may lead to tiredness or pain in any body part *most of the time* correspond to 17.24%, while those performed *all the time* correspond to 25.48%. Additionally, during the 2009-2012 period, the recognition of workplace related diseases increased 42%, with a main component arising from musculoskeletal disorders – 88%. (Ministry of Labour, 2013)

To carry out this research, we contacted Benavides Amaya LTDA, a restaurant chain located in Bogotá, operating since 2008. This chain has 6 (six) branches, all of which offer table service. This restaurant chain carries out the following activities: food cutting, peeling, grating and processing; additionally, most workers hold a bipedal position most of the time. Hence, the research problem is posed, thus aimed at identifying MSDs related to repetitive movement and inadequate posture. The research was conducted in 2013, based on related literature, research projects that developed a comparable research line, needs observed within the restaurant chain, prior knowledge, justified by the high incidence of MSDs in the country and in this economic sector as

well as by the great amount of money paid for work-related disabilities, permanent or partial, that belong to this group of musculoskeletal pathologies.

Key words: inadequate posture, repetitive movement.

Relevance to ergonomics: Is a proposed form of muscle-skeletal disorders prevention for people who work as laborers in restaurants..

1. INTRODUCTION.

Work performed in restaurants requires agility and speed; many times this work is carried out in limited space areas and, usually, by female workers of different ages, which may lead to occupational injuries. Besides burns and cuts, restaurant workers are likely to suffer back injuries, traumas, sprains as well as injuries caused by repetitive movement and inadequate posture. At the same time, workplace absenteeism may arise, a fact that affects companies at different levels now that its repetitive and prolonged occurrence alters the proper fulfillment of goals and objectives established by the company since processes, tasks and activities designed may be affected. Workplace absenteeism may also lead to discomfort in the work team.

Figures regarding the economic activity that the company develops show a significant increase in the country in 2006 and 2011, in connection with workplace disability, permanent or partial, with 43 cases and 100 respectively; some of these diseases are workplace related. For 2011, the Colombian Insurers Federation reports that 10.9% of workplace diseases correspond to diseases such as carpal tunnel syndrome and tendinitis. Hence, it is vital to identify the factors that impact or affect work places.

2. OBJECTIVE.

The main objective of this study is to identify musculoskeletal disorders (MSDs) in upper limbs associated to repetitive movement and inadequate posture in the workers of a restaurant chain.

3. METHODOLOGY.

To develop this research, we contacted Benavides Amaya LTDA, a restaurant chain with 6 (six) branches, all of which offer table service. While at work, workers are exposed to biomechanical hazards arising from food processing related activities. This research follows a quantitative approach; it is also a descriptive, cross-sectional research. The sample is comprised of 25 workers.

Workers were given informed consents expressing their intention to participate; afterwards, they were given Nordic Questionnaires (adapted to Colombia). Then, 10 out of 25 workers, who showed some musculoskeletal symptoms, were administered the

Rapid Entire Body Assessment (REBA) method and ANSI Z-365 Checklist. Criteria are as follows:

1. Personnel working exclusively in the kitchen, and
2. Full-time personnel with more than 12 months working within the company.

4. OUTCOMES.

Workers performing jobs such as assistant cook, grillmaster and chefs are mainly women, whose average age ranges from 20 to 30. Among these workers, overweight, obesity (type I and II) as well as right hand dominance were detected. Most of these workers reported neck, shoulder, elbow and wrist discomfort.

According to the assessment performed, workers are exposed during working hours to positions higher to 20° in connection with neck flexion and extension as well as 15° higher in connection with wrist flexion and extension, positions with a higher risk to trigger MSDs in such body parts. The sample population shows that they handle light objects (3 to 6 hours) and heavy objects (30 min. to 2 hours). When assessing repetitive movement, we can infer that most workers perform repetitive movement more than 10 times per minute with their arms, elbows and forearms.

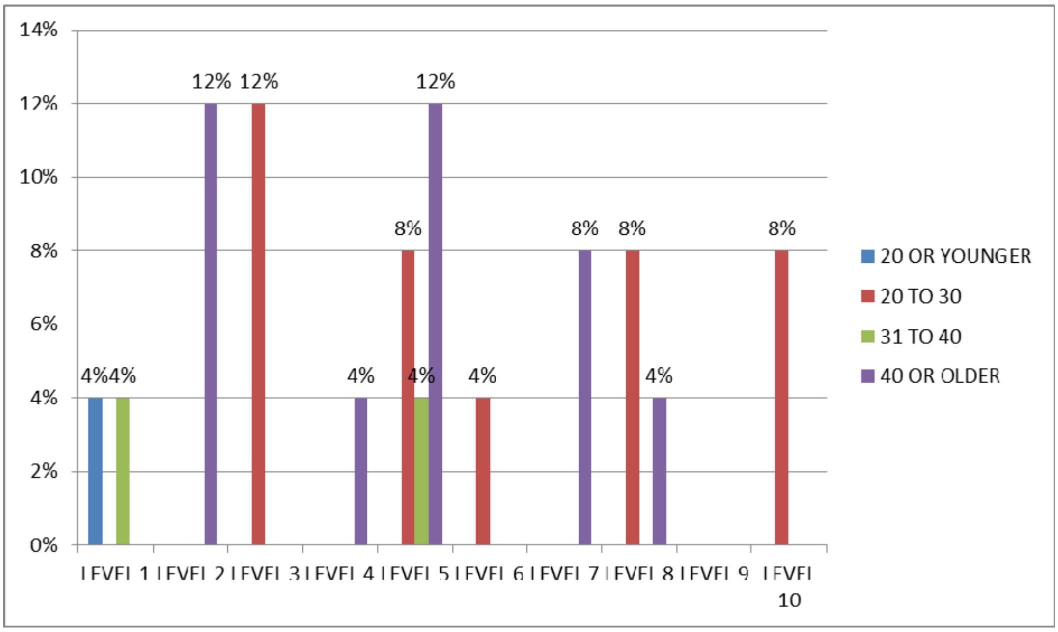

Figure 1. Age Range vs. Discomfort Intensity

The sample population is made up of 25 persons out of which 12 (48%) reported some level of pain according to the guidelines set in the Nordic Questionnaire; hence, a percentage breakdown of the level reported was conducted, thus classifying it according to age range. Consequently, it was found that the 40 or older age range shows the highest number of reports followed by the 20-30 age range.

The discomfort intensity in upper limbs and trunk that prevails in cervical, dorsal and lumbar regions, shoulder and wrist was identified. The age range with the highest discomfort compromise corresponds to the group of 40 or older with a pain level of 2, 3, 4, 5, 7 and 8; followed by the 20-30 age range with a pain level of 3, 5, 6, 8 and 10. This suggests that age is not a factor to initiate or show MSDs in upper limbs as they are also present at a younger age. It is important to note that adult ages show discomfort at various pain levels due to individual and natural personal factors.

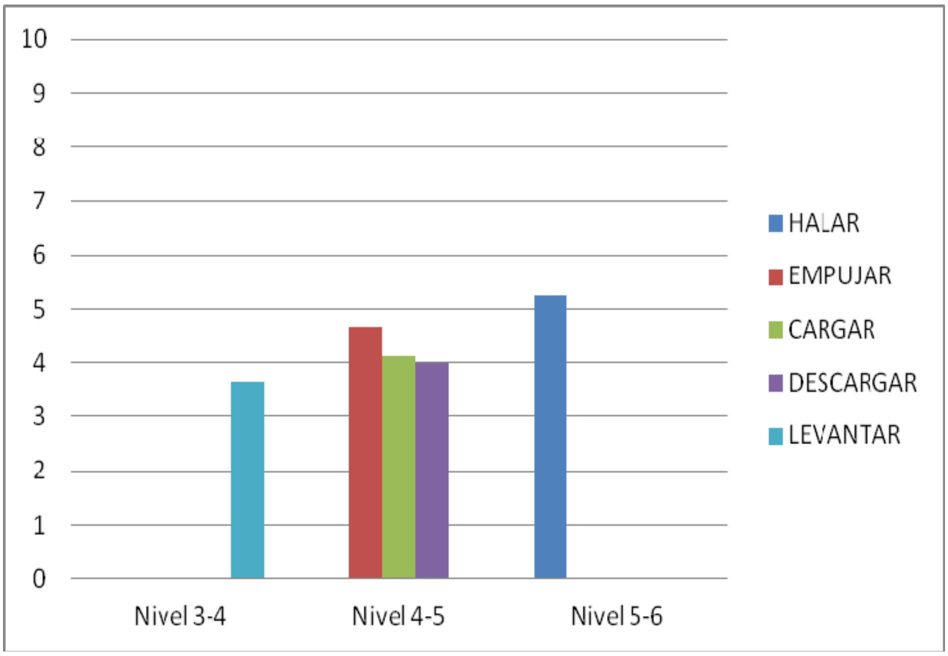

Figure 2. Discomfort Intensity vs. Frequent Efforts

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From the entire sample population (25 persons), those workers whose everyday activities involve this type of efforts were selected and, then, pain assessment reports were extracted from any of the segments analyzed (neck, shoulders, elbow, wrist and hands), grouping them in different ranges, as follows: a) 3 to 4, b) 4 to 5, and c) 5 to 6, for most frequent activities during working hours, thus finding that “pulling” activities represent the highest value; however, this is not decisive as the percentage of working hours during which this effort is made is not central. This activity is occasional and corresponds to an approximate percentage lower to 10% of the total daily work.

The Evidence-Based Comprehensive Care Scheme for non-specific low-back pain and disc disease related to hand load manipulation and other risk factors at the workplace (GATISO for its Spanish acronym) describes that load lifting and forced movement are strongly associated; it is considered that the risk increases 3 times with such an exposure. Dose-response relationships were identified, thus implying that the higher exposure intensity of frequency, the higher chances of disorders. Their effects range from slight discomfort to permanent disability. Manual load lifting and/or moving, according to a NIOSH study, lead to intense effort causing tear as well as steady disc and intervertebral joint deterioration. It was frequently associated with other risks such as inadequate posture. (Ministry of Social Protection, 2006)

It is recommended to accomplish an induction and re-induction process of workers that guarantees knowledge standardization regarding the most adequate ways to perform activities and tasks within the company in order to minimize the chances of appearance of MSDs as a result of repetitive movement and inadequate posture, promote healthy habits and lifestyles, offer healthy meal plans and posture hygiene training sessions so as to provide workers with the necessary tools to accomplish their daily work appropriately along with the necessary information to keep a stable and balanced health to minimize risks. It is vital to highlight the development and implementation of an epidemiosurveillance program. Finally, it is recommended to implement a prevention program to improve workers´ lifestyles and draft an occupational fitness exercise handbook that includes active breaks, postural hygiene and physical condition.

5.- CONCLUSIONS.

To reach an adequate physical, mental and social state, individuals must be able to identify and fulfill their goals, satisfy their needs and adapt to their environment.

A relationship among reported symptoms, repetitive movement and adopted posture was observed, along with the need to accomplish and execute a prevention program directed to workers according to their work place. This program needs to emphasize on posture hygiene, ergonomic conditions, biomechanical and ergonomic hazards, psychosocial factors and active breaks, among others.

It is necessary to implement a series of preventive measures to avoid potential risk factors, i.e., monitor repetitive manual work to prevent arm disorders, assess and redesign workplaces, and avoid asymmetrical manual work. All these measures shall be implemented under a preventive approach.

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RISK ASSESSMENT OF ACQUIRING CTD´s IN A MANUFACTURING COMPANY.

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Resumen: El proyecto se desarrollóen una empresa Metal-Mecánica, ubicada en el municipio de Tlalnepantla de Baz,dedicada a la fabricación e importación de herramientas de corte. Se originó en el departamento de Forja, debido a que los operarios del área de troquelado manifestaron sentir intenso dolor de oído provocado por el ruido generado por la prensa Míster y malestares musculares en diversas áreas del cuerpo. En el presente trabajo se analizaron los factores de riesgo de lesiones por DTA´S (Desorden Traumático Acumulativo); con el fin de identificar si la estación de trabajo afecta la salud de los trabajadores, dando lugar a enfermedades profesionales. La investigación es tipo Transversal y de aplicación básica, por lo que los resultados muestranel diagnóstico y evaluación del estado actual del proceso, el estudio permitió determinar las afectaciones en la salud de los operarios por tipo de actividad e identificó los factores de riesgo que existen en el área de troquelado. La evaluación ergonómica se realizó con la aplicación de los métodos: Ergotec, Plibel y Rula. Los factores laborales considerados fueron: procedimientos, movimientos, posición, frecuencia, peso, ruido, vibración, temperatura e iluminación. Losno laborales: edad, género, antropometría y enfermedades crónico degenerativas. Los efectos se clasificaron como de bajo, mediano y alto riesgo. Con base en los resultados obtenidos se modificó el proceso productivo y se rediseño la estación de trabajo; con estos cambios los trabajadores manifestaron menos malestares y un incremento en la productividad.

Palabras claves: Ergotec Riesgo, Lesiones, Estación de trabajo.

Abstrac: The project was developed in a Metal- Mechanics Company , located in the municipality of Tlalnepantla de Baz , dedicated to the manufacture and import of cutting tools. It originated in the Department of Forge, because the operators of said die area feel intense ear pain caused by the noise generated by Mr. press and muscle aches in different body areas . In this study the risk factors for injury were analyzed by DTA 'S (Cumulative Traumatic Disorder) in order to identify whether the workstation affects the health of workers, leading to diseases. Research is Transversal and basic application type, so that the results show the diagnosis and assessment of the current state of the process , the study allowed us to determine the effects on health of workers by activity and identified the risk factors that exist in die area . Ergonomic evaluation was performed with the application of methods: Ergotec, Plibel and Rula. The occupational factors considered were: procedures movements, position, frequency, weight, noise, vibration, temperature and lighting. Non-labor: age, gender, anthropometry and chronic degenerative diseases. The effects were classified as low, medium and high risk. Based on the results of the production process was modified and workstation redesign with these changes workers reported fewer aches and increased productivity.

Key words: Ergotec, Risk, Injury, Workstation.

Relevance to Ergonomics: The study contributes tothe spread of knowledgeand awarenessofthe importanceof ergonomicsin the design ofworkstations andproduction processes,highlightingthe most important thingis thehealth and lifeof the workerswithout neglectingproductive andfunctional partof the company.

1.- INTRODUCTION

Todayorganizationsto be competitive, they must maintain high standards inquality, price andconvenience, specificallyfocusingthe consumer.However, toachieve itsobjectives, it isimportant thatthe working conditionsin the variousproduction processeswillbeappropriatefor their relevanceasmajor factorsin the efficiency ofthe operation.

1.1 Procedure.

The workstation in the press area is the operation of the machine, where the worker has to lift, carry and unload objects size, shape and different weight. To perform its functions, workers have personal protective equipment provided by the company (safety shoes, ear plugs safety glasses and gloves thread).

The supply of materials is performed in cardboard boxes that are placed on one side of the machine on a wheeled base , it does not have lateral supports and the materials tend to fall often also is at ground level , so the operator must bend , take the parts and supply the machine.

Previously the activity of press operation Mister was considered a high-risk activity , critical to the operation of the service , where workers often expressed earache well as muscle discomfort, the various positions and repetitive movements in the performance of their job. However, he was not given the importance and came to be considered a "natural and normal" consequence of the activity. This paradigm had an impact on staff turnover as a central problem. Fatigue, stress and boredom charged advantage against the desire and willingness to work , diminishing the efforts and attention from day to day activities.

1.2 **Process press.**The basic element ofthe pressisthe die andthisin turnhas twoessentialpartstothe process thatisthe punchthathas the shape anddimensions of thedesignis to be madeand the diecuttingwherethe punchis inserted whenis pushedaggressivelyby the powerthat givesthe presstodieby a drivewhich encouragesa dry,sharp blowon the materialto be punchedproducingclean cut, itdepends on thetool usedandthe characteristics of thefeaturessame. TheMisterpressshown inFigure 1.

Figure 1. Mister Press.

1.3 **Problem.**The Process ofMr.presstwo workerswere concerned, the firstoperated thepress in the processoffeeding thematerialpunchingmachine, punchingandmaterialfallingon a conveyor beltwhichcarried thematerial to acontainerwhere the piecesfell,thecontainerfloor andbecause the processwas very quick andthe second operatordid not have timeto feedthesepartsto anothermachine calledstraightener, emerging partsof this machinethe operatorplacedthe parts inanother containermaterialandcutting andstraightening.

2. OBJETIVE

General:
Identify methods through Ergonomic risk factors that can cause one or more cumulative traumadisorders(DTA's) on staff whooperatethepress Míster.
Specífic:
•To study the behavior of risk factors associated with poor posture, cargo handling and its interface to determine the effec tof these environmental conditions in exposed workers.
•Identify and assess factors associated withinjuries from repetitive movements andsustained postures.

•Generate preventive measures to avoid injuries caused by repetitive movements and positions held.

3. METHODOLOGY

Ergonomic evaluationof the positions of workers, manual activities performed to manufacture of limes in blanking process, handling of materials, use of tools and operator performance.

The study population was seventeen people forming presses area. Data were collected directly in the workplace and asked that the tasks hould play on a regular basis, it is worth mentioning that the workers showed a favorable attitude to the study and voluntarily agreed to participate, availability and showing great enthusiasm.

3.1 Measuring instruments.

1-Listings Ergotec verification method.
2-Listings verification method Plibel
3-.Listings verification method Rula

3.2 Variables evaluated.

***A.-* Labor.** Procedures, movements, position, frequency, weight, noise, vibration, temperature and lighting

***B.-* No Week day:** Age, Gender,Chronic Degenerative Diseases Anthropometry.

3.3 Evaluation Criteria:

- ✓ Identification of body postures..
- ✓ Time remaining standing or sitting.
- ✓ Shift work.
- ✓ Postures to perform its task.
- ✓ Software Metrix-VR the was used to perform calculations

3.4 Evaluation

3.4.1 Metod Ergotec.

Dr. Enrique De la Vega created ERGOTEC basis of a method performed by The Joyce Design Team Training Institute in 1992. Ergonomic evaluation of this method is done with a checklist for data collection and evaluation. The list contains only meaningful questions. The possible results of this evaluation are jobs classifieds as low, medium or high risk. The first study to be performed in the area of lime stamping the container where the pieces are located below the operator's waist and this causes each the operator has to bend too much and thus it causes back pain.

The operator has to find the exact location of loading the pieces with your hands to deposit them in the feeder of the machine and the weight of the parts and movements have to do to take the pieces and put them to the feeder transport causes them pain and tired wrists. Working conditions are shown in Figure 2.

Figure 2. Conditions Workstation Mister Press.

3.4.2Metod Plibel

Although it is called a method , actually PLIBEL is a checklist given by Kemmlert (1995) for the identification of ergonomic hazards.

The Checklist is formatted questions with answers YES and NO detection areas most likely to risk of injury (DTA ` s) Sum of SI responses are considered increased risk of injury in the dominant muscle group.

The checklist was designed so that the questions ordinarily verified in the post of assessed work for ergonomic hazards , were listed and attached a 5 corresponding to regions of the body (neck , back, upper limbs , feet, knees, thighs and symbols lower back). The list consists of questions regarding working poor posture, poor design of tools or workplace or organizational stressors and environmental conditions. In PLIBEL criterion there is no duration of activity. Working conditions are shown in Figure 3.

3.4.3 Method Rula.

McAtamney and Corlett(1993) present a method known as RULA (Rapid Upper Limb Assessment). This method was developed to investigate the risk factors associated with upper extremity disorders.

This system for the review of positions in working conditions that generate fatigue, because the procedure provides the determination of the angles between body parts, the first step is observation supported photographs will apply. The result is determined by the ratios cores also developed considering the type of the applied force and muscle activity, from which the relevant recommendations specified by the level of risk will arise. Working conditions are shown in Figure 4

Figure 3.Stressful conditions Workstation.

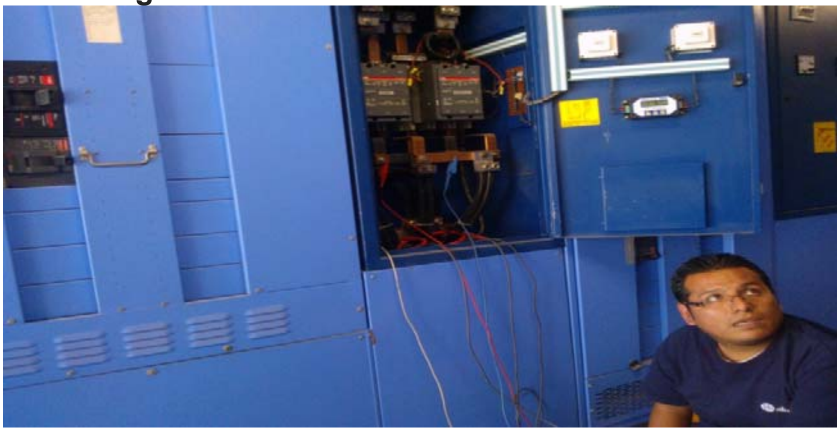

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Figure 4.Stressful conditions Workstation.

3.4.4 Anthropometry

Anthropometry is considered as the science that specifically studies the human body measurements, in order to establish the differences between individuals or groups.The dimensions of the human body vary according to age, sex, race and even the labor group. A key example is the difference in average height between countries and variations with in the same groups to consider a study of dimensions of the human body must be classified into two main types: structural and functional. Height in the Figure 5.

Resumen

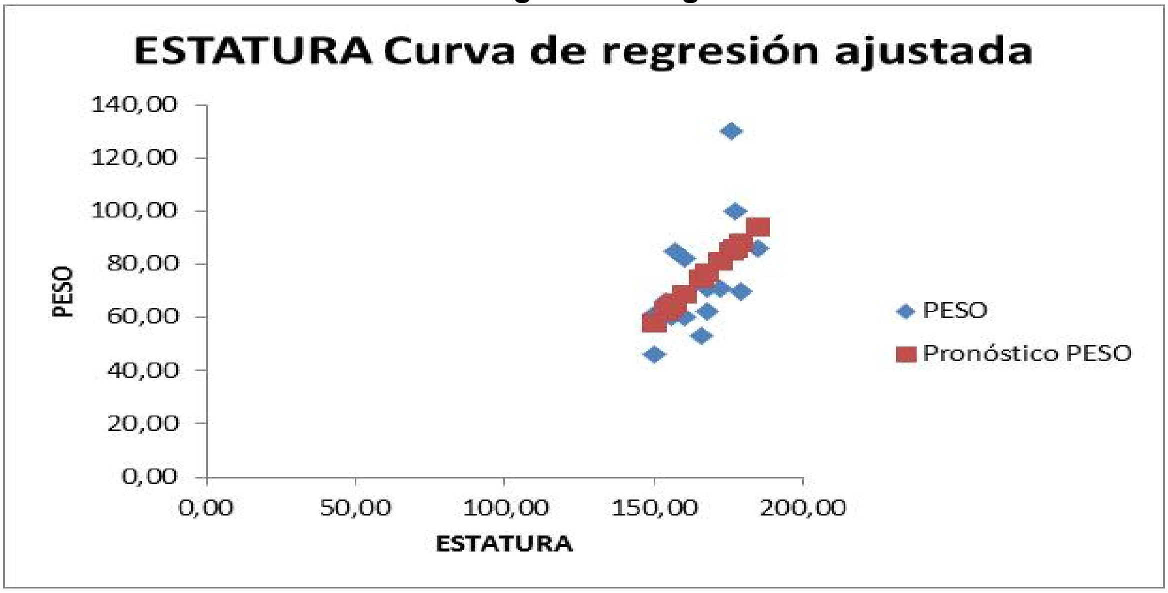
Estadísticas de la regresión	
Coeficiente de correlación múltiple	**0,567**
Coeficiente de determinación R^2	**0,321**
R^2 ajustado	**0,276**
Error típico	**16,876**
Observaciones	**17,000**

ANÁLISIS DE VARIANZA

	Grados de libertad	*Suma de cuadrados*	*Promedio de los cuadrados*	*F*	*Valor crítico de F*
Regresión	**1,000**	**2022,117**	**2022,117**	**7,100**	**0,018**
Residuos	**15,000**	**4272,118**	**284,808**		
Total	**16,000**	**6294,235**			

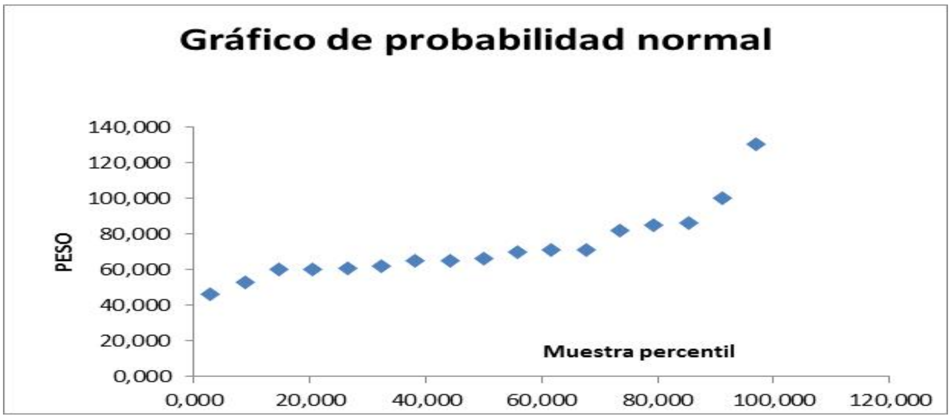
	Coeficientes	*Error típico*	*Estadístico t*	*Probabilidad*	*Inferior 95%*	*Superior 95%*
Intercepción	**-96,734**	**63,656**	**-1,520**	**0,149**	**-232,413**	**38,944**
ESTATURA	**1,032**	**0,387**	**2,665**	**0,018**	**0,207**	**1,858**

Figure 5. Height



In the Figure 6 following chart the trends of increasing body weight seen**.**

Figure 6. Trend weight



3.4.5 Environmental Conditions

The immediate work place operator, their machines, their arrangement with the environment, their interaction with other operators and how to operate your system were consideredto demonstrate howsignificantlyaffect their performance and their feelings of comfort. However, these environmental conditions are "visible", the operator can see and affect it in terms that limit their actions, their judgment and their immediate perceptions. But there is less tangible aspects (perhapsthe “invisible”) environment, the ubiqui to us sensation to which it is exposed from the various pieces of machinery or components of your workplace. Thus, in addition to other factors, these pollutants include lighting, noise and temperature.

- ✓ **Noise.**

The sound levelthroughoutthe dayis variable, starting the analysis withthe physical environment orthe environment as asectionofnoise,we can see thatthe intensityat whichoperatorsare subjectbeyondthe limits.Despite usingearplugsand noiseto whichworkersare exposedis harmful toyour health.Apparatusthat emitmoresound, plus the hornshownin Figure 7.

The worker is exposed to 88.5 dBA for a period of 5-6 hours at 100 dBA for 2 hours (Data providedby the Department ofSafety and Health).

Note: The valueof 0.75 was obtained by linear interpolation of the data table shows Permitted Noise.

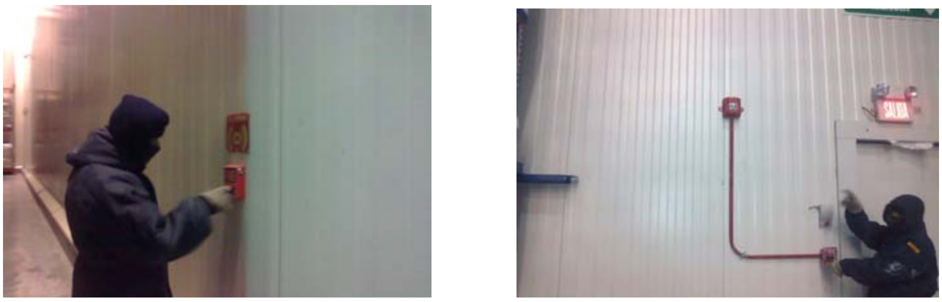
Exposure to impulsive or impact noise should not exceed the peak level of 140 dBA sound pressure, and as you can see, the noise dose that was obtained is 166.67, indicating that the worker is prone to injury by this condition, which derives from the shock caused by the same presses and the sound emitted by the exhaust of compressed air at low press.

Figure7. Noise conditions

- ✓ **Temperature**

The climate in the area is at a temperature of 27ºC with a humidity of 45%,, taking overall heating and current temperature of 0.6m/s wind chill is warm, ventilation devices are not suitable because they do not have fans or air conditioning and thus not implemented measures regulating exposure limits, workers do not use clothes to keep out the heat. As shownin Figure 8.

Figure 8. Temperature conditions



•Finally, results obtained with software METRIXX VR, some people expressed their grievances to a lesser extent by the movement ofhis hands.

Therefore, it was observed that the risks of postures and movements have high impact on worker performance and productivity efficiency so then givesome suggestions to counter these conditions. As shownin Figure 9.

3.4.5MetabolicEnergyExpenditure

When physical activity is increased, muscle energy demand of this chemical also increases and the body responds by increasing the heart and breathing rate when the

Figure 9. Terms operator with hand pain

muscle requirements are not met (the metabolic energy expenditure exceeds the body's ability to produce energy: This Aerobic capacity is called Maximum Power), physical fatigue occurs and can develop a stroke. Physical fatigue compromises accuracy, productivity and worker safety.

There are several direct and indirect methods to determine the metabolic demands of a job. Direct measurement of oxygen consumption measures the amount of oxygen consumed while the worker performs work, this volume is converted to energy units for a favor scaling, which is a more accurate and reliable method, however, requires special knowledge and special technical equipment. Also needs to be applied to a different group of workers performing the same work group to develop information metabolic energy expenditure.

One of the most common complaints by staff fatigue foot work.Although a ten-minute break is granted, you do not have a space dedicated to carrying out this objective. Therefore, you must provide a sufficient recovery to allow the body to recover from fatigue to ensure comfort and rehabilitation of the worker to return to activity. Another proposal to that effect and that is related to the psychosocial aspect is to allow rotation of the operating personnel during the work day because the work is monotonous. This proposal will also benefit the union of the working group and the proposal of a mat that allows cushion your tired benefiting less weight.

4. RESULTS

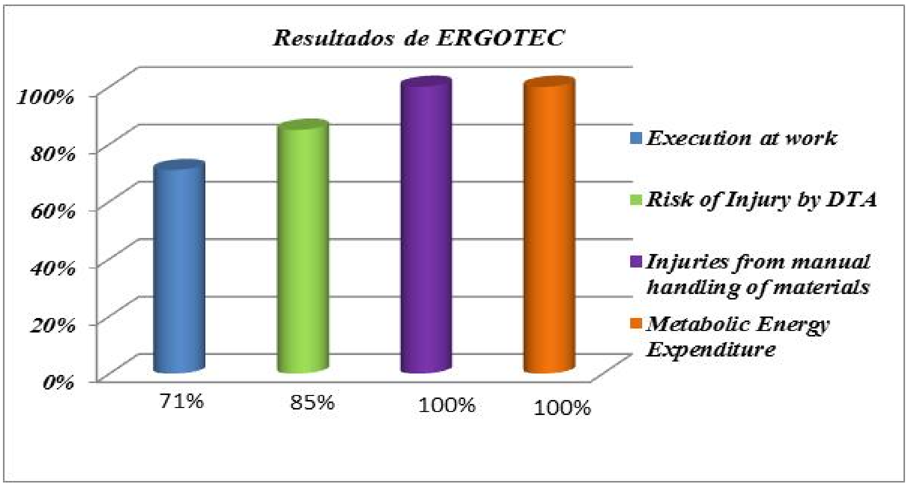
With the results, the procedure was modified, tables and racks are retrofitted facilitating the movement of operators and minimize redesign outpara lay it travels. Based on the changes implemented workers had fewer complaints and an increase in productivity was obtained.

In communication with the head of the area , their knowledge became the three proposals for evaluation and together with industrial safety improvements be made to the conditions of DTA 'S eliminate risks .The results are showninthe table. The results are shownin Figure 10.

Figure 10. ERGOTEC results.

SCORES	
Execution at work	71%
Risk of Injury by DTA	85%
Injuries from manual handling of materials	100%
Metabolic Energy Expenditure	100%

Tab	
HIGH	60%-100%
MEDIUM	21%-59%
decline	0%-20%



Operators say that not only prevents twisting of the trunk. If the time destined to that activity and processes will be more efficient and more easily reach the standard and reduce fatigue and tiredness not eliminated. Figure 10 Plibel and Rula results.

Figure 11. PLIBEL AND rula results.

PLIBEL	
Neck, shoulder and upper back	100%
Forearms, elbows and hands	100%
feet	62.5%
Knees and hips	82.5%
lower back	90.47 %

RULA	
Neck, shoulder and upper back	100%
Forearms, elbows and hands	100%

Also is the height of the table that influences the positions taken on different workstations.

If the noise can not be controlled at the source, how to isolate the team responsible for the noise responsible for noise is investigated, ie control the noise from a machine enclosing all or only part of it in an insulated container. Often the noise present in the environment can be reduced by isolating the source of the noise from the rest of the structure, which prevents the camera sound effect In situations where insulation of the machinery does not interfere with the operation and accessibility can ensure a more satisfactory container design.

The personal protective equipment may include different types of hearing protection, some of which may attenuate noise of all frequencies to sound pressure levels of 110 dB or more. They are also in the market earmuffs attenuate noise of 125 dB. In general, the type of filler devices (for example, the expandable foam) provides better protection than earmuff -type devices

Of course, you first need to determine the needs of area lighting, selecting appropriate sources of light. For this, two parameters related and necessary artificial light in the next assessment are efficiency (light output per unit energy, and color processing). Efficiency is particularly important because it is related to the cost.

The company is available to any suggestion that can be done with the resources it currently has, therefore, most of the proposals is performed considering operators on the issue and hence the acceptance of the majority.

The work environment has a positive influence on motivation, satisfaction and performance of operators in order to improve the performance of the organization. Creating a good working environment as a combination of human and physical factors

5. CONCLUSIONS.

The proposed job design through the application of ergonomic aspects along with the decrease of DTA 'S METRIXXVR and implementation of system environment throws as a result of competitive and more efficient work which improves the welfare of worker, work quality and prestige of the organization. Further promoting a safer working environment so that operators in the area of presses can do more work on the ground, improve performance and still have enough energy to enjoy life

Changes in working methods are decisions from analysis and assessment of the workplace, the conditions of the operator and the willingness of managers to allow implementing this proposal achieves promote safety. Therefore it is necessary to apply the most current equipment already used the general conditions surrounding the work area ergonomic technology.

Also should provide adequate flexibility to where the computer is located and the environment of the workstation as personal protective equipment and suggested mat, so you can meet the variations in height, reach, strength, among others. Similarly, there are other variations equal or greater by the employee, such as visual acuity , ability to hear , to feel and manual dexterity , each of which triggers different levels of risk assessments are carried out .

This proposal is based on the analysis of site work, study tools and ergonomic movements methods and evaluation team of environmental conditions such as light meter, through this identification a number of proposals were made to establish changes in the working method with the minimum cost and maximum acceptance and effectiveness. Some of the suggestions will be proposed in the enterprise. The results have been a key piece to start the process of change in the method of work, coupled with this was allowed to develop a procedure for executing tasks in the workplace in order to reduce injury , but mainly to introduce in the company conditioners care to cater to the previously refused fix as most of the organizations in our country, assuming that they will continue the certification obtained from the TS- 16949 methodology where work can be creative personnel safety and to achieve compliance with the requirements of the product, plus cleaning of facilities , it is concluded that the organization must maintain its facilities in a state of order, cleanliness and repair consistent with the product and the process manufacturing needs , this is fully covered as the company s 5's practices and performs audits.

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ANALYSIS OF WORKSTATION USING JACK® TO VALIDATE ERGONOMICS STUDIES

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Resumen: El presente trabajo muestra el desarrollo del estudio de elementos ergonómicos realizados para estaciones de trabajo bajo el auxilio de una herramienta informática con la que se valoran los diferentes criterios y parámetros que rigen los aspectos fundamentales de un análisis ergonómico. Se recurre a soluciones digitales para minimizar los inconvenientes físicos que se presentan en torno al personal de una estación de trabajo, pero también como una estrategia de potencializar y difundir el desarrollo de temas de ergonomía en el contexto laboral.

Palabras Clave: Ergonomía, Humanoide, Estación de Trabajo

Abstract: This paper shows the development of ergonomic elements research made for workstations supported by a software tool. It evaluates different criteria and parameters that govern the fundamental aspects of an ergonomic analysis. It uses digital solutions to minimize the physical disadvantages that appear around the staff of a workstation, but also as a strategy to potentiate the development add dissemination of ergonomic issues in the emplayment environment.

Key Words: Ergonomics, Humanoid, WorkStation

Relevance to Ergonomics: The design of workstations impacts in the productivity, the form in how to work and security of operations. This paper shows the possibility of planning design workstations and assimilate the ergonomics of work as a condition inherent in any organization**.**

1. INTRODUCTION

The Mexican workplace (and in this case focusing on the manufacturing environment of Puebla) has a lot of risks and away from the ergonomical principle that takes people to the center of the workplace, indeed, industrial safety should not be an relevant issue. Even though the labor law, created since 1931 mentions work environment an that provides security and protection to the worker, Konz [1] refers to the goal of improving the worker life in which the environment (including method) work is fundamental.

However the progress of this discipline should be recognized because it is not a simple matter of ethics, ergonomic factors improvement is directly related to the rate of productivity increase of the environment work, maximizing the training to staff, etc. Pedro Mondelo [2] presents a clear justification in reference to the dimensions , information and data from a design job.

The gathering of the values for a ergonomic analysis of a workstation that is already on is trough observation. On the other side, this research proposes the virtual human usage to support the results criteria. Finally the digital solution Jack ® from Siemens connect the design elements of workstations, postures, anthropometry and working methods.

2. OBJETIVES

To Perform analysis a workstations analysis by using specialized digital solutions (Jack ® Siemens) to promote the culture of ergonomics workplace in companies of Puebla.

3. DELIMITATION

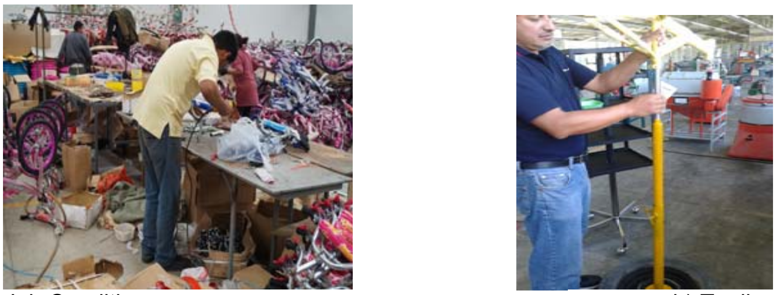
The study is bounded by the modules analysis that Jack ® contains, the software tool is friendly for any analysis and particularly for workplaces that have a system of repetitive manual operations.

4. METHODOLOGY

Jack ® the digital solution provides an interactive three-dimensional environment supported by a powerful graphic environment which allows to simulate the applications, evaluations and characteristics of a work environment to simulate the possible challenges the worker will deal with.

1 - Data collection and working conditions in the field.

The first phase of the work begins with the evidence of the physical environment, the data collection time, environmental conditions and relevant values to the study. Actually, the characteristics of emerging companies in the development of ergonomic workstations have large areas of opportunity. In this paper, it is presented some information for the outside due to treaties to maintain confidential information under a measured approach conditions.



a) Job Conditions b) Tooling Work

Fig. 1 Job Conditions in site.

2. - Data collection and transfer to the virtual environment.

The software requires the creation of a support scene for development work, lifting objects that composed the environment, They can be designed from any design software (eg solid edge or catia) and be exported to the scene of Jack by preserving its scale and main characteristics.

Fig. 2 Scenarios created in Jack

3. – Basic Analysis.

Although there are many studies and probabilities to analyze each of the joints, as well as anthropometric and ergonomic elements, in this case, fundamental studies are proposed.

- Analysis of areas of scope

The scope tool helps to create areas of maximum and convenient scope for digital humans, a "mesh" that assists the designer workstations to observe the tools that will be used according to the complexion and physical characteristics of the operator. Comfortable scope areas include the joints in the shoulder, elbow, wrist, hip, knee and ankle, based on recognized standard data sources of comfort.

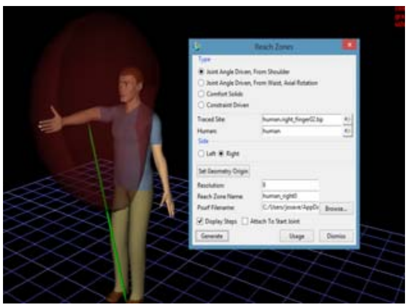


Fig. 3 Areas of scope

- Analysis of Low Back (l4 y l5)

Low Back analysis evaluates the forces that acts on the spine of a virtual human, in any position and load condition. The study presents an involvement in back injuries as a criterion to determinate the effort to the lumbar vertebrae.

In the low back analysis tool, a biomechanical model from a color coded is used to involve operator height and working posture. Weight is a factor that also considers the analysis either statically or dynamically.

- Prediction of Static force

The tool that predicts the static force (SSP) helps assess the involvement of complex tasks that requires physical effort such as the rotation of the torso in relation to the functions of posture, anthropometry, etc. The tool evaluates the jobs by comparing for percentage. This present the idea of which activities belong to the male gender or which conditions a high physical performance is required in or even a higher resistance.

The tool can permanently evaluate the ability of performing the task virtually, as the virtual worker moves through the task. The monitoring agency notifies when the conditions affect the specified resistance of the user.

- NIOSH

The Analysis lifting tool (NIOSH) helps to evaluate symmetric and asymmetric lifting tasks, including elevators with less optimal couplings among the object and the worker's hands. In a lifting operation the tool gives an estimate of the level of physical stress associated with manual lifting task.

Also, it estimates the relative physical quantity that is required for a task prioritizing ergonomic design lifting loads.

- Analysis of Posture

The OWAS tool provides a simple method to check the comfort of working posture based on the System Ovako Working Posture (OWAS), the Jack´s advantage is the fast to evaluate a position working for its potentially. Thus, it serves as a guide to identify and prioritize work postures which need the most urgent attention of an ergonomic modification.

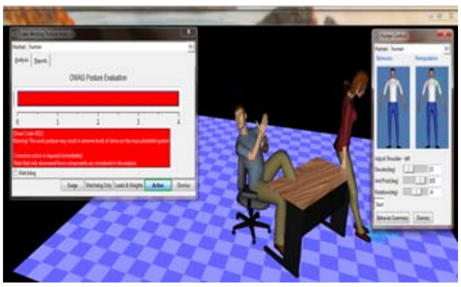


Fig. 4 Criteria of OWAS

- RULA

The Rapid Upper Limb Assessment (RULA) helps assess the exposure of workers to the risk of upper limb disorders, based on posture, muscle use, the weight of the load, the duration and frequency of the task. It assign a value to the task that shows the intervention degree required to reduce the upper extremities injury risk.

RULA gives risk values for a manual task by specifying the most vigorous posture of the task. RULA designates a risk factor for the posture based on the joint angles and twist arm, wrist, neck, trunk and legs. It should be involved if the posture is kept during more than a minute or even if it is repeated more than four times per minute. It should be specified the weight of the load, and finally it if is static or repeated

5. RESULTS

Inclined scope zone to an operator for obtaining plate.

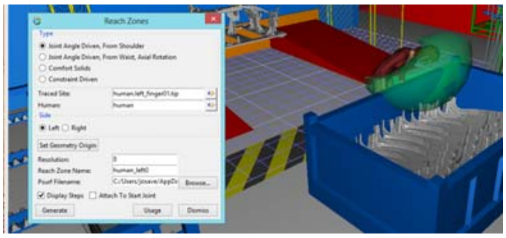


Fig. 5 Reach Zone in the scenario

The tool for the analysis of low back measures the compressive force and shear forces that act on the vertebral joint L4/L5

A posture example of an operator's position to duck is presented. It looks for elements that shows a low back injury. It can be added a graphic that indicates which muscles present a greater tension because of the work done.

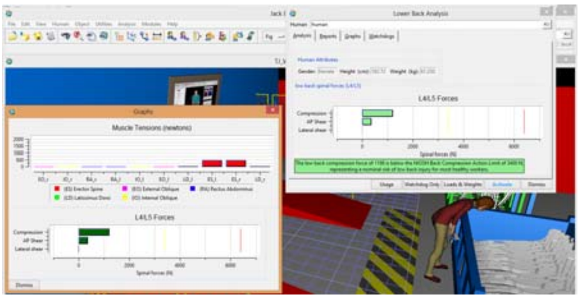


Fig. 6 Analysis low back

The lateral and axial spinal of reaction in the L4/L5 disc, represent the effect of the upper body and hand weight reacyion forces, so it must be considered the levels of muscle activity required to balance the moments of the spine, including the activity of erecting the column as a fatigue perception factor.

NIOSH

NIOSH tool is relevant for the weight of the material that the operator manipulates. The recommended weight limit (RWL) is the weight of the load that any healthy worker can handle for a reasonable time (not more than eight hours) without increasing the risk of developing low back pain associated with lifting loads.

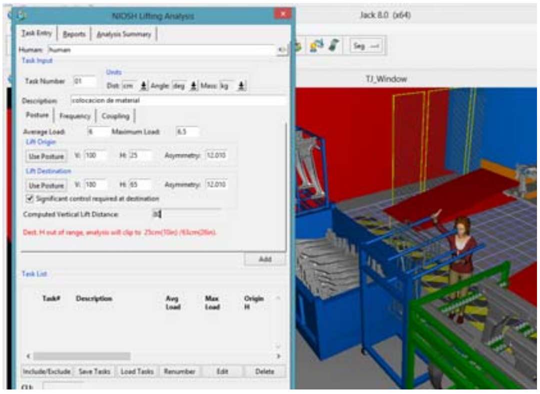


Fig. 7 NIOSH analysis

The lifted index (LI) is a relative estimation of the level of physical stress associated with a manual lifting task, it compares the actual weight of the load for a task with the recommended weight. The higher the LI is, the greater risk of low back pain will be.

The values of RWL and LI show the impact of the load weight, the vertical height of the hands on the ground, the vertical distance of the hands between the origin and the destination of lift and the nature of the coupling head-to-object between other factors involving that involve the frequency and duration of load surveys.

RULA uses a scoring system based on posture, muscle use and the strength to the action level assigned to the task assessed.

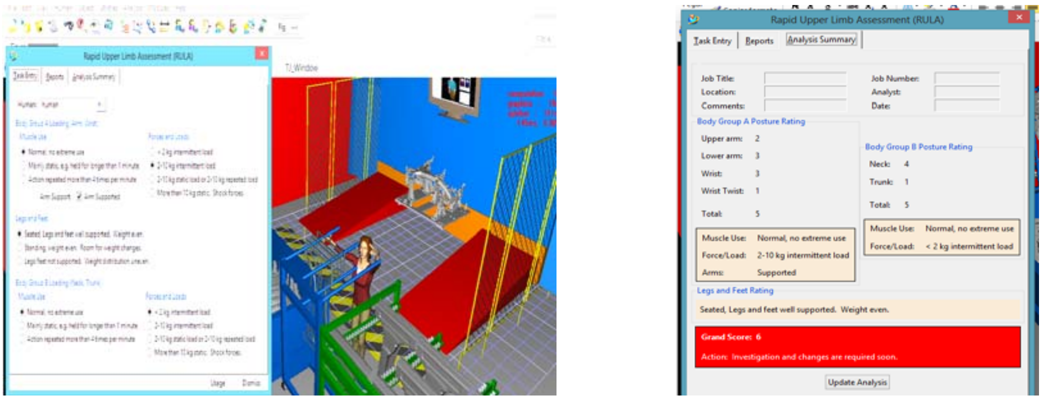


Fig. 8 Analysis RULA

The criterions used for RULA are:

Level 1: acceptable position if it is not maintained or repeated for long periods

Level 2: Further research needed,

Level 3: Research, the necessary changes before

Level 4: Research, required changes immediately

The results of a RULA analysis can be used to design a manual task to postural minimal risk of fatigue, discomfort or upper extremities injury It is important to mention that RULA provides guidance to draw attention to the activities with high risk of upper limb disorders. It does not provide quantitative information about the magnitude of injury risk or stress in the upper limbs.

6. CONCLUSIONS

The digital manufacturing has the potential to become an everyday tool. The simulation and digital elements ease allow to distinguish a faster height of this type of tools. A could be considered the ergonomic assimilation as a problem even worst than the adoption of this software for the design of workstations in México

The Mexican companies should incorporate the worker concept as the center of the productive process and to proceed on the same topic if the advancement of foreign companies are not desired on the idea that productivity means employment environment. The resistance of incorporating new tools to the work area will allow Jack ® job and its interface obtain higher relevance. Further research is needed in order to compare the different techniques of work and, obviously, the educational impact on students needs to be explored

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HIERARCHICAL TASK ANALYSIS: A LITERATURE REVIEW

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RESUMEN: En el presente documento se muestran los elementos clave para conocer el Método de Análisis Jerárquico de Tareas (Hierarchical Task Analysis HTA), desarrollado por Annett y Duncan (1967); como parte de una revisión de literatura sobre el tema. Los objetivos de este documento son: dar a conocer los conceptos más importantes sobre el método y sus componentes, autores principales que han contribuido a su desarrollo y casos de aplicación. La búsqueda consideró trabajos de los últimos cinco años consultando bases datos como Science Direct y Ebscohost, aunque se incluyen trabajos relevantes con mayor antigüedad. Un total de 18 trabajos fueron incluidos y organizados por autor, año y casos de aplicación.

Palabras clave: Análisis jerárquico de tareas, ergonomía cognitiva, factor humano.

ABSTRACT: This paper shows the key elements of the Hierarchical Task Analysis method, developed by Annett and Duncan (1967) as part of a literature review. The objectives of this paper are: to present the most important concepts of the method and its components, and main authors who have contributed to its development and applications. The criteria search for papers was made by key words using data bases like Science Direct and Ebscohost of the last five years, although some earlier works were included by its relevance. As results 18 works were found and classified by author, date and application.

KEYWORDS: Hierarchical task analysis, Cognitive Ergonomics, Human Factor

Relevance to Ergonomics: HTA have been successfully applied as a prelude for most of the Cognitive Ergonomics analysis and Human Factors methods. It enhances the comprehension of the task and provides an excellent job description supporting human error and mental workload assessments.

1. INTRODUCTION

The Hierarchical Task Analysis (HTA; Annett, 2004) is one of the most popular methods of task analysis and has become widely used to support most cognitive and Human

Factors (HF) methods such as human error and mental workload analyses. Originally developed in response to the need for greater understanding of cognitive tasks (Annett, 2004); HTA involves a description of the activity as the object of study in terms of a hierarchy of goals, sub-goals, operations and plans. The end result is a complete description of the activity of the task. The popularity of this method is due to its flexibility and scope for further analysis provided to Human Factors and Ergonomics (HFE) practitioners.

HTA acts as a preamble to many HFE analysis methods, such as; identification of human error (Human Error Identification (HEI)), functional allocations, assessment of workload, interface design and evaluation, among others. According to Stanton (2004), at least twelve additional applications have been related with HTA, including interface design and evaluation, training, work assignment, job description, work organization, manual design, job descriptions, work load assessment and error prediction analysis, team task analysis.

1.1 Advantages of using the HTA method:

Stanton, Walker, Baber, Salmon y Jenkins (2005) have found some advantages of HTA.

- HTA requires minimal training and is easy to implement.
- The output of an HTA is extremely useful for numerous entries of HF analysis for methods such as; human error analysis, design and evaluation of interface and functional allocation analysis.
- HTA is an extremely flexible method that can be applied in any field for a variety of purposes.
- Quick to use, in most circumstances.
- The output provides a comprehensive overview of the task under analysis.
- HTA has been widely used in a broad range of contexts.
- Conducting an HTA gives the user a great understanding of the task analysis.
- HTA is an excellent method to be used when a job description is required for further analysis. If successfully realized, the HTA should show everything you need to do in order to complete the task at hand.
- The method is generic and can be applied to any task, in any domain.
- Tasks can be analyzed for any level of detail, depending on the purpose of the study.

1.2 Disadvantages of using the HTA method:

Stanton et al. (2005) have defined some advantages of HTA.

- Provides primarily descriptive rather than analytical information.
- The content of HTA that can be used directly to provide design solutions is relatively low.
- HTA excludes the cognitive components of the task under analysis.
- It is laborious and time consuming for complex tasks.

- The initial phase of data collection is time consuming and requires the analyst to be competent in a variety of HF methods; such as interviews, observations and questionnaires.
- The reliability of the method may be questionable in some cases. For example in the case of the same task, a different analyst can produce very different descriptions for the task.
- Conduct a HTA is more an art than a science and requires a lot of practice before the analyst is competent in the application of this method.
- It is not available an appropriate software version of the method.

2. DESCRIPTION OF THE METHOD

According to Stanton et al. (2005), it is necessary to follow the following steps to develop a HTA:

Step 1: Define the task under analysis.

The first step in conducting a HTA is the identification of the task analysis; you must also define the purpose of the analysis of the same.

Step 2: Data collection process.

Once you have clearly defined the task to analyze, specific data regarding the task under analysis must becollected. Data regarding the task steps involved, the technology used, interaction between man and machine and team members, decision making and task constraints should be collected. Data collected during the process is used to begin the analysis, once the data are sufficient, begin with the development of HTA.

Step 3: Determine the overall goal of the task.

The overall goal of the task under analysis should be specified firstly on the top of the hierarchy.

Step 4: Determine the sub-goals of the task.

The next step is to decompose the overall goal in specific sub-goals that usually can be about 4 or 5 which together constitute the task to achieve the main objective.

Step 5: Decomposition of sub-goals.

In this step, the analyst should continue decomposing sub-objectives identified in the previous step into additional sub-goals and operations in accordance with the element of the task at hand. This process must continue until proper operation of the task. The lower level of any branch in a HTA must always be an operation. Operations are actions that should be taken by the operator or by an automated device to complete the associated target thereof.

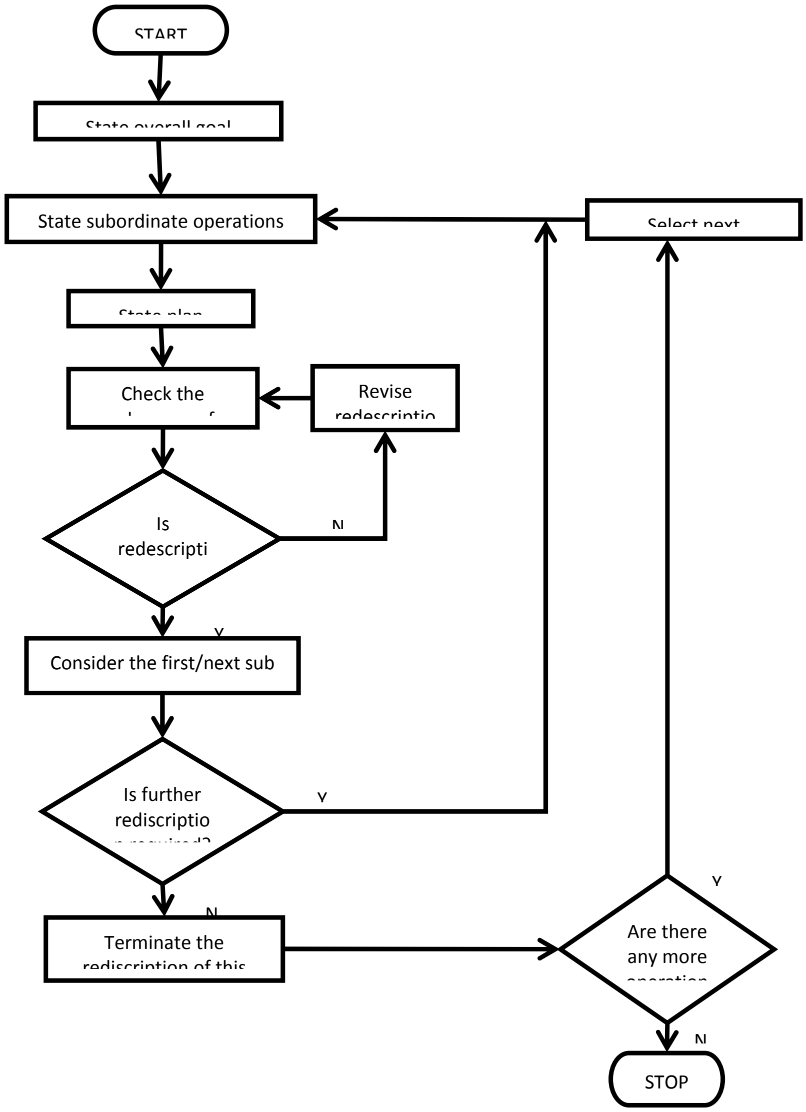
Step 6: Analysis of plans

Once all the sub-goals and operations have been fully described, it is necessary to add the plans. The plan refers to the sequence of actions to complete the sub-goal. Once the plan is completed, the analist returns to the top level. Different types of plans are presented in Table1. In Figure 2 the flow diagram is shown for a HTA

Table 1. Plan types of HTA

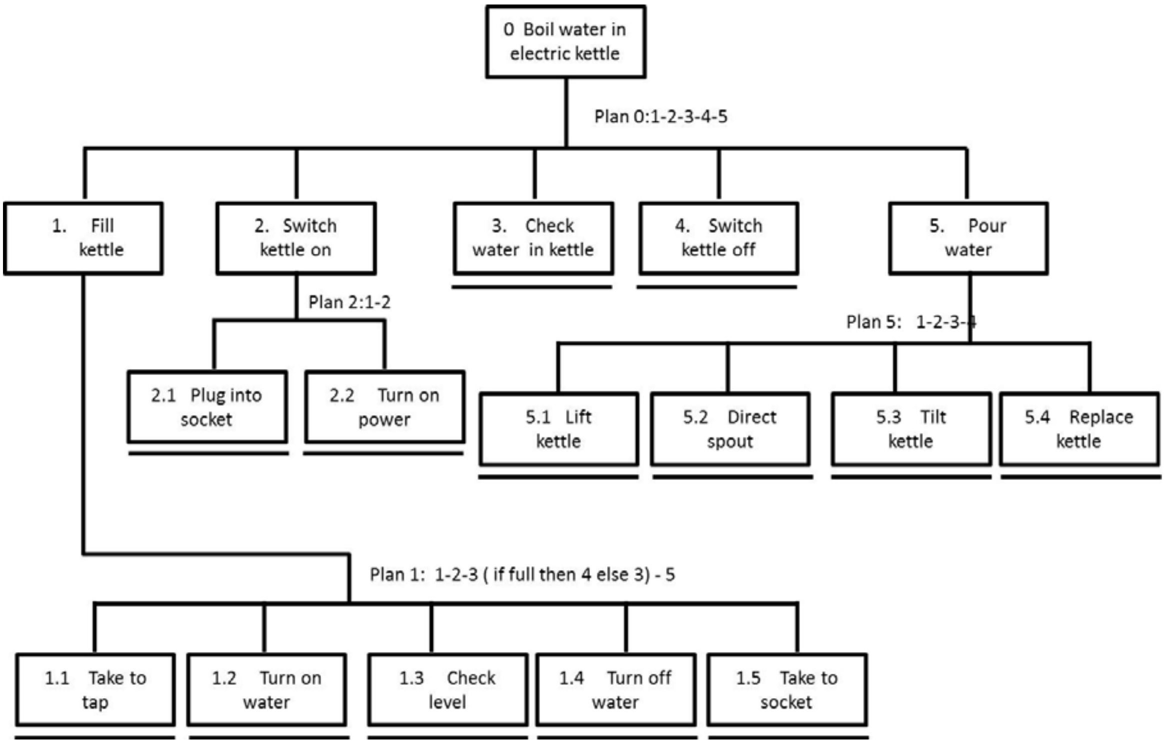
Plan	Example
Linear	Do 1 then 2 then 3
Non-linear	Do 1, 2 and 3 in any order
Simultaneous	Do 1, then 2 and 3 in any order
Branching	Do 1, if X present then do 2 then 3, if X is not present then EXIT
Cyclical	Do 1 then 2 then 3 and repeat until X
Selection	Do 1 then 2 or 3

Figure 1. Flow chart of HTA



Example:
In Figure 2 it is shown an example of HTA for the task of boiling water using an electric device. The same HTA shows a tabular format in the Table 2. This is usually the starting point in the training process of the method.

Figure 2. HTA of the task boiling water using an electric kettle (Stanton et al. (2005))



Results of Literature Review about Applications of HTA
As results, 18 works were found and classified by authors' last name in alphabetical order, date of the work and a description of the application. Table 3 shows the results found from literature review.

Table 2.Tabular HTA for the task for boiling water (Stanton et al. (2005))

0. Boil kettle Plan 0: Do 1 then 2 then 3 then 4 then 5	
1. Fill kettle Plan 1: Do 1 then 2 then 3 (if full then 4 else 3) then 5	
	1.1 Take to tap 1.2 Turn on water 1.3 Check level 1.4 Turn off water 1.5 Take to socket
2. Switch kettle on Plan 2: Do 1 then 2	
	2.1 Plug into socket 2.2 Turn on power
3. Check water in kettle	
4. Switch kettle off	
5. Pour water Plan 5: Do 1 then 2 then 3	
	5.1 Lift kettle 5.2 Direct spout 5.3 Tilt kettle 5.1 Replace kettle

Table 3.- Literature Review.

Authorand date	**Application**
Al-Hakim, L. et al. (2013)	Hierarchical task analysis in combination with identification of human error was used to improve the position of the patient during the surgery process of the lumbar spine.
Asimakopoulos, S. et al. (2011)	Hierarchical task analysis was used for the analysis of production task for sales forecastdetermination.
Bass, A. et al. (1995)	A prototypeof software is proposed, which supports the hierarchical task analysis. This tool provides a direct manipulation of an HTA diagram editor.

Bora, A. (2011)	A design and development of a system based on the hierarchical task design software is presented. The software provides an intuitive user interface to create HTA.
Colligan, L. et al. (2010)	They used the hierarchical task analysis for verifying if a process mapinfluences improvements in the quality process.
Hodgkinson, G.P., y Crawshaw, C.M. (1985)	The hierarchical task analysis was applied in the design and evaluation of sound consoles.
Lane, R. et al. (2006)	Used hierarchical task analysis to model the administration of medication, then the systematic and predictive approach to reducing human error was used to predict that errors are likely to occur.
Miller, C., y Vicente, K. (2001)	They made a comparison between the hierarchical task analysis and technical analysis of spatial decomposition. The comparison showed that both techniques produce different but complementary information about the interaction the users should have with the system.
Mills, S. (2007)	The hierarchical task analysis was used to analyze the design of software. Hierarchical Task Analysis together with usability analysis showed benefits in the collection and analysis of user needs.
Osquei, R., y Rousta, M. (2012)	The hierarchical task analysis was used to systematically analyze the anthropometric measurement with a conventional gauge.
Phipps, D. et al. (2011)	The hierarchical task analysis was used to identify the cognitive demands and the design requirements of information.
Phipps, D. et al. (2008)	The hierarchical task analysis was developed in the task of applying anesthesia.
Raduma, M. A. et al. (2012)	The hierarchical task analysis tool was used to analyze the importance of preparing for the transfer of doctors in a serious medical assessment unit.

Reagan, I. J., y Kidd, D.G. (2013)	Hierarchical task analysis for a set of in-vehicle tasks was performed using auditory-vocal systems of four different 2013 models to assess the number of cases necessary to complete tasks and manual-visual interfaces.
Sarker, S. et al. (2008)	Hierarchical task analysis was used to support surgical tasks. The result was that the method is feasible and reliable for surgical task or any other operating procedure; the method could be used to analyze and evaluate specific technical skills in trainees and expert surgeons.
Stanton, N. (2006)	Development, application, and extension of the hierarchical task analysis. The HTA has been used in a wide range of applications; interface design and evaluation, assignment of function, design job aids, prediction error, and evaluation of the workload.
Sarker, S. et al. (2006)	Hierarchical task analysis was used to analyze the task of laparoscopic cholecystectomy; it was performed by expert surgeons.
Zhiqiang, S. et al. (2008)	The hierarchical task analysis was used to decompose the tasks for identification of human error.

2. CONCLUSIONS

The objectives of this paper have been accomplished, because the HTA method and its components are described; the most important concepts have been also presented about this method. Its versatility to analyze any task in any domain is consider its main advantage. In the other hand, there are several implications about its reliability as well as the laborious and time consuming application.Literature review shows that the method has extended its application to the medical area with very reliable results and some software applications have been created recently aiding the scope of the method.

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Evaluation of physical fatigue and CDT's in the use of straightening irons in aesthetic of the city of Los Mochis, Sinaloa

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RESUMEN. En la ciudad de Los Mochis Sinaloa, existe una cantidad considerable de personas que trabajan en estéticas y aún cuando se tiene la idea de la presencia de fatiga física y DTA's en las labores propias de estas empresas.OBJETIVO. Determinar fatiga física y los posibles desórdenes de traumas acumulativos de trabajadoras en estéticas mediante la aplicación de métodos de evaluación subjetivos. DELIMITACION. Esta investigación estuvo delimitada a estilistas de la ciudad de los Mochis. METOLOGÍA. Se tomó una muestra poblacional de 34 trabajadoras de las diferentes estéticas existentes en esta ciudad de Los Mochis, debido a que es el número de personas que accedieron a las encuestas diariamente por tres semanas.

Después de seleccionar la población se procedió a determinar la fatiga de los sujetos bajo estudio utilizando los métodos Yoshitake, 4 puntos de Luke y Corlett &Bishop.

RESULTADOS. De las ocho personas que salieron afectadas, se realizó el estudio individual y en el mapeo de Corlett & Bishop, muestra que se presentó mayor queja (molestia y/o dolor) en hombros y espalda alta, obteniendo que una persona desarrollo Dta´s en espalda alta y hombro, otra persona desarrollo Dta's en hombro. CONCLUSIONES. De acuerdo a los datos analizados se determina que sí se presenta fatiga física y Dta`s en personas que participan en la encuesta.

Palabras clave: Fatiga física, DTA´s, estilistas.

ABSTRACT. In the city of Los Mochis Sinaloa, there is a considerable amount of people working in aesthetic and even if you have the idea of the presence of physical fatigue and CDT's in the tasks associated with these companies OBJECTIVE. Determine Possible physical fatigue and cumulative trauma disorders of workers in aesthetics through the use of subjective evaluation methods. DELIMITATION. This research was delimited to stylists in the city of Los Mochis. METHODOLOGY. A sample population of 34 workers of different aesthetic existing in the city of Los Mochis, because it is the number of people who accessed the surveys daily for three weeks. After selecting the population proceeded to determine the fatigue of the subjects under study using the methods Yoshitake, 4 points from Luke and Corlett & Bishop. RESULTS. Of the eight people who came affected, the study was conducted individually and in mapping Corlett & Bishop, shows that there was greater concern (discomfort and / or pain) in shoulders and upper back, obtaining a person's development in CDT´s upper back and shoulder, another development in CDT's shoulder. CONCLUSIONS. According to the analyzed data is presented determines that physical fatigue and CDT `s in people participating in the survey.

KEYWORDS; Physical fatigue, CDT's. Stylists.

CONTRIBUTION TO ERGONOMICS: Hairstylistis a little studied activity, this investigation is a beginning for a future investigation works for occupations related to this profession, new hand-tools designs to improve the execution of this activity.

1. INTRODUCTION.

In the past there were those old hair alaciadoras aluminum plates it took to reach the temperature necessary for a good straightening, not to mention none of whom were able to maintain a stable, so that sometimes the hair burned and as many I pulled and broke. New technologies have brought floating plates that achieve a uniform in less time straightening, ceramic resistors, reaching the selected temperature held constant, which in turn promotes hair care allowing safe handling and reduced abuse of it, but very little is said about ergonomic plate.

In our society the use of this article has crossed borders, ages and customs is not improper for a twelve year old girl with her hair straightening is to go to school has become very common, but the study is aimed to the stylists and they are people who frequently used this on their daily work.

However, this fatigue can also be caused by the adoption of poor posture at work, to perform routine tasks requiring continuous effort and similar movements or excessive physical exertion, for example, start their day very early in the morning spend many hours standing and favorable environmental conditions, due to excessive heat prevailing in our city, the hustle and bustle there is in these places.

Physical ailments caused by work fatigue can affect the circulatory, muscular, nervous, digestive and respiratory systems. But in addition, fatigue also has an impact on mental health and can cause depression, nervousness, anxiety, anxiety, irritability, sadness, loss of appetite, headaches, insomnia, memory loss and diminished capacity care, among others.

As for the effects of fatigue on the worker, generally, these translate into labor mismatch, decreased productivity, poor performance at work and an increase in accidents due to lack of concentration and fatigue, both physically and mentally.

Fatigue is present in multiple work activities based on various factors. In this study, interest is to know if you have fatigue and CDT's in workers employed in aesthetic.

2. OBJECTIVE.

To determine the physical fatigue and cumulative trauma disorders of workers in aesthetic by applying subjective assessment methods: Yoshitake, 4-point scale of Luke, and 4 body mapping of Corlett & Bishop.

3. METHODOLOGY.

In order to obtain valid results was necessary to use an appropriate methodology then shows how it was carried out and how the study was conducted to achieve the desired goal.

A sample population of 34 workers of different aesthetic existing in the city of Los Mochis, because it is the number of people who came to the polls daily. After selecting the population proceeded to determine the fatigue of the subjects under study for this work using subjective methods of evaluation of fatigue, as the guest Yoshitake (1978), the scale of 4 points from Luke (1999) and mapping of Corlett & Bishop for the study of cumulative trauma disorders (CDT's).. Rose et al (1998), the questionnaire used to measure fatigue Yoshitake, which was validated because they gave similar results as objective evidence. The work performed in this type of study was a manual operation was used in which the upper and lower body. The questionnaire captures the presence or absence of fatigue by means of a validated survey (30 questions) for industrial work. The questionnaire is divided into 3 groups of questions, the first consisting of 10 questions related to symptoms of drowsiness and monotony, the second with 10 questions related to difficulty concentrating and third are 10 questions related to physical symptoms or physical harm projection . After them, we calculate the frequency of complaints of fatigue, presented as a percentage, where it divides the number of "yes" answered between the total numbers of questions and multiplied by 100.

Luke et al (1999) used a scale to determine the level of fatigue in pregnant women. On this scale, called the 4 points of Luke, are rated fatigue levels after a normal working day, where the measurement scale is: "not tired" 1 point "tired" 2 points "very tired "3 points" extremely tired "4 points. Responses to "very tired" and "extremely tired" were grouped into fatigue. Ramirez L. (2005) applied the subjective questionnaire Yoshitake and four-point scale of Luke in children in popular markets and supply centers and reported that fatigue was greater in children from 3 days, as shoulders arms and hands has discomfort and pain.

1. He talked with the owners and / or employers of research on the benefits that could bring them and requested their cooperation, as well as themselves drawn to the possible candidates to participate.

2. We select employees to be interviewed, they explained the nature of the study and requested their cooperation in order to create a comfortable and reliable answers.

3. An assessment of each worker daily for three weeks, filling the mapping format Corlett & Bishop, Yoshitake and 4-point scale of Luke.

4. Once completed the evaluation of the 34 workers for three weeks, was performed focused on the responses Excel.

5. We analyzed the results of the concentrate and interpreted to draw conclusions and suggest the study's recommendations.

4. RESULTS.

Yoshitake questionnaire results also helped us determine the frequency of complaints of fatigue (FQF).

As a result, the frequency of complaints of fatigue were obtained: at the beginning of time counting the three weeks, 2% presented symptoms of sleepiness and monotony as in the symptoms of difficulty concentrating and bodily symptoms or projection of damage, and 94% without complaint. At the end of day yielded a significant increase in the three types of symptoms from baseline to day, 8% in symptoms of sleepiness and monotony, 7% in symptoms of difficulty concentrating and 6% projection symptoms of damage, having thus 79% without complaint. The results in the frequency of complaints of fatigue at the beginning of work week, was: in the first week showed a 3% in the symptoms of drowsiness and monotony, 2% in the symptoms of poor concentration, 1% in the symptoms of projection of 94% damage and without complaint. While the survey results in the graphs Yoshitake frequency of complaints of fatigue at the end of the day, was: in the first week was 8% in the symptoms of drowsiness and monotony, 5% in the symptoms of difficulty concentration, 6% in the projection of damage symptoms and 81% without complaint.

In the second week in symptoms of sleepiness and monotony was obtained by 3%, 2% in symptoms of poor concentration, 2% in the projection of damage symptoms and 93% without complaint. In the second week, the symptoms of drowsiness and dullness to 8%, symptoms of difficulty concentrating 7%, and symptoms of damage being projected at 7%, leaving 78% without complaint. The third week, 2% was found in symptoms of sleepiness and monotony, symptoms of difficulty of 3% concentration, symptoms of damage projected 1% to 94% without complaint. The last week were increasing symptoms of drowsiness and dullness with 8%, symptoms of difficulty in concentration also increased to 7%, symptoms of damage projection of 7% and 78% without complaint.

Survey Results 4 point Luke. Is displayed when starting the day 75% comes all tired, and others, ie, 25% are tired, very tired I get none or extremely tired. and got that 14% at the end of their day out at all tired, tired, 71%, also with 14% finished very tired and only 1% term extremely tired.

Results of mapping Corlett & Bishop. In upper back by three weeks. At the start of the workday, 9% had complaints a day, two days 3%, 3% three days, four days 3%, 3% 3% five days and six days, 79% had no complaint. At the end of the workday, 17% had complaints a day, two days 12%, 9% three days, four days 3%, 3% six days.

Taking into account the three-week legs. At the start of the workday, 6% had complaints a day, 3% three days, five days 3% and 88% had no complaints any day. At the end of the workday, 9% had complaints a day, 6% two days, five days 3% and 82% had no complaints.

In feet counting the three weeks the beginning of the workday, 14% had complaints a day, 6% in four days, 3% in five days, 3% in seven days and 74%. At the end of the workday, 6% had complaints a day, six days 3%, 91% had no complaint.

The study showed that there are 8 people that show fatigue and possible CDT's. Table 1 presents the results obtained in individually for FqF. Table 2 presents the results obtained on an individual basis for 4-point scale of Luke and Table 3 presents the results obtained on an individual basis for mapping Corlett & Bishop.

4.1TABLES

Often complain of fatigue (%)								
Name	Start of work day				End of the workday			
	Symptoms of drowsiness and dullness	Symptoms of difficulty concentrating	Projection of bodily symptoms or damage.	no complaint	Symptoms of drowsiness and dullness	Symptoms of difficulty concentrating	Projection of bodily symptoms or damage.	no complaint
Alba	2	5	2	91	12	13	10	65
Alejandra	4	2	2	92	9	9	9	73
Daniela	3	3	1	93	9	12	7	72
Marielos	2	1	1	96	4	5	3	88
Miriam	4	4	2	90	10	12	7	71
Miroslava	4	4	4	88	8	8	9	75
Vianey	5	7	2	86	12	16	7	65
Lucia	3	3	2	92	10	11	13	66

Table 1. Results obtained in individually for FQF.

Luke 4 points (days)								
	Start of work day				End of the workday			
Name	nothing tired	tired	very tired	extremely tired	nothing tired	tired	very tired	extremely tired
Alba	6	11	0	0	2	8	7	0
Alejandra	10	7	0	0	1	12	4	0
Daniela	10	7	0	0	3	12	2	0
Marielos	13	4	0	0	0	16	1	0
Miriam	8	9	0	0	2	11	4	0
Miroslava	14	2	0	0	1	12	3	0
Vianey	10	7	0	0	2	10	5	0
Lucia	9	8	0	0	2	10	5	0

Table 2. Results were obtained individually for the 4-point scale of Luke.

	Corlett & Bishop (complaints)															
	Start of work day								End of the workday							
Name	Head	Shoulders	High Back	Legs	Knees	Ankles	Foot	Arms	Head	Shoulders	High Back	Legs	Knees	Ankles	Foot	Arms
Alba	0	0	1	-	-	-	-	-	5	7	4	-	-	-	-	-
Alejandra	0	0	0	-	-	-	-	0	5	6	6	-	-	-	-	4
Daniela	0	0	0	-	-	-	-	-	3	3	5	-	-	-	-	-
Madelos	1	-	0	0	-	-	0	-	2	-	2	2	-	-	1	-
Miriam	0	0	1	-	0	-	-	-	2	7	7	-	5	-	-	-
Miroslava	1	7	2	-	-	0	-	-	3	9	1	-	-	1	-	-
Vianey	1	1	0	5	-	-	-	-	3	4	9	1	-	-	-	-
Lucia	0	3	3	-	-	-	-	-	5	13	10	-	-	-	-	-

Table 3. Results obtained in individually for mapping Corlett & Bishop.

5. DISCUSSION/CONCLUSIONS.

Other factors should be careful not to develop fatigue and CDT `s, among which may include: time devoted to overwork, job design deteriorated, and old equipment, activities before and after working hours, noise.

According to the analyzed data is presented determines that physical fatigue and CDT `s in people participating in the survey.

Of the eight people who came affected, the study was conducted individually and in mapping Corlett & Bishop, shows that there was greater concern (discomfort and / or pain) in shoulders and upper back, obtaining a person's development in CDT´s upper back and shoulder, another development in CDT's shoulder.

The ergonomic use of iron would be helpful to workers aesthetics.

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