# ERGONOMÍA OCUPACIONAL

## INVESTIGACIONES Y APLICACIONES

VOL. 13

2020

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

2020

# ERGONOMÍA OCUPACIONAL

## INVESTIGACIONES Y SOLUCIONES

## VOL. 13

EDITADO POR:

CARLOS ESPEJO GUASCO
Presidente SEMAC 2017-2020

ELISA CHACON MARTINEZ
Presidente SEMAC 2012-2014

ENRIQUE DE LA VEGA BUSTILLOS
Presidente SEMAC 2002-2004

FRANCISCO OCTAVIO LOPEZ MILLAN
Presidente SEMAC 2014-2017

**ISBN: 978-0-578-79186-9**

# Prefacio

Este año hemos tenido muchos cambios debido a la pandemia que ha azotado todo el mundo. 11 de marzo la OMS catalogó el COVID-19 como una pandemia. En el caso de Mexico, a partir del 17 de marzo se decretaron las primeras medidas que pretendian mitigar los efectos del covid-19 y el 30 de marzo, se decretó la «emergencia sanitaria por causa de fuerza mayor», lo que implica la suspensión de actividades no escenciales. Por otra parte, la Secretaria de Educacion Publica emitio un documento el 20 de marzo que decia "En atención a las recomendaciones y medidas implementadas por la Organización Mundial de la Salud (OMS) para contener las afectaciones de este virus, se informa que el receso escolar comprenderá del lunes 23 marzo al viernes 17 de abril, por lo que se reanudarán las labores el lunes 20 de abril, siempre y cuando, se cuente con todas las condiciones determinadas por la autoridad sanitaria federal en cada plantel escolar. Como nos dimos cuenta, el regreso a las actividades presenciales en las Instituciones de Educacion Superior no se reanudaran, cuando menos, en lo que resta del año. Aunque en el ambito industrial ya se regreso a las actividades con restricciones sanitarias para todos los empleados, hoy hay riesgo de un repunte de los contagios.

A pesar de la pandemia, la actividad docente y de investigacion no se han detenido y la prueba de eso es este libro que recoge las investigaciones y aplicaciones que tanto investigadores como docentes y alumnos han desarrollado durante el ultimo año.

Por último, tenemos noticias alentadoras. A finales del año pasado, el 23 de Octubre del año 2019 entro en vigor primera etapa de la la Norma Oficial Mexicana NOM-035-STPS-2018, Factores de riesgo psicosocial en el trabajo- La política; las medidas de prevención; la identificación de los trabajadores expuestos a acontecimientos traumáticos severos, y la difusión de la información. Y el 23 de octubre de este año entro en vigor la segunad etapa de esta norma: La identificación y análisis de los factores de riesgo psicosocial; la evaluación del entorno organizacional; las medidas y acciones de control; la práctica de exámenes médicos, y los registros. A partir de esta fecha la NOM-035-STPS-2018 entra en vigor de forma completa y es de observancia en todos los centros de trabajo en todo el territorio nacional.

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

---

Enrique de la Vega Bustillos

Presidente SEMAC 2002 – 2004

SOCIEDAD DE ERGONOMISTAS DE MÉXICO A.C.

"Trabajo para optimizar el trabajo"

# CONTENT

## ANTHROPOMETRY



## COGNITIVE ERGONOMICS



## DESIGN

## FATIGUE



## INDUSTRIAL ERGONOMICS

# COMITÉ ACADÉMICO

JAIME ALFONSO LEON DUARTE
Universidad de Sonora

JEAN PAUL BECKER
Ergon, Guadalajara, Jal.

JESUS EVERARDO OLGUIN TIZNADO
Univesidad Autonoma de Baja California, Campus Ensenada

JESÚS RODOLFO GUZMÁN HERNÁNDEZ
Universidad de Sonora, Campus Caborca

JOAQUIN VASQUEZ QUIROGA
Universidad de Sonora, Campus Caborca

JORGE LUIS GARCIA ALCARAZ
Universidad Autonoma de Cd. Juarez

KARLA PATRICIA LUCERO DUARTE
Instituto Tecnologico de Hermosillo

MARTHA ESTELA DIAZ MURO
Instituto Tecnologico de Hermosillo

MAURICIO LOPEZ ACOSTA
Instituto Tecnologico de Sonora, Campus Navojoa

MIGUEL BALDERRAMA CHACON
Sociedad de Ergonomistas de Mexico, A.C.

OSCAR ARELLANO TANORI
Instituto Tecnologico de Hermosillo

PATRICIA EUGENIA SORTILLON GONZALES
Universidad de Sonora

ROSALIO AVILA CHAURAD
Universidad de Guadalajara

VICTORIO MARTINEZ CASTRO
Salud y Asesoria en Salud Industrial S.A. de C.V.

ENRIQUE JAVIER DE LA VEGA BUSTILLOS
Instituto Tecnologico de Hermosillo

# ANTHROPOMETRIC STUDY IN HANDS TO ESTIMATE THE NUMBER OF PEOPLE USING THE APPROPRIATE CELL PHONE ACCORDING TO THEIR MEASURES

**Karina Luna Soto, Diego Francisco Estrada Rosas, Edwin Bladimir Santos López, Monica Maria, Montoya Romero, Jesús Iván, Ruiz Ibarra**

Industrial Engineering Department
Tecnológico Nacional de México / I T de Los Mochis
Blvd. Juan de Dios Bátiz, & 20 de Noviembre, 81259
Los Mochis, Sinaloa, México.
E-mail: karina.ls@mochis.tecnm.mx[1], monicamontoyar@gmail.com[4]

**Resumen.** Los teléfonos celulares representan la base de la comunicación y el estilo de vida actual, es casi imposible ver a una persona, en especial a un joven sin este dispositivo en su mano la mayor parte del día, por esta misma razón, estos aparatos están comenzando a tener efectos sobre la salud de las personas.

Los efectos pueden ir desde un leve dolor de mano hasta lesiones en los tendones de los pulgares, es evidente que el uso excesivo de estos es un factor muy importante a la hora de diagnosticar la causa de los problemas, pero otro factor que se ha ido agregando es el tamaño de estos, ya que la tendencia en el diseño de teléfonos celulares son pantallas cada vez más grandes, repercutiendo directamente en el tamaño total de estos.

Con esta nueva problemática, se decide hacer un estudio antropométrico en las manos y celulares de una muestra de la población de los estudiantes de octavo semestre de ingeniería industrial del Instituto Tecnológico de Los Mochis, considerando que la mayoría, cuentan con un teléfono celular. ¿Se realizan cartas antropométricas para registrar las medidas del pulgar y medida de agarre de la mano con la que utilizan principalmente el celular, así como las medidas del largo y ancho del dispositivo, los datos obtenidos se organizaron por categorías en base a un test llamado “Does Your Hand Fit Your Phone Screen?” donde se proponen estas, y posteriormente se obtuvo el porcentaje de personas que cuentan con el teléfono adecuado de acuerdo a sus medidas.

**Palabras clave**: Ergonomía, medidas antropométricas, teléfonos celulares

**Relevancia para la ergonomía**: El uso ergonómico de la utilización del celular adecuado para evitar lesiones. El celular incorrecto puede incrementar el riesgo de lesiones si no se adoptan posturas ergonómicas y no se tienen unos adecuados hábitos posturales. Al tener un estimado del porcentaje de personas que utilizan el teléfono correcto de acuerdo con la medida de sus manos, se da una idea de la magnitud del problema para poder proponer soluciones.

**Summary.** Cell phones represent the basis of communication and current lifestyle, it is almost impossible to see a person, especially a young person without this device

in his hand most of the day, for this same reason, these devices are beginning to have effects on people's health.

The effects can range from mild hand pain to injuries to the tendons of the thumbs, it is evident that the excessive use of these is a very important factor when diagnosing the cause of the problems, but another factor that has been been added is the size of these, as the trend in the design of cell phones screens are becoming more large, directly affecting the overall size of these.

With this new problem, it was decided to carry out an anthropometric study on the hands and cell phones of a sample of the population of students in the eighth semester of industrial engineering at the Technological Institute of Los Mochis, considering that the majority have a cell phone. Anthropometric charts are made to record the measurements of the thumb and the grip of the hand with which they mainly use the cell phone and the measurements of the length and width of the device, the data obtained were organized by categories based on a test called "Does Your Hand Fit Your Phone Screen?" where these are proposed and subsequently the percentage of people who have the appropriate telephone according to their measurements was obtained.

**Keywords** : Ergonomics, anthropometric measurements , cell phones

**Relevance for ergonomics**: The ergonomic use of using the appropriate cell phone to avoid injury. The wrong cell phone can increase the risk of injury if ergonomic postures are not adopted and adequate postural habits are not followed. By having an estimate of the percentage of people who use the correct telephone according to the size of their hands, an idea of the magnitude of the problem is given in order to propose solutions.

## 1. INTRODUCTION

Cell phones are one of the artifacts that the population manipulates the most on a daily basis, representing almost an extension of the human body, so it is necessary that they have measures adapted to the hands of users, in this way to prevent discomfort in them.

" *Today cell phones for young people are like a garment that can not be lacking "* is mentioned in the "U tesina excessive so of the cell phone by teenagers, counterproductive aspects" ( Rodriguez , IAR, Sancho, LC, & Bermúdez, 2013) .

These devices have increased in size in recent years, becoming difficult to handle for some people, and even causing discomfort in the hands and arms due to the anti-ergonomic positions and movements that this causes. Gripping requirements change depending on the size and shape of the device being grasped (Edgren, Radwin, & Irwin, 2004). That is, an inappropriate size for the hand will make it difficult for it to grasp or hold.

Kristin Zhao, a specialist in biomedical engineering, explains that cell phones cause uncomfortable movements in the thumbs when being used, which is why it causes the joints to loosen and loosen so that the bones move differently than normal, “could be causing the onset of pain and eventual osteoarthritis”, he said (infobae, 2017).

The anthropometric charts used study two measurements, the length of the thumb and the grip that exists between the crease of the thumb and the middle joint of the index finger (main measurements in cell phone use). Measurements of the length and width of the cell phones used by each person are also taken in order to estimate which of them have the right phone.

In this research postures or positions are not taken into account, only cell size is considered , conjecturing that this is the basis for adopting good postures or instrument grips.

## 2. DELIMITATION

This research was developed and applied to students in the eighth semester (Jan-Jun 2020) of the Industrial Engineering career at the Technological Institute of Los Mochis.

## 3. METHODOLOGY

The sample was obtained from a population of 268 students with a confidence level of 9 0 % and an error of 10 %, using the formula (1) (Aguilar-Barojas, 2005):

$$n = \frac{N \times Z^2 \times p \times q}{d^2 \times (N-1) + Z^2 \times p \times q} \quad (1)$$

Where:
N = population size
Z = confidence level,
p = probability of success, or expected proportion
q = probability of failure
d = precision (Maximum permissible error in terms of proportion).

It was replaced as follows:

$$n = \frac{(268) \times (1.645)^2 \times (0.5) \times (0.5)}{0.10^2 \times (268-1) + (1.645)^2 \times (0.5) \times (0.5)} \quad (2)$$

$$n = 54.1770$$

Resulting in a sample of 54 students, these students were randomly chosen.

The measures considered for both hands and cell phones were taken in reference to the test “Does Your Hand Fit Your Phone Screen?” (Canipe, DeBold, Fowler, & Mike Sudal, 2014), as can be seen in figures 1, 2 and 3.

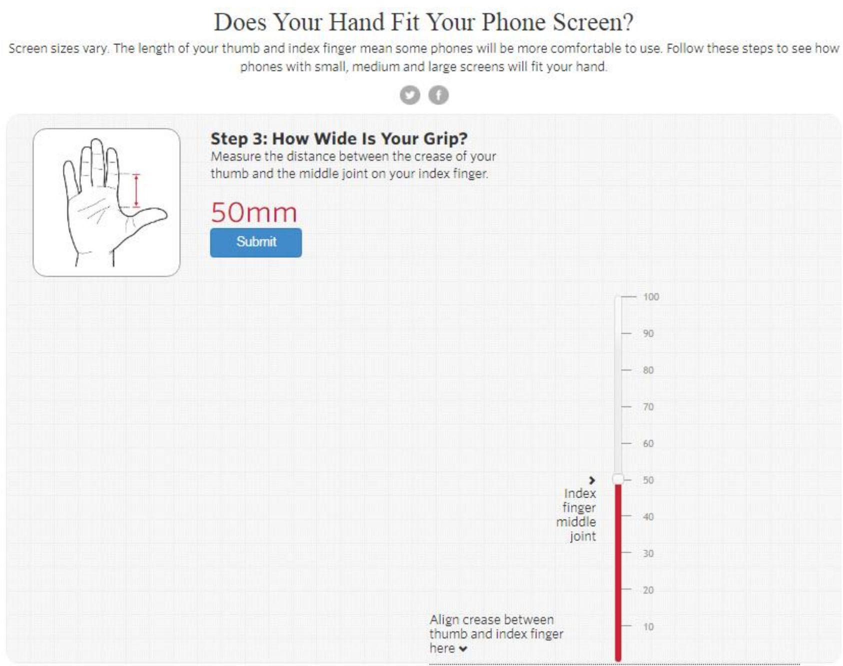



Figure 1. Grip measurement reference (Canipe, DeBold, Fowler, & Mike Sudal, 2014)

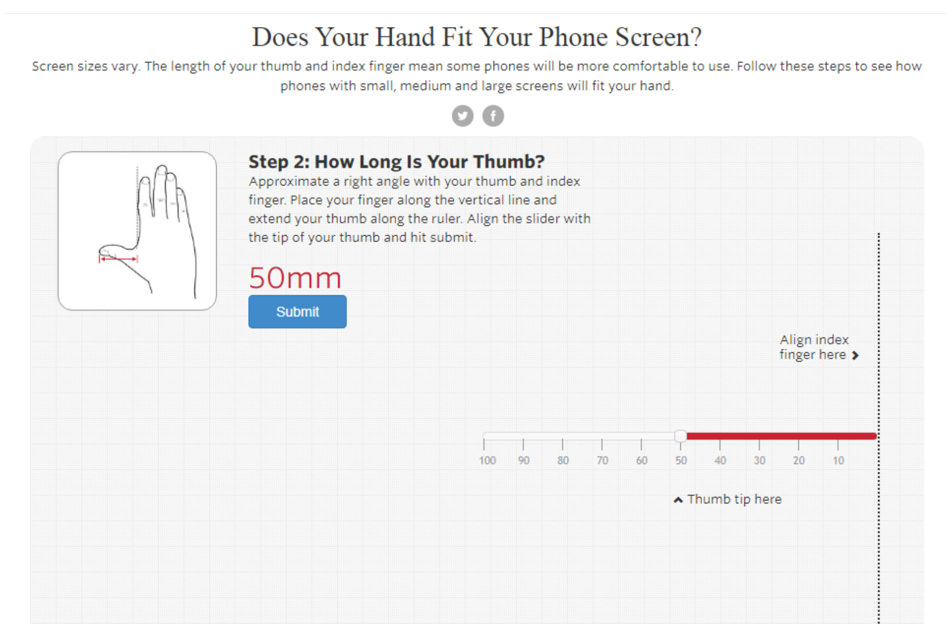



Figure 2. Thumb length measurement reference (Canipe, DeBold, Fowler, & Mike Sudal, 2014)

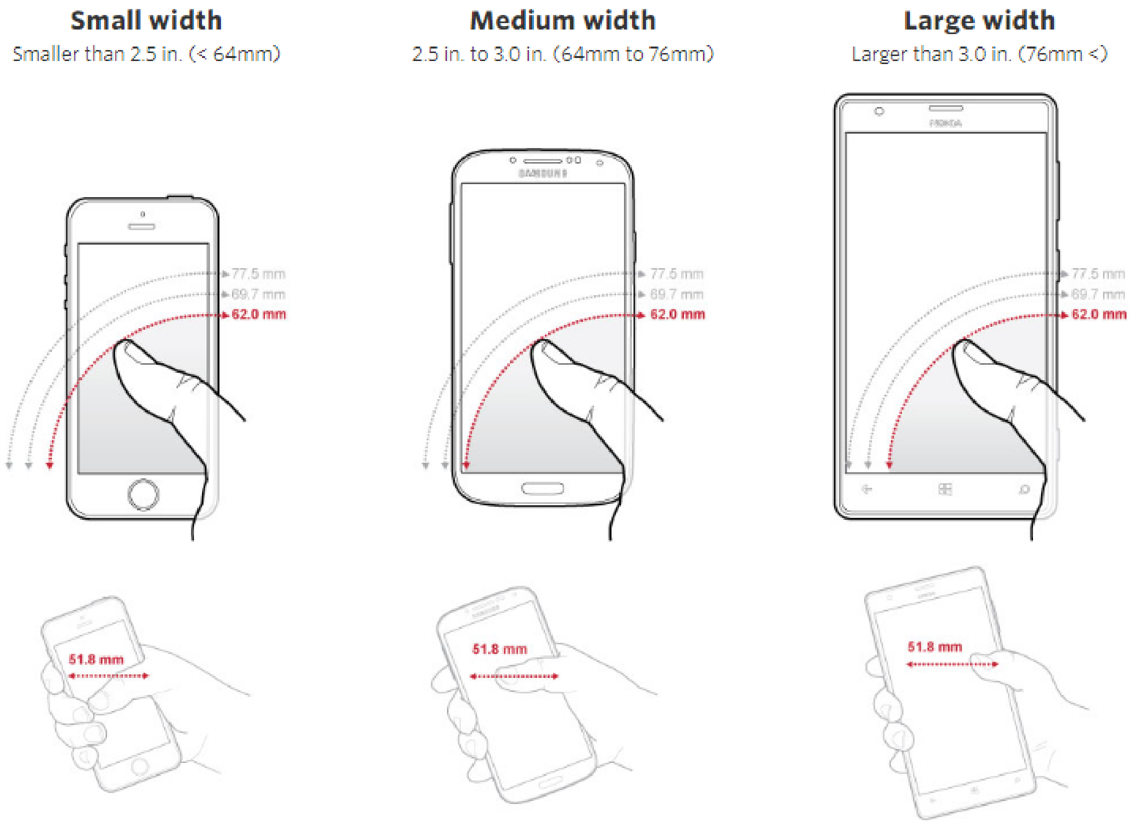



Figure 3. Cell phone length and width reference (Canipe, DeBold, Fowler, & Mike Sudal, 2014)

With a Vernier, the measurements of the hands, the length of the thumb and the grip that exists between the crease of the thumb and the middle joint of the index finger were taken, as shown in figures 4 and 5, these being the most important at the moment. handling a cell phone.

Figure 4 . Grip measurement

Figure 5 . Thumb length measurement

Subsequently, with the same Vernier tool, the cell phone width and length measurements were taken as shown in Figures 6 and 7, of the phones belonging to these people.


Figure 6 . Cell phone length measurement

Figure 7 . Cell width measurement

Measuring the height of the cell was take up to one with research purposes of this dimension, since as shown in Figure 3, the thumb either model (small, medium or large) achieves cover of the high total of screen, the width of the cell phone being the most important dimension, since it is the one that directly affects its grip.

The data obtained from the four measurements were recorded in an anthropometric chart, where the age and gender of the people studied were also recorded (Table 1).

Table 1. Measurements of the total sample . (Source: own creation)

| | Age | Gender | Thumb length (in millimeters) | Grip measuring (in millimeters) | Phone width (in millimeters) | Phone length (in millimeters) |
|---|---|---|---|---|---|---|
| 1 | 22 | Woman | 54 | 43 | 80 | 153.5 |
| 2 | 22 | Man | 66 | 49.5 | 72.5 | 154 |
| 3 | 22 | Man | 62 | 49.5 | 62.5 | 138 |
| 4 | 22 | Man | 68 | 49 | 78 | 157 |
| 5 | 22 | Man | 59 | 43 | 72 | 145 |
| 6 | 21 | Man | 67 | 55 | 79 | 152 |
| 7 | 21 | Man | 69 | 51 | 74 | 149 |
| 8 | 21 | Man | 69 | 50 | 76 | 148 |
| 9 | 21 | Man | 70 | 48 | 79 | 163 |
| 10 | 21 | Man | 71 | 41 | 72 | 145 |
| 11 | 22 | Man | 62 | 42 | 67 | 122 |
| 12 | 21 | Man | 68 | 58 | 70 | 140 |
| 13 | 21 | Man | 67.5 | 51 | 72 | 159 |
| 14 | 22 | Woman | 61 | 37 | 85 | 158 |
| 15 | 21 | Woman | 62 | 42 | 72 | 153 |
| 16 | 21 | Woman | 59 | 42 | 73 | 146 |
| 17 | 22 | Man | 62 | 49 | 74 | 153 |
| 18 | 22 | Man | 59 | 44 | 72 | 145 |
| 19 | 22 | Man | 58 | 46 | 79 | 162 |
| 20 | 21 | Woman | 61 | 46 | 75 | 150 |
| 21 | 21 | Woman | 64 | 45 | 71 | 140 |
| 22 | 21 | Man | 62 | 47 | 80 | 161 |
| 23 | 21 | Man | 64 | 40 | 78 | 160 |
| 24 | 21 | Man | 65 | 49 | 75 | 153 |
| 25 | 21 | Man | 67 | 44 | 80 | 159 |
| 26 | 21 | Woman | 61 | 43 | 81 | 160 |
| 27 | 21 | Man | 61 | 47 | 79 | 163 |
| 28 | 21 | Woman | 57 | 40 | 69 | 140 |
| 29 | 21 | Woman | 54 | 45 | 80 | 160 |
| 30 | 21 | Woman | 59 | 42 | 72 | 142 |
| 31 | 21 | Woman | 55 | 45 | 72 | 153 |
| 32 | 21 | Woman | 60 | 44 | 79 | 160 |
| 33 | 22 | Man | 62 | 46 | 80 | 160 |
| 34 | 21 | Man | 60 | 34 | 72 | 152 |
| 35 | 21 | Man | 63 | 49 | 73 | 151 |
| 36 | 21 | Woman | 51 | 43 | 76 | 153 |
| 37 | 21 | Man | 68 | 48 | 70 | 78 |
| 38 | 22 | Woman | 65 | 45 | 78 | 158 |
| 39 | 21 | Woman | 54 | 44 | 76 | 149 |

Table 1. Measurements of the total sample . Continuation . (Source: own creation)

| | | | | | | |
|---|---|---|---|---|---|---|
| 40 | 23 | Man | 66 | 60 | 68 | 149 |
| 41 | 23 | Man | 62 | 46 | 75 | 154 |
| 42 | 21 | Man | 60 | 61 | 69 | 149 |
| 43 | 26 | Man | 70 | 55 | 72 | 154 |
| 44 | 22 | Man | 69 | 51 | 74 | 143 |
| 45 | 22 | Man | 70 | 43 | 74 | 150 |
| 46 | 21 | Woman | 59 | 51 | 75 | 150 |
| 47 | 24 | Man | 63 | 41 | 78 | 160 |
| 48 | 21 | Man | 68 | 50 | 72 | 149 |
| 49 | 22 | Man | 69 | 49 | 70 | 142 |
| 50 | 21 | Woman | 59 | 51 | 77 | 152 |
| 51 | 22 | Man | 60 | 42 | 79 | 161 |
| 52 | 22 | Woman | 61 | 41 | 83 | 183 |
| 53 | 26 | Man | 75 | 49 | 74 | 151 |
| 54 | 22 | Man | 68 | 62 | 79 | 163 |

Once the data were recorded, the measurements on the hands were classified into three categories:

- Suitable for small cell phones (less than 64 mm)
- Suitable for medium cell phones (64 to 76 mm)
- Suitable for large cell phones (greater than 76 mm)

These categories proposed in the test "Does Your Hand Fit Your Phone Screen?" published in The Wall Street Journal (Canipe, DeBold, Fowler, & Mike Sudal, 2014) .

These categories were divided into two more, which are according to the length of the thumb and according to the grip, since the hands could belong in a category suitable for a type of cell phone using the measurement of thumb length and another category using the measurement grip. These categories are shown in tables 2, 3 and 4.

Table 2. Suitable for small cell phones according to thumb length (less than 64 mm) . (Source: own creation)

| | Age | Gender | Thumb length (in millimeters) | Phone width (in millimeters) |
|---|---|---|---|---|
| 1 | 21 | Woman | 51 | 76 |
| 2 | 21 | Woman | 54 | 80 |
| 3 | 22 | Woman | 54 | 80 |
| 4 | 21 | Woman | 54 | 76 |
| 5 | 21 | Woman | 55 | 72 |
| 6 | 21 | Woman | 57 | 69 |
| 7 | 22 | Man | 58 | 79 |
| 8 | 22 | Man | 59 | 72 |
| 9 | 21 | Woman | 59 | 73 |
| 10 | 22 | Man | 59 | 72 |
| 11 | 21 | Woman | 59 | 72 |
| 12 | 21 | Woman | 59 | 75 |
| 13 | 21 | Woman | 59 | 77 |
| 14 | 21 | Woman | 60 | 79 |
| 15 | 21 | Man | 60 | 72 |
| 16 | 21 | Man | 60 | 69 |
| 17 | 22 | Man | 60 | 79 |
| 18 | 22 | Woman | 61 | 85 |
| 19 | 21 | Woman | 61 | 81 |
| 20 | 21 | Man | 61 | 79 |
| 21 | 22 | Woman | 61 | 83 |
| 22 | 21 | Woman | 61 | 75 |
| 23 | 22 | Man | 62 | 62.5 |
| 24 | 22 | Man | 62 | 67 |
| 25 | 21 | Woman | 62 | 72 |
| 26 | 21 | Man | 62 | 80 |
| 27 | 22 | Man | 62 | 80 |
| 28 | 23 | Man | 62 | 75 |
| 29 | 22 | Man | 62 | 74 |
| 30 | 21 | Man | 63 | 73 |
| 31 | 24 | Man | 63 | 78 |

Table 2 shows the people whose thumb is smaller than 64 mm, which is why they are considered to be people who should use small cell phones, this is compared with the width of the phone they currently use. Cells marked with red indicate the person with the appropriate phone for their category.

Table 3. Suitable for medium cell phones according to the length of the thumb (From 64 to 76 mm) . (Source: own creation)

| | Age | Gender | Thumb length (in millimeters) | Phone width (in millimeters) |
|---|---|---|---|---|
| 1 | 21 | Man | 64 | 78 |
| 2 | 21 | Woman | 64 | 71 |
| 3 | 21 | Man | 65 | 75 |
| 4 | 22 | Woman | 65 | 78 |
| 5 | 23 | Man | 66 | 68 |
| 6 | 22 | Man | 66 | 72.5 |
| 7 | 21 | Man | 67 | 80 |
| 8 | 21 | Man | 67 | 72 |
| 9 | 21 | Man | 67 | 79 |
| 10 | 21 | Man | 68 | 70 |
| 11 | 21 | Man | 68 | 70 |
| 12 | 21 | Man | 68 | 72 |
| 13 | 22 | Man | 68 | 79 |
| 14 | 22 | Man | 68 | 78 |
| 15 | 21 | Man | 69 | 74 |
| 16 | 21 | Man | 69 | 76 |
| 17 | 22 | Man | 69 | 74 |
| 18 | 22 | Man | 69 | 70 |
| 19 | 21 | Man | 70 | 79 |
| 20 | 26 | Man | 70 | 72 |
| 21 | 22 | Man | 70 | 74 |
| 22 | 21 | Man | 71 | 72 |
| 23 | 26 | Man | 75 | 74 |

Table 3 shows the people with a thumb measuring between 64 and 76 mm, which is why they are considered people who should use medium cell phones, this is compared with the width of the phone they currently use. Cells marked with red indicate the person with the appropriate phone for their category.

Table 4. Suitable for small cell phones according to grip (less than 64 mm) . (Source: own creation)

| | Age | Gender | Grip measuring (in millimeters) | Phone width (in millimeters) |
|---|---|---|---|---|
| 1 | 21 | Man | 34 | 72 |
| 2 | 22 | Woman | 37 | 85 |
| 3 | 21 | Man | 40 | 78 |
| 4 | 21 | Woman | 40 | 69 |
| 5 | 24 | Man | 41 | 78 |
| 6 | 22 | Woman | 41 | 83 |
| 7 | 21 | Man | 41 | 72 |
| 8 | 22 | Man | 42 | 67 |
| 9 | 21 | Woman | 42 | 72 |
| 10 | 21 | Woman | 42 | 73 |
| 11 | 21 | Woman | 42 | 72 |
| 12 | 22 | Man | 42 | 79 |
| 13 | 21 | Woman | 43 | 81 |
| 14 | 22 | Man | 43 | 74 |
| 15 | 22 | Woman | 43 | 80 |
| 16 | 22 | Man | 43 | 72 |
| 17 | 21 | Woman | 43 | 76 |
| 18 | 21 | Man | 44 | 80 |
| 19 | 21 | Woman | 44 | 79 |
| 20 | 21 | Woman | 44 | 76 |
| 21 | 22 | Man | 44 | 72 |
| 22 | 21 | Woman | 45 | 80 |
| 23 | 21 | Woman | 45 | 72 |
| 24 | 22 | Woman | 45 | 78 |
| 25 | 21 | Woman | 45 | 71 |
| 26 | 22 | Man | 46 | 79 |
| 27 | 22 | Man | 46 | 80 |
| 28 | 23 | Man | 46 | 75 |
| 29 | 21 | Woman | 46 | 75 |
| 30 | 21 | Man | 47 | 80 |
| 31 | 21 | Man | 47 | 79 |
| 32 | 21 | Man | 48 | 79 |
| 33 | 21 | Man | 48 | 70 |
| 34 | 22 | Man | 49 | 74 |
| 35 | 21 | Man | 49 | 75 |
| 36 | 21 | Man | 49 | 73 |
| 37 | 22 | Man | 49 | 70 |
| 38 | 26 | Man | 49 | 74 |
| 39 | 22 | Man | 49 | 78 |

Table 4. Suitable for small cell phones according to grip (less than 64 mm) Continuation. (Source: own creation)

| | | | | |
|---|---|---|---|---|
| 40 | 22 | Man | 49.5 | 72.5 |
| 41 | 22 | Man | 49.5 | 62.5 |
| 42 | 21 | Man | 50 | 76 |
| 43 | 21 | Man | 50 | 72 |
| 44 | 21 | Man | 51 | 74 |
| 45 | 21 | Man | 51 | 72 |
| 46 | 22 | Man | 51 | 74 |
| 47 | 21 | Woman | 51 | 75 |
| 48 | 21 | Woman | 51 | 77 |
| 49 | 21 | Man | 55 | 79 |
| 50 | 26 | Man | 55 | 72 |
| 51 | 21 | Man | 58 | 70 |
| 52 | 23 | Man | 60 | 68 |
| 53 | 21 | Man | 61 | 69 |
| 54 | 22 | Man | 62 | 79 |

Table 4 shows the people who have a grip measuring less than 64 mm, which is why they are considered people who should use small cell phones, which in this case is the total sample, this is compared with the width of the phone that currently use. Cells marked with red indicate the person with the appropriate phone for their category.

## 4. RESULTS

Once the data had been organized into categories, the percentage of people who used the appropriate telephone was obtained.

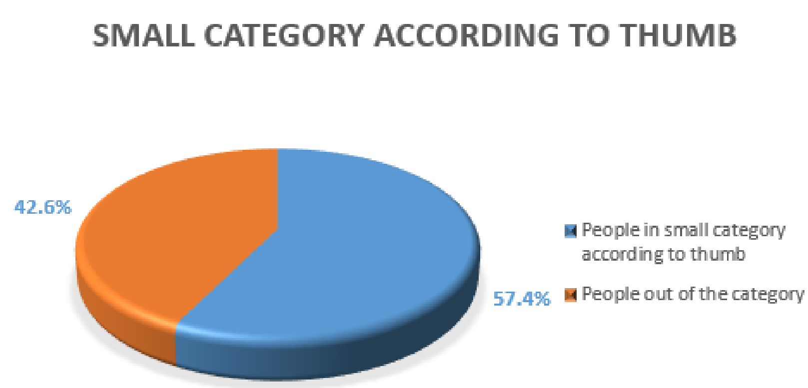



Figure 8. Small category according to thumb

Table 2 shows that 31 people from the total sample fit into the category suitable for small cell phones according to the length of the thumb , this represents 57.4% of the sample.
(31/54) × 100% = 57.40741%. This is shown in figure 8.

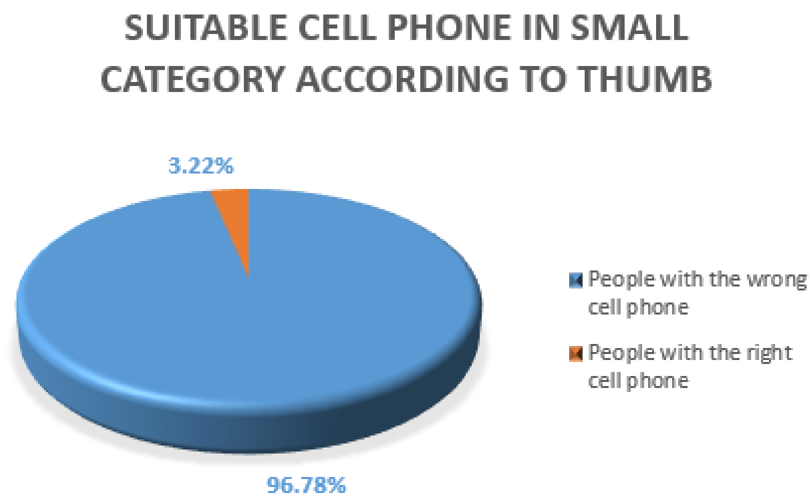



Figure 9 . Suitable cell phone in small category according to thumb

In this category only one person uses the right phone, representing 3.22% of that category. This can be seen in figure 9 .
(1/31) × 100% = 3.225806%

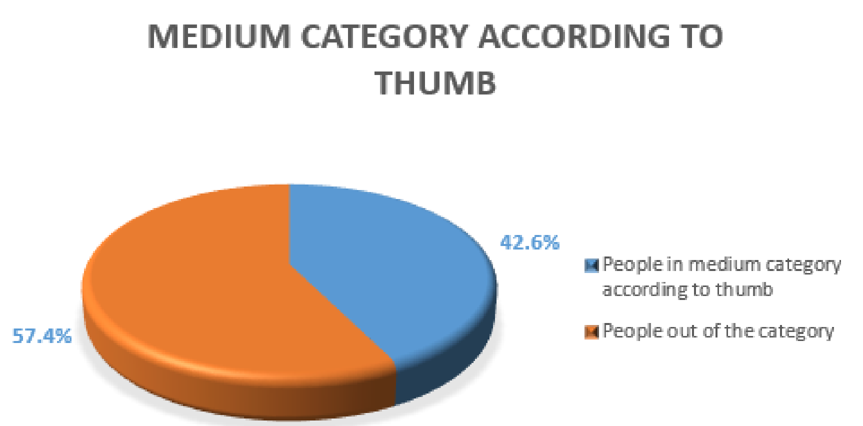



Figure 10. Medium category according to thumb

On the other hand, in Table 3 it can be observed that 23 people of the total sample fit into the category suitable for medium cell phones according to the length of the thumb, which represents 42.6% of the sample. This is shown in figure 10.
(23/54) × 100% = 42.59259%

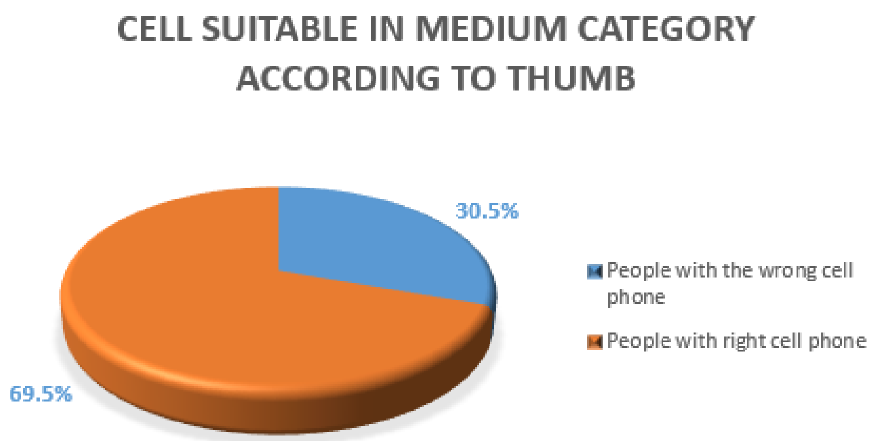



Figure 11 . Cell suitable in medium category according to thumb

Within this category , 16 people use the appropriate telephone, which represents 69.5% of that category. This can be seen in figure 11 .
(16/23) × 100% = 69.56522%

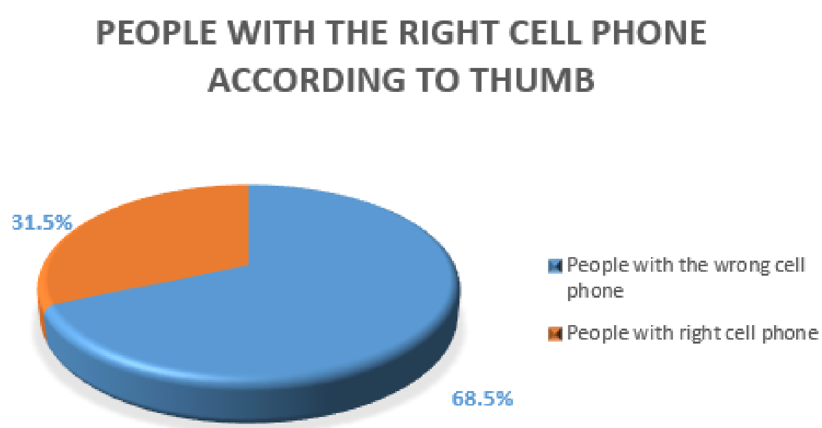



Figure 12 . Cell suitable according to thumb

Considering the thumb length criterion in a general way , 17 people of the 54 sampled have the appropriate cell phone, which represents 31.5% of the sample. This can be seen in figure 12.
(17/54) × 100% = 31.48148%

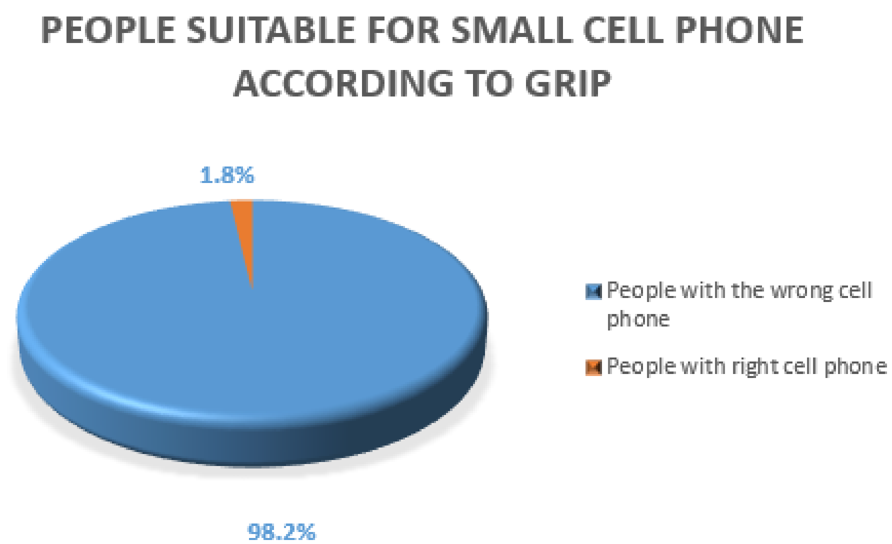



Figure 13 . Small category according to grip

While in Table 4, it can be seen that the total sample falls into the category of small cell phones taking into account the hand grip, as there is only one cell phone with these characteristics, only 1.8% of said category uses the suitable cell phone. This can be seen in figure 13 .
$(1/54) \times 100\% = 1.851852\%$

On the other hand, no person with a grip or thumb with a length greater than 76 mm was registered, which means that no suitable people were found for the category of large cell phones with either of the two criteria.

## 5. CONCLUSIONS

According to the study carried out, the majority of students do not use a cell phone suitable for the size of their claw and thumb length, so it is very important to know the ideal measures so that in the long term it is not a risk factor for having a type of injury or at the time of use does not occur an accident that affects the device in question.

Currently there are known conditions caused by excessive use of the cell phone, as mentioned in an article published in Infobae " *Excessive use of the finger when writing can lead to joint stress and even generate Quervain's tenosynovitis (inflammation of the sheath envelope of the abductor longus tendon and the extensor pollicis brevis, which occurs when passing through the tunnel at the level of the radial styloid) and rhizarthrosis of the thumb* " (infobae, 2017) . It is clear that if the excessive use of these devices is added an inappropriate size, the repercussions to health can be even greater.

A published article called " Tendinitis in the hand due to the use of mobile devices " mentions that the index fingers when receiving the load from the mobile support and responding to the force equivalent to the pressure of the thumbs to keep the phone in balance, can cause tendinitis in them (Sanitas, 2020) . This risk can increase significantly if the cell phone has dimensions that are difficult to manipulate in relation to the hand.

*“The risk factors for radial styloid tenosynovitis (De Quervain) are not fully defined. However, cases of radial styloid tenosynovitis (De Quervain) associated with repeated activities, forced joint positions, direct pressure on the wrist, exposure to vibration and the appearance of exaggerated forces have been reported ”, they* mention in the article Radial styloid tenosynovitis (from quervain ): focus on physical therapy ”(Pérez, 2018). Characteristics that are strongly related to the use of cell phones.

It is said that stenosing tenosynovitis is a common pathology, which is why it is one of the most recurrent reasons for surgery in the area of trauma and orthopedics in hospitals (De la Parra-Márquez, Tamez-Cavazos, & Zertuche-Cedillo, 2008).

In addition to tenosynovitis, there are other conditions that are related to cell phone use, such as neck pain, since it was proven that young people adopt poor posture when using these devices, being a risk factor (Fraire, 2020). Therefore, it would be convenient to continue doing ergonomic studies on cell phones, since they are increasingly posing a risk to people's health.

It is clear that cell phones will continue to be part of daily life, nowadays it is an almost essential tool, but one must be aware of the possible damage that it can cause to health if this tool is increasingly large and sometimes heavy.

As a recommendation, it is proposed that in the boxes where cell phones are sold, a visual guide be provided where the most suitable phone for the user is advised depending on the length of fingers and grip, similar to the packaging of gloves, where a guide is provided to know the ideal size according to the size of the hands.

## 6. REFERENCES

Aguilar-Barojas, S. (2005). Formulas for the calculation of the sample in health research. *Health in Tabasco* , 5.

Canipe, C., DeBold, T., Fowler, G., & Mike Sudal, M. (March 27, 2014). *The Wall Street Journal* . Retrieved from http://graphicsweb.wsj.com/documents/smartphone-ergonomics/

De la Parra-Márquez, ML, Tamez-Cavazos, R., & Zertuche-Cedillo, L. (2008). Risk factors associated with stenosing tenosynovitis. Study in cases and controls. *medigraphic* .

Edgren, C., Radwin, R., & Irwin, C. (2004). Grip Force Vectors for Varying Handle Diameters and Hand Sizes. *researchgate* .

infobae. (June 6, 2017). *infobae* . Obtained from https://www.infobae.com/salud/2017/06/06/la-inesperada-enfermedad-provocada-por-los-celulares-que-preocupa-a-los-medicos/

Sanitas. (October 11, 2020). *Sanitas* . Obtained from https://www.sanitas.es/sanitas/seguros/es/particulares/biblioteca-de-salud/Lesiones/lesion-tendinosa/tendinitis-mano.html

Pérez Apaico , GL (2018). Radial styloid ( quervain's ) tenosynovitis : focus on physical therapy

Rodriguez , IAR, Sancho, LC, & Bermúdez, EXCESSIVE USE OF THE CELL PHONE BY ADOLESCENTS, COUNTERPRODUCTIVE ASPECTS.

# MANUAL FORCE MEASUREMENT BY ISOMETRIC DYNAMOMETRY AS A POSITIVE HEALTH INDICATOR IN WORKERS IN THE MADERO REGION, JULY TO OCTOBER 2019.

**Juan Casillas Espriella[1], Omar Reséndez Del Ángel[1], David Roberto Cisneros Alemán[1], Diego Octavio López Mendoza[1], Karina Teresita González Rodríguez[2].**

[1]Department of Occupational Health,
[2] Department of Internal Medicine
Hospital Regional Ciudad Madero, PEMEX,
4a. Avenida S/N, Jardín 20 de Noviembre, 89440
Ciudad Madero, Tamaulipas.
e-mail: juan_9973@hotmail.com

**Resumen:** El objetivo es establecer valores de referencia para la fuerza de agarre manual con dinamometría isométrica en la población trabajadora de la región Madero y analizar si es un indicador positivo de salud de utilidad para los protocolos de estudio de ingreso y vigilancia periódica de los trabajadores. Diseño: prolectivo, transversal, descriptivo y observacional. Materiales y Métodos: se analizaron un total de 888 trabajadores de la región Madero de Petróleos Mexicanos. Se llevó a cabo la medición de la fuerza de agarre manual con el dinamómetro Jamar® estándar, se realizaron mediciones antropométricas de circunferencia de antebrazo y muñeca, y longitudes de palma y mano, calculando las variables antropométricas obtenidas para la integración de masa corporal total, se realizó la revisión de los expedientes electrónicos de cada trabajador; todos los datos fueron recolectados en un dispositivo electrónico. Resultados: se obtuvieron medidas de tendencia central para las mediciones de fuerza de agarre manual, por género, dominancia, departamento y centro de trabajo, se efectuó el análisis estadístico obteniendo significancia estadística con el coeficiente de correlación de Spearman entre las variables antropométricas y la fuerza de agarre manual ($p = <.001$), la prueba de Kruskal-Wallis demostró significancia estadística en las mediciones de fuerza entre los rangos de edad, centros de trabajo y departamentos o talleres analizados ($p = <.001$), se efectuaron análisis de regresión múltiple estandarizada, encontrando ecuaciones de regresión significativas, $p = <.001$, X2 ajustada de 0.733. Discusión y conclusión: creamos valores de referencia de fuerza manual mediante dinamometría isométrica que podrán ser utilizados en diferentes áreas de la salud para la valoración multidisciplinaria de la funcionalidad musculoesquelética y que podrán ser en beneficio de trabajadores de distintas ocupaciones de nuestra región.
**Palabras clave:** Fuerza de agarre manual, Dinamometría isométrica manual, indicador positivo de salud, Medicina del Trabajo, trabajadores mexicanos.

**Relevancia para la ergonomía:** Valores predichos de fuerza de agarre manual para población trabajadora mexicana. Nuestros resultados son muy relevantes para el área clínica y laboral, ya que es el primer estudio nacional que evalúa la medición de la fuerza manual mediante dinamometría isométrica en trabajadores, estableciendo con ello valores de referencia inexistentes en nuestro país previamente. Lo que podría ser el punto de partida de futuras investigaciones en el campo de la rehabilitación y reincorporación laboral, seguimiento de trabajadores lesionados y su recuperación, y diseño de puestos de trabajo adoptando la fuerza estimada como un parámetro para estos, entre otros campos de investigación.

**Abstract:** This study aimed to establish normative data for manual grip strength with isometric dynamometry in working population and analyze whether it is a positive health indicator useful for protocols of study (admission and periodic monitoring of workers). This study was transversal, descriptive and observational. The participants were a group of workers of Petroleos Mexicanos in Cd. Madero. To measure manual grip strength, standard Jamar® dynamometer was used, anthropometric measurements of forearm and wrist circumference, palm and hand lengths were made, calculating the anthropometric variables obtained for the integration of total body mass; All data was collected on an electronic device. Central tendency measurements were obtained for manual grip strength, by gender, dominance, workshop and workplace, statistical analysis was performed obtaining statistical significance with Spearman's correlation coefficient between anthropometric variables and grip strength (p = <.001), the Kruskal-Wallis test showed statistical significance for the grip strength between age ranges, workplace and workshops analyzed (p = <.001), standardized multiple regression analyzes were performed, finding significant regression equations, p = <.001, adjusted X2 of 0.733. Finally, we used Mann Whitney's U-test to verify whether manual grip strength could be useful as a positive health indicator, resulting in our population not being able to use it for this purpose. We propose normative data of grip strength that could be used in multiple areas of health for the multidisciplinary evaluation of the musculoskeletal functionality and that could be in benefit of workers of different occupations of our region.

**Keywords**: Grip strength, hand-held isometric dynamometry, occupational health, mexican workers, mexican population.

**Relevance to Ergonomics:** normative data of grip strength for the Mexican working population. Our results are very relevant for the clinical and occupational area, beause it is the first national study that evaluates the measurement of manual force using isometric dynamometry in workers, thereby establishing previously non-existent reference values in our country. What could be the starting point for future research in field of rehabilitation and reincorporation, follow-up of injured workers and their recovery, and job design adopting the estimated force as a parameter for them, among other research fields.

## 1. INTRODUCCIÓN

The muscle strength assessment test provides data that enables clinicians to integrate an overview of individuals' musculoskeletal and functional integrity with respect to their age, gender, or work activity skills. There are few well-validated techniques for assessing muscle strength that involve assessing strength using isokinetic dynamometric and isometric grip strength methods. Manual grip force is generally evaluated using an adjustable manual dynamometer, which measures force mechanically, hydraulically, or electrically. Among the methods for evaluating muscle strength and specifically manual strength, we find manual dynamometry that can be categorized into two aspects currently used: isokinetic manual dynamometry and isometric manual dynamometry, which are very useful as they are low-cost tools and effective tests performed with a portable device.

Manual dynamometry is a useful tool in the multidisciplinary assessment of the workers' health, which has been used by different specialties in the health area such as sports medicine, nutrition, medical rehabilitation, among others. This method correlates closely with measurements of muscle strength from other muscle groups, including the lower extremities, and is an ideal tool for identifying physical limitation. Furthermore, manual grip strength is a marker of nutritional status and is a better predictor of clinical outcomes than strength calculation using muscle mass, it is also a powerful predictor of specific mortality (Lauwers & Gachette, 2018), and can help identify population with higher risk of deterioration of health (Heimburger et al., 2000).

The type of occupation has a specific correlation with the degree of strength tested, in turn the grip strength is typically influenced by the health status of the individual and the level of physical activity of a person (Chau et al., 1997).

The interpretation of manual grip force can only be objectively if there are reference values, however, they are limited, especially for the Mexican population and specifically null for the working population, resulting in subjective hand force assessment being subjective. for clinical interpretation (Coronel & Amaro, 2018).

## 1.1 Grip strength

Many factors influence hand and wrist strength, which has been measured in various laboratory or field studies. These include, but are not limited to: orientation to the work surface, plane of rotation of the hand, reach distance, type of tool, resistance to force dynamics, repetition of movements, duration of a single grip, method grip (pinch and full grip variations), full grip diameter and surface area, surface roughness or coefficient of friction, use of gloves, gender, age, hand (dominance), worker or individual.

Understanding the strength and movement capabilities of the hand and wrist, as well as the methodologies to determine them are important in the design of tasks and tools to minimize the frequency and severity of work-related upper extremity disorders (Karwowski W., 2006).

Manual grip strength is used clinically in rehabilitation areas (Bohannon et al., 1997), and has been recommended as a basic measure in the evaluation of musculoskeletal function, thus establishing weakness or disability. Measurement determined by isometric manual dynamometry allows to identify not only upper extremity muscle weakness, but also to provide an indicator of global strength (Bohannon R., 2012). Manual dynamometry is relatively simple, fast, cheap and is a non-invasive test, and it has also been considered a positive marker for health (Bohannon R., 2008). Measurement of isometric muscle strength from manual grip is influenced by posture, age, sex, anthropometric characteristics (Fong & Gy, 2001), fat index and body mass index (Mathiowetz et al., 1985). In isometric movement, there is no joint movement, the distance between the origin and the muscular insertion is not variable (Sengupta et al., 2011).

In the assessment of manual grip strength, the most important role is played by the use of isometric dynamometry, for this reason an isometric evaluation must always precede an isokinetic and isotonic dynamometric study (Coronel & Amaro, 2018). The dynamometer is considered an adequate and reliable instrument for evaluating the manual gripping force of the study individual; although the reliability of the evaluation can be affected by the gender of the individual, weight and body posture (Lagerström C., et al, 1996). Proper body posture seems to be a relevant factor for measuring force, since motor control increases with an optimal position, it is at 0 ° of flexion and abduction, the elbow is flexed at 90 °, the forearm in neutral pronosupination and the wrist in extension 15-30 degrees (Kong Y., et al, 2011). When making the measurement, the worker must maintain the contraction for at least three seconds and verbal stimulation must be given to guarantee maximum effort. Healthy people are able to exert maximum effort in less than two seconds and maintain it for at least three seconds (Chandrasekaran et al., 2010). A reliable mean is considered, the average of three trials, that do not have a coefficient of variation greater than 10% (Clerke & Clerke, 2001).

The assessment of manual grip strength with the help of dynamometric instruments is a useful and objective tool, low cost and accessible. In our country, there are no studies that refer to manual grip force values in workers, which limits the interpretation of the data obtained with these tests. Multiple studies show significant differences between the data reported by different countries such as Nigeria, Spain, Brazil, Germany, Greece, Switzerland, Australia, the United States, Malaysia, England, Canada, Finland, New Zealand, Sweden and Zimbabwe, among others, these have their own reference values so they have no difficulty interpreting the results. In Mexico, these data do not exist, or the reference data is taken from international studies (González C., et al, 2017).

Having reference values and instruments for measuring isometric manual grip strength will be a very useful objective tool to determine force as a positive indicator of health in workers, assess the response to treatment of different musculoskeletal pathologies and occupational reincorporation. However, force can vary according to work activities, so, it will be very useful to establish normal values regarding the degree of physical demand that each job, department or workshop will require in the sample selected for study.

## 2. METHODOLOGY

### 2.1 Study design:

Prolective, cross-sectional, descriptive and observational.

2.1.1 Materials and Methods

A total of 888 workers from Madero region of Petróleos Mexicanos were analyzed: “Francisco I. Madero Refinery, Marine Terminal Madero and Hospital Regional Ciudad Madero (sample size calculation 95% CI). The selection criteria were as follows: inclusion criteria: working population over 18 years and under 70 years with indistinct health status, of any category, working hours, work status; exclusion criteria: workers who did not want to participate in the study and workers with cervical root disease, osteopenia, sarcopenia or severe systemic disease that could affect the strength of the upper extremities; elimination criteria: workers who decide to leave the study; workers who during the measurement obtain a coefficient of variation greater than 10, subjects who have made more than 5 attempts at manual effort without obtaining consistency in the study. The manual grip force measurement was carried out with the standard Jamar® dynamometer, making anthropometric measurements of forearm and wrist circumference, and palm and hand lengths, calculating the anthropometric variables obtained for the integration of total body mass. performed the review of the electronic files of each worker; all data was collected on an electronic device (tablet).

2.1.2 Data collection:

Qualitative and ordinal, nominal and dimensional, discrete and continuous quantitative variables were used in this study. Data collection was carried out in the digitally produced formats, with direct connection and instant upload to the cloud for collection in a database.

2.1.3 Manual Grip Strength Measurements

They were taken using a standard, adjustable JAMAR® dynamometer, which has an excellent tool with good reproducibility and reliability among different evaluators (Portney & Watkins, 1993). At the beginning of the procedure it was explained and amply demonstrated what the test consisted of. The test was performed in the position recommended by the American Society of Hand Therapists (ASHT). Both hands of each individual were evaluated, obtaining three measurements from each worker and the highest score was used in all analyzes. The manual grip force was captured at most in kilograms of force during the procedure. They were made with the JAMAR® manual dynamometer manufactured and calibrated by Performance Health Supply, Inc. W68 N158 Evergreen Blvd. Cedarburg, Wisconsin 53012, no. serial: 20180411870 and using measurement techniques according to the procedure established by the Biomedical Research Center of the Southampton National Institute for Health Research (NIHR Southampton Biomedical Research Center).

## 2.2 Statistical análisis:

A database was developed in the Microsoft® Excel® program for Office 365 and analyzed in the IBM SPSS® version 25 statistical analysis package. We obtained measures of central tendency such as mean, median, minimum, maximum, range, standard deviation and percentile distribution. The Kolmogórov-Smirnov test was used to visualize normality of the results obtained, then non-parametric tests were chosen. The correlations between right and left strength were analyzed with the Wilcoxon signed rank test, the Mann-Whitney U test was used to observe the difference in strength between gender, the comparison of the strength obtained between age groups, departments and work center was explored with the Kruskal-Wallis test. The Spearman Correlation test (rho) was used to assess the correlation of the anthropometric variables with the obtained force and to determine the impact of the anthropometric variables on the force, the coefficient of determination was used. A variable prediction model was performed using the standard multiple regression for the elaboration of reference values using prediction equations according AIC Criteria, adjusted to the parameters obtained for our population. Finally, to compare the data obtained from strength, the groups of healthy and sick individuals were analyzed using the Mann Whitney U test.

## 3. RESULTS:

Central tendency measures (means, medians, percentile distribution, standard deviations) were obtained for manual grip strength measurements, by gender, dominance, age ranges, department and workplace, we performed the Kolmogorov-Smirnov test finding an Abnormal (bimodal) distribution shown in Figure 1, for the manual grip force results, so we used non-parametric statistical tests for inferential statistical analysis.

The manual grip force was analyzed, resulting in an average force for the right hand of 43.79 kg, with a minimum of 20 kg, maximum of 76 kg and a standard deviation (SD) ± 11.81 kg, while for the left hand it was observed an average force of 42.21 kg with a minimum of 18 kg, maximum of 74 kg and a standard deviation (SD) ± 11.76 kg. Wilcoxon's sign test revealed a statistically significant difference between the strength of the right hand (Md = 46) and the left hand (Md = 42), z = -10.15, p = <.001, with a medium effect size (r = .2408). Using the Mann Whitney U test, a statistically significant difference was observed between the force obtained for the male gender (Md = 50) and the female gender (Md = 30), U = 178,807, z = 24.02, p = <.001, r = 0.806, shown in figure 2.

The difference in strength between age ranges was explored with the Kruskal-Wallis test, finding that there are statistically significant differences, X2 (4, n = 888) = 15,908, p = .003. Furthermore, it revealed that there is a statistically significant difference in force measurements between the three work centers studied considering both genders, X2 (2, n = 888) = 50.86, p = <.001. The workplace with the highest force was Marine Terminal Madero (Md = 47) followed by the Francisco I. Madero Refinery (Md = 46) and finally Hospital Regional Ciudad Madero (Md = 35), shown in Figure 3. It was observed that there are statistically significant differences in force measurements between each of the departments in the three work centers, Francisco I. Madero Refinery: X2 (21, n = 366) = 55.39, p = .005, Madero Maritime Terminal: X2 (18, n = 316) = 44.52, p = <.001 and HRCM: X2 (15, n = 206) = 68.80, p = <.001. See Table 1 and Figure 4 (Marine Terminal Madero work center).

The relationship between the variable Strength of both hands (FMED) and the anthropometric variables were investigated using the Spearman correlation coefficient (rho). Overall, a strong positive correlation was found for the variables muscle mass, weight, height, forearm, wrist circumference and hand length; an intermediate correlation force for palm length, and a weak positive correlation for body mass index, and no correlation was found between fat mass and manual force measurement (p = <.001). See Table 2. In addition, the scatter plots for manual force measurement and the variables that showed greater statistical significance with the Spearman correlation coefficient (rho) are shown globally and for the female and male groups. Figures 5 and 6.

Finally, for the construction of manual grip strength reference values, we used the standardized multiple regression adjusted with AIC criteria for the studied variables, three models were created for the total population, adjusting them for the nominal dichotomous variants: right and left hand, thus determining the models that best fit for the population as a whole and for each hand, finding the following: the variables that gave the greatest impact to the model were chosen, finding a statistically significant regression equation (F (7, 878) = 348.08, p = <.001), with an adjusted X2 of 0.733, this means that the model has an accuracy of 73.3%, creating with them reference values for manual grip strength. See Table 3. Finally, we used the Mann Whitney U test to verify if manual grip strength could be useful as a positive indicator of health.

Thanks to the models used, the following reference values were created, classifying them by age and gender ranges, the weight of manual grip strength, expressed in kilograms, was cataloged as: normal, low, very low, high and very high. See tables 4, 5, 6 and 7.

## 4. DISCUSSION:

The measurement of manual grip strength using isometric dynamometry turns out to be a useful and simple tool for multidisciplinary medical assessment, however, it should be mentioned that there are no national studies that report such measurement as a possible health indicator or establish ranges of reference for it. The results obtained in our study are influenced by various individual characteristics such as age, gender, dominance, types of work and anthropometric characteristics, finding in our study greater strength in males and greater strength in the dominant hand as reported by Innes et to the. in 1999. Regarding age, it was observed in our study population that it tends to a linear increase in the ages of 30 to 39 years, which is similar to the results obtained by Günther et al. in 2008, reporting the maximum peak in these age ranges, which also follows the findings published by Wang et al. in 2018.

Regarding the influence of the manual grip force with the execution of different types of work, various international studies have contributed to the world bibliography reference values that have been developed in workers in the automotive, construction, office workers and health (Phillips J., 2013, Preetha S., 2018, Rawat S., 2016), in our study we have carried out an analysis of the working population including a total of 66 different types of occupational groups, divided into workshops or departments, finding Important statistical significance for the workshops or departments that obtained the highest degree of strength, and which required the highest level of physical demand, for example: the Fire Department of the Francisco I. Madero Refinery, the machine and tool workshop of Marine Terminal Madero and the Maintenance department in Hospital Regional Ciudad Madero, while the departmens with office jobs or similar, for example: Accounting and costs of the Francisco I. Madero Refinery, Superintendency of Naval Maintenance of Marine Terminal Madero and Financial Resources at Hospital Regional Ciudad Madero, see tables 8, 9 and 10 , showed lower levels of manual grip strength, which is similar to that reported by Josty et al. in 1997, which mentions that: workers with heavy manual occupations (farmers) have a higher manual grip force, followed by workers with light grip (mechanical) and for last, office workers; while other investigations found no statistical significance between the type of work and the manual grip force (Nygård et al., 1987, Harth & Vetter, 1994).

The standardized multiple regression models allowed to include the best explanatory variables for the creation of statistically significant equations in the study population, maintaining the model that obtained the highest degree of precision with 73.3%, since it is a heterogeneous sample of workers in their occupations with a total of 66 different departments.

This study presents reference values and equations for the evaluation of manual grip strength calculated with anthropometric variables and occupational characteristics for workers in the Madero region of Petróleos Mexicanos. The predicted values are for the working population, being the first national study to present these values calculated by isometric measurement for different types of work, the results obtained differ from the only national publication by Hernández Amaro H, 2018, where it evaluated the general population and carried out isokinetic measurement of muscle strength.

The ranges of manual grip strength found in our population vary according to what has been reported in different international studies (Mathiowetz, 1985, Bohannon RW, 1997, Koopman J., 2015), while other studies share similar results to ours (Massy -Westropp et al, 2011), this is because there are significant anthropometric differences between the different populations throughout the world; weight, height and body mass index determine normative data for manual grip strength in the regions and / or continents studied, it should be noted that in these studies they have used the same measurement instrument (standard Jamar® dynamometer) in different positions (second or third position) (Hoffmaster et al., 1993, Boadella et al., 2005) obtaining good results, in our research we adopted the second position according to the anthropometric variables of palm and hand length.

The results obtained were analyzed to assess the usefulness of manual force as a positive indicator of health, however, no statistical significance was found, given that the study population conformed to an average BMI = 29.3 kg / m2, with a variability of entities. Chronic degenerative (obesity, Diabetes Mellitus II, dyslipidemias, metabolic syndrome, etc.) that altered the comparison process, even observing greater strength in the group of workers with obesity, differing from what was found in other studies, where individuals with a BMI Normal obtained a higher degree of manual grip strength than those with obesity and overweight (Hammed A., 2018, Deepak GB, 2014) and where it has been used as a positive indicator of health at the extremes of age in different populations (Bohannon RW, 2008). Therefore, with the data found, we conclude that manual force measurement using isometric dynamometry cannot be used as a positive indicator of health in our population. However, these normative data in relation to having managed to establish through precise statistical tests, reference ranges by age groups and gender of manual grip strength measured by isometric dynamometry that were not available in our country, may be used with other purposes of functional assessment for different occupations and for different medical specialties.

## 5. CONCLUSION:

The main objective of the study when trying to establish the measurement of manual grip strength by isometric dynamometry as a positive indicator of health, it was not possible to demonstrate since the anthropometric characteristics and chronic-degenerative diseases of our population, mainly obesity, impacted the degree of force even observing to be greater in this subgroup of workers, however, the proposed reference values represent valuable parameters that have never been established in our country before, and that can serve as an interpretation guide for the multidisciplinary assessment of musculoskeletal functionality of the upper extremities of workers in different occupations.

Our study provides accurate and valuable information since we carried out an analysis of the largest working population nationwide, almost 900 workers, which includes a total of 66 different types of occupational groups (divided into workshops or departments) from the three centers. of work with the largest population in the Madero region in the state of Tamaulipas, which allowed us a broad overview of the strength of each type of work.

The reference ranges that we present may be useful for different medical specialties that require an objective study of manual griip force obtained by isometric dynamometry to assess the functional integrity of the upper extremities, muscle mass, and nutritional status of individuals. Specialties such as Sports Medicine, Rehabilitation, Nutrition and Occupational Medicine will benefit from the findings found since the data were weighted qualitatively for age and gender ranges for proper clinical interpretation.

## 6. FIGURES AND TABLES:

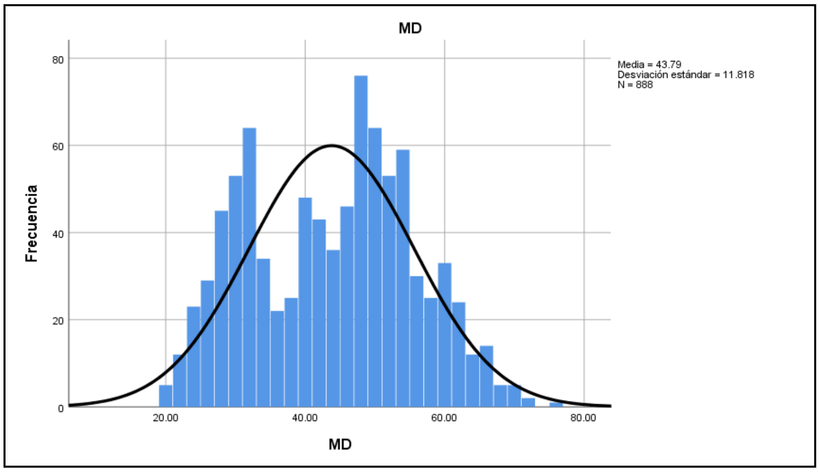



Figure 1. Right Hand force distribution graph, n = 888.

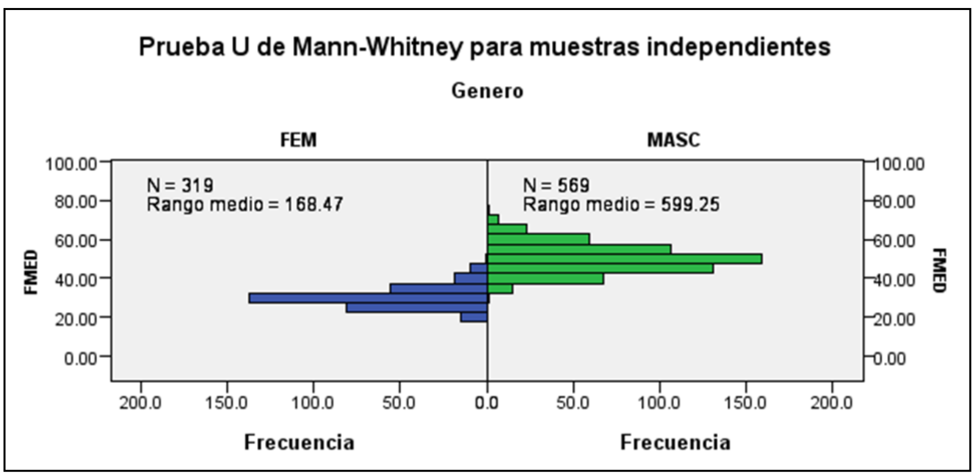
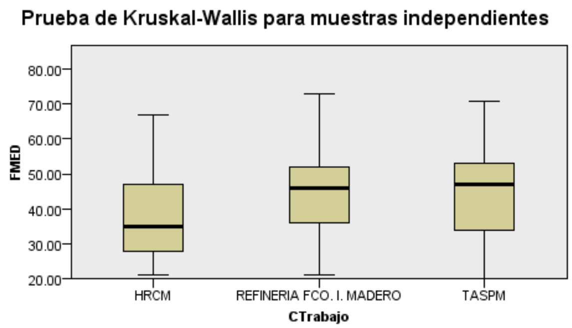



Figure 2. U Mann-Whitney test graph between genders, n=888.



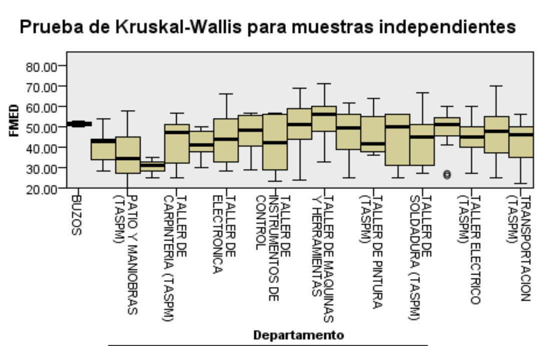

| | |
|---|---|
| **N total** | 888 |
| **Estadístico de contraste** | 50.869 |
| **Grados de libertad** | 2 |
| **Sig. asintótica (prueba bilateral)** | .000 |

**Estadísticos**

FMED

| | | | |
|---|---|---|---|
| HRCM | N | Válido | 206 |
| | | Perdidos | 0 |
| | Mediana | | 35.0000 |
| REFINERIA FCO. I. MADERO | N | Válido | 366 |
| | | Perdidos | 0 |
| | Mediana | | 46.0000 |
| TASPM | N | Válido | 316 |
| | | Perdidos | 0 |
| | Mediana | | 47.0000 |

Figure 3. Kruskal-Wallis test for the three work centers studied. (HRCM = Hospital Regional Ciudad Maderol, TASPM = Marine Terminal Madero).




| | |
|---|---|
| **N total** | 316 |
| **Estadístico de contraste** | 44.520 |
| **Grados de libertad** | 18 |
| **Sig. asintótica (prueba bilateral)** | .000 |

1. Las estadísticas de prueba se ajustan para empates.

Figure 4. Kruskal-Wallis test for each department of the Madero Maritime Terminal

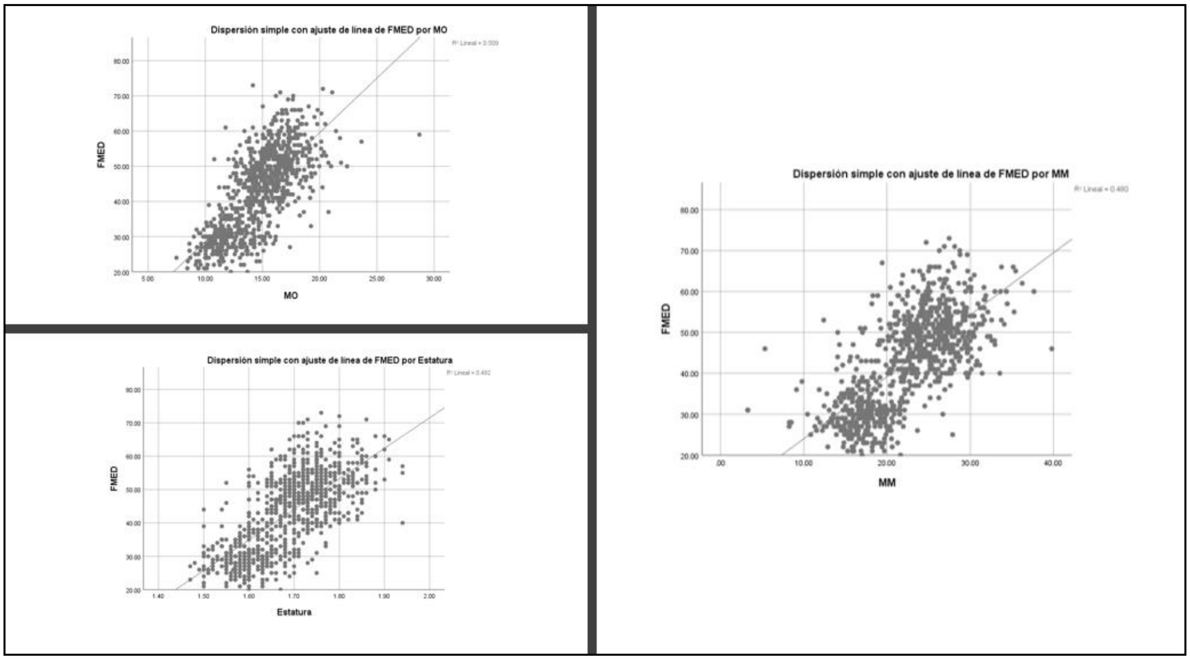
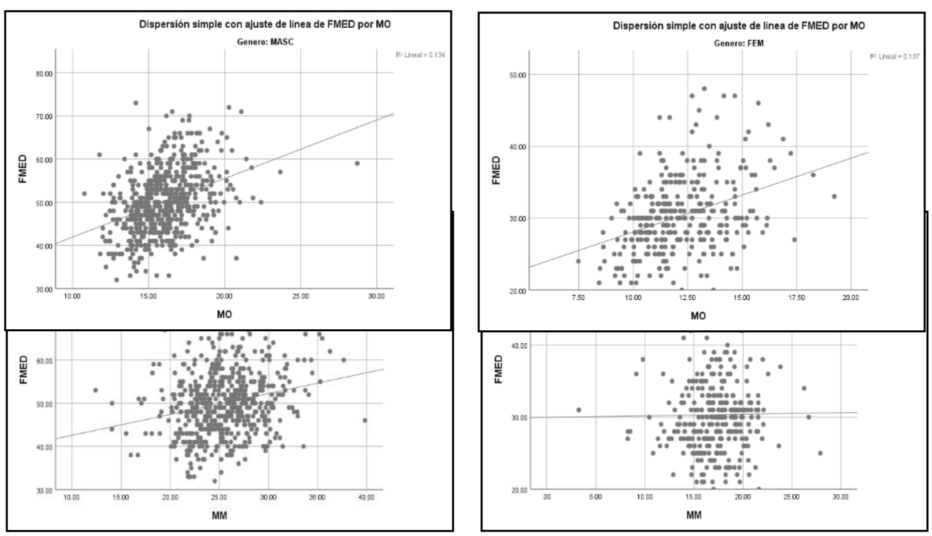



Figure 5. Scatter plots for the variables bone mass, muscle mass and height with manual, global force measurement. p = <.001.




Figures 6. Scatter plots for the variables bone mass and muscle mass, male and female gender. p = <.001.

Table 1. Maximum force in kilograms (median) of the Marine Terminal Madero by departments, are ordered from highest to lowest.

| Terminal Marítima Madero | | | |
|---|---|---|---|
| **Departamento** | **Percentil 25** | **Percentil 50 (Mediana)** | **Percentil 75** |
| **Taller de máquinas y herramientas** | 42 | 56 | 61 |
| **Buzos** | 50.25 | 51.5 | 52.75 |
| **Taller de mantenimiento electromecánico** | 44 | 51 | 59 |
| **Taller de tubería** | 45.25 | 51 | 54.75 |
| **Taller de refrigeración** | 30.25 | 50 | 56 |
| **Taller de pailería** | 38.5 | 49.5 | 56 |
| **Taller de hojalatería y herrería** | 40.25 | 48.5 | 55.75 |
| **Taller mecánico de piso** | 34 | 48 | 55 |
| **Taller de carpintería** | 30.5 | 47 | 51.5 |
| **Transportación** | 33 | 46 | 50 |
| **Taller de soldadura** | 31 | 45 | 51 |
| **Taller eléctrico** | 37.5 | 45 | 51 |
| **Taller de electrónica** | 31.5 | 44 | 54.5 |
| **Manejo de materiales (almacén)** | 31 | 43 | 49 |
| **Taller de instrumentos de control** | 28.5 | 42 | 56.5 |
| **Taller de pintura** | 37.75 | 41.5 | 56.75 |
| **Taller de dibujo** | 34 | 41 | 49 |
| **Patio y maniobras** | 27 | 34.5 | 45.25 |
| **Superintendencia de Mantenimiento Naval** | 25 | 31 | 35 |

Table 2. Spearman's correlation coefficient (rho) for anthropometric variables.

| FMED | | N | Circunferencia Antebrazo | Circunferencia Muñeca | Longitud Palma | Longitud Mano | IMC | Masa Muscular | Masa Residual | Masa Ósea | Masa Grasa | Peso | Estatura |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Todos | Coeficiente de correlación | 888 | .574** | .528** | .479** | .537** | .224** | .701** | .659** | .720** | 0.055 | .528** | .702** |
| | Sig. (bilateral) | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.103 | 0.000 | 0.000 |

Table 3. Global standardized multiple regression model created for the predicted.

| Resumen del modelo | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Modelo** | R | R cuadrado | R cuadrado ajustado | Error estándar de la estimación | Estadísticos de cambio | | | | |
| | | | | | Cambio en R cuadrado | Cambio en F | gl1 | gl2 | Sig. Cambio en F |
| **1** | .857[a] | 0.735 | 0.733 | 5.98667 | 0.735 | 348.084 | 7 | 878 | 0.000 |
| **a. Predictores: (Constante), IMC, Departamento, MM, LongMano, CircAb, Genero, MO** | | | | | | | | | |
| **b. Variable dependiente: FMED** | | | | | | | | | |

Table 4. Predicted values for manual grip strength in women.

| Female | | | | | |
|---|---|---|---|---|---|
| Age ranges | Very low | Low | Normal | High | Very High |
| 18-29 | <26 | 27-28 | 29-33 | 34-38 | >39 |
| 30-39 | <24 | 25-27 | 28-32 | 33-35 | >36 |
| 40-49 | <24 | 25-27 | 28-31 | 32-35 | >36 |
| 50-59 | <23 | 24-25 | 26-30 | 31-34 | >35 |
| >60 | <25 | 26-27 | 27-29 | 29-31 | >32 |

*Predictions created with an adjusted X2 of 0.733, F (7, 878) = 348.08, p = <.001.*

Table 5. Predicted values for manual grip strength in men.

| Male | | | | | |
|---|---|---|---|---|---|
| Age ranges | Very low | Low | Normal | High | Very High |
| 18-29 | <44 | 45-47 | 48-53 | 54-57 | >58 |
| 30-39 | <45 | 46-48 | 48-53 | 54-56 | >57 |
| 40-49 | <43 | 44-47 | 47-51 | 52-54 | >55 |
| 50-59 | <42 | 43-46 | 46-50 | 51-53 | >54 |
| >60 | <42 | 43-44 | 45-47 | 48-49 | >50 |

*Predictions created with an adjusted X2 of 0.733, F (7, 878) = 348.08, p = <.001.*

Table 6. Predicted values for manual grip strengthin women, both hands.

| Female | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age ranges | Very Low | | Low | | Normal | | High | | Very High | |
| | RH | LH | RH | LH | RH | LH | RH | LH | RH | LH |
| 18-29 | <26 | <24 | 27-29 | 25-27 | 30-34 | 28-32 | 34-39 | 34-37 | >40 | >38 |
| 30-39 | <25 | <24 | 26-28 | 25-27 | 28-33 | 27-31 | 33-37 | 32-34 | >38 | >35 |
| 40-49 | <25 | <24 | 26-28 | 25-27 | 28-32 | 27-31 | 32-36 | 31-35 | >37 | >36 |
| 50-59 | <24 | <22 | 25-26 | 23-25 | 27-32 | 26-30 | 32-35 | 31-33 | >36 | >34 |
| >60 | <27 | <25 | 28 | 26 | 28-29 | 26-27 | 29-31 | 28-29 | >32 | >30 |

*Predictions created with an adjusted X2 of 0.711 for the right hand (RH), F (7, 878) = 312.26, p = <.001, and an adjusted X2 of 0.705 for the left hand (LH), F (7, 878) = 302.71, p = <.001. In left-handed people, MD will be considered as the dominant hand.*

Table 7. Predicted values for manual grip strength in men, both hands.

| Male | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age ranges | Very Low | | Low | | Normal | | High | | Very High | |
| | RH | LH | RH | LH | RH | LH | RH | LH | RH | LH |
| 18-29 | <44 | <43 | 45-48 | 44-47 | 49-54 | 47-52 | 54-58 | 53-57 | >59 | >58 |
| 30-39 | <45 | <44 | 46-49 | 45-47 | 49-54 | 47-52 | 54-57 | 52-56 | >58 | >57 |
| 40-49 | <44 | <42 | 45-47 | 43-46 | 48-52 | 46-50 | 52-55 | 51-54 | >56 | >55 |
| 50-59 | <43 | <41 | 44-46 | 42-45 | 47-51 | 45-49 | 51-53 | 50-51 | >54 | >52 |
| >60 | <42 | <41 | 43-45 | 42-43 | 46-48 | 44-46 | 49-50 | 46-47 | >51 | >48 |

*Predictions created with an adjusted X2 of 0.711 for the right hand (RH), F (7, 878) = 312.26, p = <.001, and an adjusted X2 of 0.705 for the left hand (LH), F (7, 878) = 302.71, p = <.001. In left-handed people, MD will be considered as the dominant hand.*

## 7. REFERENCES:


Bohannon RW. Reference values for extremity muscle strength obtained by hand-held dynamometry from adults aged 20 to 79 years. *Arch Phys Med Rehabil*. 1997. January 1;78(1):26–32. 10.1016/S0003-9993(97)90005-8.

Bohannon R. Are hand-grip and knee extension strength reflective of a common construct? *Perceptual and Motor Skills* [Internet]. 2012 [citado 4 Julio 2019];114(2):514-518. Disponible en: https://journals.sagepub.com/doi/abs/10.2466/03.26.PMS.114.2.514-518.

Bohannon R. Hand-grip dynamometry predicts future outcomes in aging adults. *Journal of Geriatric Physical Therapy* [Internet]. 2008 [citado 4 Julio 2019];31(1):3-10. Disponible en: https://insights.ovid.com/pubmed?pmid=18489802.

Boadella J, Kuijer P, Sluiter J, Frings-Dresen M. Effect of self-selected handgrip position on maximal handgrip strength. *Archives of Physical Medicine and Rehabilitation* [Internet]. 2005 [citado 4 Septiembre 2019];86(2):328-331. Disponible en: https://www.archives-pmr.org/article/S0003-9993(04)00663-X/abstract

Chau N, Bourgkard E, Pétry D, Huguenin P, Remy E, André J. Comparison between estimates of hand volume and hand strengths with sex and age with and without anthropometric data in healthy working people. *European Journal of Epidemiology*. 1997;13(3):309-316.

Chandrasekaran B, Ghosh A, Prasad C, Krishnan K, Chandrasharma B. Age and anthropometric traits predict handgrip strength in healthy normals. *Journal of Hand and Microsurgery*, 2010;2(2):58-61.

Clerke A, Clerke J. A literature review of the effect of handedness on isometric grip strength differences of the left and right hands. *Am J Occup Ther*. 2001; 55(2):206-211.

Coronel M. Determinación de la fuerza isométrica de prensión manual gruesa en población en edad laboral con dinamometría obtenida con el equipo terapéutico Baltimore. *Revista Mexicana de Medicina Física y Rehabilitación*. 2019;30(1-2):10.

De S, Sengupta P, Maity P, Pal A, Dhara P. Effect of body posture on hand grip strength in adult bengalee population. *Journal of Exercise Science and Physiotherapy*. 2011;7(2):79-88.

Deepak G, Laxmikant J, Rasika D. Study of correlation between dominant hand's grip strength and some physical factors in adult males and females. *Int J Pharm Res Health Sci*. 2014;2(4):316–323.

Fess EE. Grip Strength, 2nd edition. Chicago: American Society of Hand Therapists, 1992

Fong P, Ng G. Effect of wrist positioning on the repeatability and strength of power grip. *American Journal of Occupational Therapy* [Internet]. 2001 [citado 4 Julio 2019];55(2):212-216. Disponible en: https://ajot.aota.org/article.aspx?articleid=1868976Lauwers T. Grip & Pinch Strength in Relation to Anthropometric Data in Adults. *Orthopedic Research & Physiotherapy*. 2018;4(1):1-7.

González Correa C. Different reference values for hand dynamometry: a conflicting issue. *Nutrición Clínica y Dietética Hospitalaria*. 2017;37(3):104-110.

Günther CM, Bürger A, Rickert M, Crispin A, Schulz CU. Grip-strength in healthy Caucasian adults: Reference values. *J Hand Surg Am*. 2008;33(4):558-65.

Hammed A, Obaseki C. Interdependence of body mass index with handgrip strength and endurance among apparently healthy teenagers. *Turk J Kin,* 2018;4(1):1-7.

Harth, A, & Vetter W. Grip and pinch strength among selected adult occupational groups*. Occupational Therapy International*. 1994;1:13–28.

Heimbürger O, Qureshi A, Blaner W, Berglund L, Stenvinkel P. Hand-grip muscle strength, lean body mass, and plasma proteins as markers of nutritional status in patients with chronic renal failure close to start of dialysis therapy. *American Journal of Kidney Diseases*. 2000;36(6):1213-1225

Hoffmaster E, Lech R, Niebuhr B. Consistency of sincere and feigned grip exertions with repeated testing. *Journal of Occupational Medicine*. 1993;35:788–794.

Innes E. Handgrip strength testing: A review of the literature. *Australian Occupational Therapy Journal*. 1999;46(3):120-140Karwowski W. International encyclopedia of ergonomics and human factors. 2nd ed. London: Taylor & Francis; 2006.

Josty, I, Tyler P, Shewell C, & Roberts N. Grip and pinch strength variations in different types of workers. *Journal of Hand Surgery*. 1997;22B:266–269Kong Y, Song Y, Jung M. Effects of hand position on maximum grip strength and discomfort. Presentación expuesta el; 2011; *HFESA 47th Annual Conference 2011. Ergonomics Australia.*

Koopman J, Van Bodegom D, Van Heemst D, Westendorp R. Handgrip strength, ageing and mortality in rural Africa. *Age Ageing*. 2015;44:465–70.

Lagerström C, Nordgren B. Methods for measuring maximal isometric grip strength during short sustained contractions, including intra-rater reliability. *Upsala Journal of Medical* Sciences, 1996;101(3):273-286.

Massy-Westropp et al.: Hand Grip Strength: age and gender stratified normative data in a population-based study. *BMC Research Note*s. 2011;4:p.127

Mathiowetz V, Kashman V. Grip and pinch strength: normative data for adults. Archives of Physical Medicine and Rehabilitation. 1985;66(2):69-74.

NIHR Southampton Biomedical Research Centre. (2016). Procedure for Measuring Hand Grip Strength Using the Jamar Dynamometer. NIHR Southampton Biomedical Research Centre (BRC, 2, 6. 27/06/2019, de http://www.uhs.nhs.uk.

Nygård, C, Luopajärvi T, Cedercreutz G, & Ilmarinen J. Musculoskeletal capacity of employees aged 44–58 years in physical, mental and mixed types of work. *European Journal of Applied Physiology and Occupational Physiology*. 1987;56:555–561.

Phillips J, Lindstrom-Hazel D, Courtnay C. Grip and Pinch Strength Norms for Michigan Workers. *The Open Journal of Occupational Therapy*: 2013;1:(3):1-6.

Preetha S, Makkhan M, Himanshu C, & Govind D. A comparative assessment of static muscular strength among female operative's working in different handicraft occupations in India. *Health Care for Women International*, 2017;2:1-15.

Rawat S, Varte L, Singh I, Choudhary S & Singh S. Anthropometry based prediction of dominant hand grip strength in Indian office going females. *Asian Journal of Medical Sciences*, 2016;7(1):58-62.

Roberts H, Denison H, Martin H, Patel H, Syddall H, Cooper C et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age and Ageing*. 2011;40(4):423-429.

Wang Y, Bohannon R, Li X, Sindhu B, Kapellusch J. Hand-Grip Strength: Normative Reference Values and Equations for Individuals 18 to 85 Years of Age Residing in the United States. *Journal of Orthopaedic & Sports Physical Therapy*. 2018;48(9):685-693.

# A MOTIVATION FOR SHARING INFORMATION IN INCIDENT MANAGEMENT

**Guadalupe Hernández-Escobedo, Arturo Realyvázquez-Vargas, Wendy Gayosso-de-la-Vega, Hugo Montelongo-Solano, Flor Itzel Villanueva-Vargas**

Departmento de Ingeniería Industrial
Tecnológico Nacional de México/Instituto Tecnológico de Tijuana
Calzada Tecnológico s/n, Fraccionamiento Tomás Aquino
Tijuana, Baja California, México 22454
Corresponding author's e-mail: guadalupe.hernandez@tectijuana.edu.mx

**Resumen:** El propósito de este documento es descubrir cómo la conciencia situacional mejora y controla el intercambio de información hacia la conciencia situacional colectiva. Se exigen tomar decisiones dentro del contexto de operación rutinaria de eventos masivos que contienen la administración de incidentes tanto rutinarios como contingentes. Este contexto considerado inexplorado, dinámico, limitado en el tiempo y complejo proporcionó condiciones excepcionalmente naturalistas para estudiar en intercambio de información. Se eligió un paradigma interpretativo que considera enfoques cognitivos y sociales para conocerlo en profundidad. Aquí, la revisión de la documentación, la observación de prácticas y la entrevista a personal experimentado fueron los métodos para recolectar datos en conciertos y partidos de béisbol en tres ciudades. Se utilizó la Teoría de la Actividad como marco conceptual y herramienta analítica y se empleó el método constante y comparativo. Los datos fueron categorizados destacando significados, riesgos y estimulación de los elementos ambientales y la conciencia de los individuos como las construcciones sociales subjetivas e intersubjetivas demandadas en el contexto.

**Palabras clave**: Consciencia situacional, Intercambio de información, Administración de incidentes, Eventos masivos, Teoría de la actividad

**Relevancia para la ergonomía**: El descubrimiento de una motivación crucial para el intercambio de información es relevante para mejorar las diversas formas en que se podrían gestionar los incidentes. Es una consecuencia para darse cuenta de las motivaciones que podrían mejorarse en el contexto de la gestión de incidentes, que es un entorno de tiempo limitado, incierto y complejo.

**Abstract:** The purpose of this paper is to uncover how situational awareness enhances and controls information sharing towards collective situational awareness. It is demanded to make decisions within the context of routine operation of major events containing the management of both routine and contingent incidents. This context considered unexplored, dynamic, time constrained and complex provided exceptionally naturalistic conditions to study information sharing. An interpretive paradigm considering cognitive and social approaches was chosen to gain in-depth insights of it. Here, the review of documentation, the observation of practices and the interview of experienced personnel were the methods to collect data in concerts and baseball matches in three cities. Activity theory was used as conceptual framework and analytical tool and the constant and comparative method was employed. Data were categorized uncovering meanings, risks and stimulation from the environmental elements and awareness of individuals as the subjective and inter-subjective social constructions demanded in context.

**Keywords**. Situational awareness, Information sharing, Incident management, Major events, Activity Theory.

**Relevance to Ergonomics**: The discovery of a crucial motivation for information sharing is relevant to enhance the diverse forms in how the incidents could be managed. It is a consequence of noticing the motivations that could be enhanced into the context of incident management, which is time constrained, uncertain and complex environment.

## 1. INTRODUCTION

The routine operation of major events implied the alignment of its principal activities to prevent routine incidents and to minimize the impact of contingent incidents (Bowdin, Allen, O'Toole, Harris y McDonnell, 2006). Major events are broadly defined as public or social things that take place with the purpose of entertaining a group of people who have leisure objectives within a place or venue. Routine operation is the set of activities, actions and operations that are performed before, during, and after the normal operation with the goal of preventing incidents or managing potential or active incidents. Incident means any unusual situation that could lead to the loss or disruption of the routine operation. Incident management is the set of activities, actions and operations that are performed before, during and after the routine or contingent incidents with the goal of preventing casualties, reducing their impact on infrastructure and returning to a state of normalcy as routine operation. The result of both types of incidents are generally claimed in strong relation to the number of casualties, the damage to infrastructure and the duration of the interruption by their management (Rozakis, 2007). For this reason, activities are focused on the creation and preservation of SA at individual and collective levels to prevent and manage those incidents. They serve to understand continuously what has happened, what is happening and what would happen in context over time (Endsley, 1995). The goal is to gain a clear picture of the context to make informed decisions (Endsley, 1997), allowing a fast return to a state of routine operation.

At that level of situational understanding, IS is crucial to pass from individual SA to collective SA because diverse types of SA are demanded by organizations. This is due to each organization is centered on achieving its goals and has significantly different understandings of the context. In other words, the context treated here helped on corroborating different situational meanings that served as mediators of IS (Endsley and Jones, 2001). Consequently, the environmental elements included in SA have different relevance to individuals and their organizations. For this reason, passing from individual SA to collective SA is a challenge.

Specifically, the challenge includes the diverse mediators employed by IS involving different technologies. They are principally represented by the information and communications technologies (ICT's) as material tools. These technologies are aligned to facilitate and command it; however, some technologies are not incorporated in the current research. For example, language is seen as control variable. Contrarily, Richardson and Ashtana (2005) suggest that language is an important element of IS by incorporating levels of efficacy and efficiency on it. This opens a gap of knowledge by activating the consideration of abstract technologies or tools. For instance, this consideration gives the opportunity to find and incorporate to the knowledge the tools used. For this reason, the question how individual SA enhances and controls IS towards collective SA? is answered helping on uncovering that SA is a relevant abstract tool in context.

The remainder of the paper is structured as follows: the next section presents a review of abstract tools employed for sharing information and SA. It is followed by an explanation of the context and the methodology employed. Next, the findings are presented followed by conclusions.

## 2. ABSTRACT TOOLS FOR SHARING INFORMATION AND SITUATIONAL AWARENESS

The goal of information sharing is to change the image of the world of individuals so that they should use in a working context (Sonnenwald, 2006). Furthermore, it is seen as nested component of information behavior, which has both cognitive and social dimensions (Wilson, 2009). This approach permits to study it from interpretive strategies enriching its understanding by using diverse paradigms, assumptions and methods. This also allows researching its motivations, types, technological mediators and challenges (Sonnenwald, 2006), specifically, the abstract mediators or tools. Thus, the literature review is only focused on abstract tools and SA.

Language is the principal abstract tool utilized to mediate and control human activity (Engestrom, 1987) and used during social interactions between individuals underpinning face-to-face interactions (Wilson, 1997). It is studied as a control variable and contextualized as the language of emergency management (Mishra, Allen and Pearman, 2011); the military (Sonnenwald and Pierce, 2000); the police (Allen, 2011) among others. Nonetheless, Richardson and Ashtana (2006) stated that professional language, as dependent variable, is an element of IS helping on clarifying relationships between individuals from diverse organizations using shared images of the world. Another abstract tool is expertise. Constant et al. (1994) argued that expertise is an element of behavior that facilitated and regulated IS, but it is strongly linked to positive attitudes. Other abstract tools are training (Hara and Kling, 2002); information culture (Meyer, 2009); body language (Sonnenwald et al., 2004); shared meanings of symbols and implications of information (Sonnenwald, 2006), among others. However, their efficacy and/or efficiency are not commented on in terms of facilitating or regulating IS. For example, Shattuck and Woods (2000) pointed out the necessity to deal with ambiguity of language in dynamic and complex environments because it can lead to misunderstandings for creating usable images of the world.

Situation awareness or situational awareness are two terms used interchangeably, but situational awareness (SA) is preferred because to point out the necessity of individuals to be aware of diverse situations in context, which analyzed and not measured (Endsley, 1994a). This allows the understanding of naturalistic situations with unique characteristics and attributes. SA is defined “as the perception of elements in the environment within a volume of time and space, the comprehension of their meaning in terms of task goals, and the projection of their status in the near future” (Endsley, 1995, p.36). Its value is critical to control dynamic, time constrained and complex environments (Sonnenwald and Pierce, 2000) by helping on projecting future states of environments permitting to make informed decisions. SA is considered a product for being a complete understanding of specific situations resulting in a mental model o picture. On the other hand, SA is considered a process for achieving stages to complete situational understandings (Endsley et al., 2003). Furthermore, SA has been informed by the information and ecological perspectives (Tenney and Pew, 2006). The former perspective involves four stages summarized as perception of environmental elements, comprehension of those elements in context, projection of states of those elements and prediction of what external variables may affect that projection (Endsley, 1995). Contrarily, the ecological approach summarizes the dynamic interaction between individuals and the environment defining SA in context (Smith and Hanckock, 1995). Flach (1995) stated that SA is the creation of “meaning with respect to both the objective tasks constraints (i.e. the situation) and the mental interpretation (i.e. awareness)” (p.151) at individual level. It is considering “who understand via awareness (the cognitive agent) and the implications of the situation (objective reality)” (Flach, 1995, p.151). It also includes the theory of affordances (Gibson, 1983). An affordance is an attribute of objects or environmental elements that allow individuals to perform actions (Gibson, 1986). That is, SA is created in relation with the situation in context shaping the tasks performed (Tenney and Pew, 2006) and at individual and collective levels.

The individual SA or SA, from here to onwards, implies the discovery of information in context to create and maintain awareness of what is going on around individuals (Millward, 2008) and it can lead to IS (Solomon, 2002), if individuals create meanings of the environmental elements (Flach, 1995). This is because differences in the mental model can lead to IS and can be observed in the diverse relationships emerged between individuals during the routine work (Endsley et al., 2003). The response can be seen in how individuals manage the information obtained and how information is shared and this starts with SA at individual level considering other individuals in context. However, certain individuals are not prepared to add their pieces of situational information in time constrained environments (Kaber and Endsley, 1998). Therefore, it is important to recognize that each individual should have particular goals to accomplish, plays a specific role, or performs a certain function in interacting with elements in the task environment by passing from individual to collective SA. Thus, individual SA plays an important role in generating and preserving collective SA (Millward, 2008).

On the other hand, the collective SA refers the shared SA or shared understandings between at least two individuals in context. It was found as team SA, distributed SA, shared SA and interwoven SA. Team SA is treated as an element required by diverse members of teams to achieve their roles by helping them with the understanding of what is happening in situations in context, and how this understanding aids with their responsibilities, accomplishing organizational processes as communication, coordination, collaboration and performance backed up by IS. Distributed SA is related related to the interaction between individuals with devices providing knowledge and information to understand situations. Shared SA is seen as the overlaps between individuals in context (Endsley and Jones, 2001) and in consideration of shared requirements (Endsley and Jones, 1997) and it is defined as “a process of knowing what is going around oneself and others with whom one interacts” (Millward 2008, p.13). He argued that there are two types: one does not demand IS (called type I) and another demands IS (called type II). Interwoven SA stressed the necessity of diverse types of SA to “facilitate task completion” (Sonnenwald and Pierce, 2000, p.471) and is defined as the “interwoven patterns of individual, intra-group and intergroup situational awareness” (Sonnenwald and Pierce, 2000, p.476). This implies the recognition of their roles, distinguishing their physical position and using tools for facilitating the interaction. However, if multiple types of SA is shared and received these can lead to misinformation and information overload (Kaber and Endsley, 1998) and using diverse sources can generate tensions with/between individuals and their organizations (Endsley and Jones, 2001). Nonetheless, the relationship of IS and SA towards collective SA has not clearly stated, so this opens a gap of knowledge. In addition, this relationship has theoretical, methodological and practical implications that are treated in the section of conclusions.

## 3. CONTEXT AND METHODOLOGY

### 3.1 The Context of the Routine Operation and Incident Management at Major Events

This research was undertaken at concerts and baseball matches in Tijuana, Los Mochis and Guasave, cities located in the northeast of Mexico. The local government of Tijuana organized the concerts during the months of September and October 2011. The managers of the franchises of the baseball teams at Los Mochis (denominate stadium 1) and at Guasave (denominate stadium 2) within the Pacific Mexican League organized the baseball matches during the regular season 2011-2012. The organizers deployed a pyramid/hierarchy organization to control the routine operation. This organization followed guidelines included in the General Law of Civil Protection (Estados-Unidos-Mexicanos, 2012), which suggested the formation of a command and control area (C2) assembled by the leaders of all participant organizations. Here the individuals exhibited the authority and responsibility in concern with their abilities, knowledge and experience managing incidents. In particular, as set out in the next section, it involves co-ordinating the activities of a number of different organizations that are not necessary used to working together with each other.

Once the C2 is deployed, the leaders agreed what areas their personnel should cover. It was usual that some individuals stayed in determined areas while others patrolled some areas of the venues over time. For example, individuals commented that these patrols helped in understanding what is happening over time within the venues and in discovering those areas that might be seen as problematic, because they can suddenly change over time. For instance, it was usual that the individuals discovered those areas for potential incidents so that they increased the patrols over time. These kinds of actions allowed the anticipation of incidents. Contrarily, the located individuals were alert to manage the contingent incidents. Nevertheless, in certain incidents, as fights, faints, drunkards, etc., they were inadequate to manage those incidents so that individuals from other organizations were involved to recover a state of normalcy.

### 3.2 Participants and Their Organizations

The study involved diverse organizations and 13 organizations were included in the study: two baseball teams (serving as organizers of baseball matches), a department of the local government (serving as organizer of the concerts), two divisions of the Police (active and commercial), the Fire Department, two Civil Protection areas, the Red Cross, two voluntary organizations and two security organizations. This allowed inclusion of individuals with experience in incident management and with roles at tactical and operational levels forming the pyramid/hierarchy organization and their leaders constituted the C2. Additionally, each organization and its members wore uniform to distinguish between each other in context.

In the concerts, the Public Relations Department of the Local Government organized the concerts and directly controlled the leaders of Firemen, the Police and the Civil Protection Department. Similarly, the Police controlled the traffic in areas surrounding the venues and guarded the entrances and the interior of the venues converging three divisions: active, transit and commercial. Likewise, the Firemen receiving support from the Civil Protection area controlled the voluntary organizations and the Red Cross. In stadium 1, the manager organized and controlled the security organizations and the Police. Both guarded the events, but the security organizations did preventive actions and the Police corrective actions. This was because the Police can arrest individuals, but the security organizations cannot. In stadium 2, the managers organized and controlled the security organization. The Police were not a permanent organization in these events, but it was common practice that periodic they patrolled the interior of the venue. Uncommonly, the Red Cross, the Civil Protection Area and voluntary groups were involved to support the routine operation.

### 3.3 Gathered Data

Observation of current practices, interview of incident responders using the Critical Incident Technique (Flanagan, 1954), and review of organizational documentation were the methods used to gather data in the fieldwork. This was done in three cities during six months at two concerts and 21 baseball matches. The fieldwork was done in three phases. The first phase involved the observation of practices in two concerts with an audience of 55,000 and 35,000 spectators respectively. The organizational documentation was reviewed and 17 semi-structured and face-to-face interviews were conducted with operative and tactical personnel. The next phase included the baseball matches. The practices were observed in 19 matches that incorporated the semifinals and the finals of the season 2011-2012. The organizational documentation was reviewed and 19 interviews were conducted with operative and tactical personnel. The final phase covered the review of organizational documentation of the concerts and 19 interviews with operative and tactical personnel. The fieldwork overall resulted in 55 interviews with operative and tactical personnel reporting 119 incidents; nearly 100 hours of observations in 21 events discovering 56 incidents, and the review of 147 documents. During this process, standard ethical guidelines were followed. For example, all gathered data was codified to assure confidentiality and the interviews were done after the participants gave their authorization to be interviewed.

### 3.4 Analysis of Data

The rationale for using Activity Theory as framework and analytical tool for the research under the information behavior approach is because it “can be quite a powerful analytical tool and conceptual framework of inquiry” (Wilson, 2006, p.9). Specifically, this framework is found useful to study IS (Hassan Ibrahim and Allen, 2012) and gives the opportunity to study the human activity in everyday practice pondering the cultural and historical context and the individual and social levels (Wilson, 2008). This is because the “human mind…and can only be understood within the context of human interaction with the world, and this interaction, that is, activity, is socially and culturally determined” (Kaptelinin et al., 1999, p.28). The object of IS helps to “understand not only what people are doing but also why they are doing it” (Kaptelinin, 2005, cited in Nardi, 2005, p.38). As analytical tool, it enables the understanding of the context where IS is studied. Engeström (1993) pointed out that it is an integrated whole containing diverse elements including the tools and artifacts within the activity system. This implies the analysis of the collected data initiating with clarifying the activity elements; following with exploring those elements with the lens of the activity principles; and finalizing with discovering inner contradictions that entail tensions on situations involving subjects that consequently change the nature of activity to overcome those strains (Engeström, 1987). Therefore, it permits to study in detail the mediation of its elements (Engeström, 1987) by analyzing separately each element and after as a whole. Its deconstruction gives also advantages for analyzing in detail IS and in gaining insights in how SA mediates and control IS in context.

It also includes "an interpretive, naturalistic approach" (Denzin and Lincoln, 2000, p.3). This permits to gain in-depth understanding of social phenomena in the naturalistic context treated here, which is "little known" (Denzin and Lincoln, 2000, p.3). This also lets to gain in-depth understandings of the SA demanded in context at individual and collective, that is associated with the personal subjective and inter-subjective meanings while they interact with the world around them (Malterud, 2001). Reality is a social construction of individuals that similarly includes other realities, a consequence of continuous interaction between them (Guba and Lincoln, 1994). Hence, these multiple-voiced constructions permit to access the meanings of individuals shared between them (Denzin and Lincoln, 2005). Furthermore, the research captures the unpredictability of situations through the meanings given by individuals (Klein and Myers, 1999) offering extra understandings of the context.
NVivo9 was chosen to facilitate the handling, management and analysis of qualitative data, offering interactivity, code and retrieval functionality, data organization among other benefits (Lewins and Silver, 2009). The language of analysis was Spanish because the collected data was in that language. In this respect, some researchers argued that work with transcripts of naturally occurring data bring transparency of the phenomenon under study (Shin et al., 2007). Consequently, some quotations were translated to English to be used in this paper. Furthermore, the inductive approach permitted the discovery of "frequent, dominant, or significant themes inherent in raw data, without the restraints imposed by structured methodologies" (Thomas, 2006, p.238). This also aided to link the concepts and themes (Rubin and Rubin, 2011). Initially, the data was revised and prepared for being analyzed in relation to the richness of the description of the incidents, facilitating the subsequent steps. The coding process is "a process of simultaneously reducing the data by dividing it into unit of analysis and coding each unit" (Calloway and Knapp, 1995, p.2). This started using the open coding procedure in which data were coded interpretatively and using the constant comparative method (Strauss and Corbin, 1998). This enables the discovery of the codes required to answer the research question and is iterative until saturation was reached. Subsequently, data were reviewed using those codes until new codes were not discovered (Strauss and Corbin, 1998). The next step is axial coding related to linking categories at the level of properties and dimensions until the point of selective coding is reached. This means that no new properties, relationships or dimensions emerged (Pickard, 2007). Although, the process of coding was iteratively, one piece of data has served to compare others to develop conceptualizations and process memos were extensively written and used gaining insights of the relationships between codes (Miles and Huberman, 1994). For example, the role of information providers and receivers and individual SA were themes classified inside of the theme collaborative SA as an outcome of IS in face-to-face interactions.

## 4. FINDINGS

Findings suggest that environmental information was employed to create situational meanings from the context and it served to project their future states in which external variables were considered. Moreover, findings suggest that individuals shared information when they obtained meanings from situations. If they were able to obtain meaning of situations (Flach, 1995), they may project future states of those elements, so they were likely to share information with other individuals (Endsley and Jones, 1997). Furthermore, the findings suggest similarities with discoveries in other investigations in collaboration (Sonnenwald et al., 2004), in the military (Endsley and Jones, 2001) and in team performance (Millward, 2008). For example, Sonnenwald et al. (2004) argued that SA included elements from the context, socio-emotional aspects and characteristics of tasks and processes performed. In this line, the findings uncovered similar sources in which emotional aspects were not considered for ethical reasons. Furthermore, Endsley and Jones (2001) and Millward (2008) argued that SA provided the elements for creating collaborative SA in others via communication. This investigation found the same elements and via considering that in this paper communication is seen as IS (as a two-way process). Moreover, the findings confirmed that SA mediated and controlled IS using other abstract and material tools as means to achieve that collaborative SA presented in the next sections.

### 4.1 Meanings of Environmental Elements

The elements included in SA captured the meanings created from environmental elements that continuously were updated (Sarter and Woods, 1991). This permitted to project the states of the situations and predict what factors may affect the situations (Endsley, 1995). In this line, individuals suggested two elements required in context, that included the state of the situation in terms of what is and what should be (Hancock and Diaz, 2002). One was in relation to what was happening in a determined place and time. The other was in reference to what is the best state of the routine operation in major events (no incidents or fast return to this state). Both implied the discovery of complexities in situations which were included in the SA created (Rauterberg, 1995). Consequently, individuals located those environmental elements that mismatch the expected state of the situations. This was seen in the continuous interaction and immersion in the environment (Gibson, 1986) allowing the adaptation of individuals to the environment (Smith and Hanckock, 1995). For instance, when individuals understood that "*beer sellers left bottles to the spectators during the baseball matches (e21)*" means that they were immersed in the environment and their tasks were shaped by it uncovering their role mediating consequently IS. This was seen when one-another noticed, "*they (bottles) can cause damage (e21)*" suggesting future states of the situations because "*bottles are used as projectiles (e21)*". For this reason, it is suggested additional research on investigating what other elements are included in SA, what meanings they have and how they are connected with future states in context.

### 4.2 Discovery of Risks in the Environment

The discovery of environmental risks was considered relevant in context. Individuals pointed out the requirements to open the vision at the moment of evaluating the situations so that they can broadly understand the situations and their risks. For instance, certain individuals should "*open the vision and evaluate the scene (e7)*" in order to "*report what happened (e7)*". Individuals should focus their attention to certain environmental elements and others should be discarded (Harrald and Jefferson, 2007). This phenomenon is named *attentional tunnelling* (Harrald & Jefferson, 2007, p. 6)" or "*tunnel vision (e7)*". However, this generated tensions between individuals for being certain of what was going on because they expected to manage incidents fast, but "*safety is relevant to individuals (e7)*". That was because individuals "*should see the intrinsic risks that can be in the surroundings, but without stopping (e7)*". For instance, when individuals evaluated the situations, they wanted to "*know if there was an incident, or they (spectators) were only try to confuse us in order to gain attention of uniformed people (policemen) and left uncovered other areas (e46)*". Furthermore, the "*evaluation of the scene helped to intervene in a safe way (e7)*". Nonetheless, this type of performance "*could be seen as selfish behavior. This was because individuals (safety and security responders) arrived to the scene, but they did not want to nurse casualties (e7)*". In other words, individuals demanded that the evaluation "*served to assess the risks included in the problematic area and what type of resources would be required to manage that incident (e7)*" triggering information sharing. Hence, it would be important to study how risks are located; what risks are relevant to safety and security areas; to what extent individuals are connected with those risks and are trained to discover them; how risks and future states of situations are united, and what type of training effectively improve the skills and abilities to avoid *attentional tunnelling* and to trigger IS in context.

### 4.3 Stimulation from of Environmental Elements

The next element of interest was the reception of the stimulation from the environmental elements which subsequently were transformed and processed (Hancock and Diaz, 2002). For instance, when individuals saw that "*there was a circle within the crowd (e49)*", individuals suggested that this was an "*unusual crowd movement (e49)*" that should be managed. Being sure of what was going on triggering IS involving those individuals who can manage the incidents and notifying those who can control and coordinated them. This was seen when "*the incident management depends on the types of incidents (e49)*". Another example was when certain individuals "*observed something unusual in the middle of the crowd, because it is notorious (e51)*", they subsequently notified to those individuals located near to that area because they should know the localization of others (Roth and Multer, 2005). Here, their positions were updated continuously verbally or being visible for using uniform. Tensions arose in context "*until the incident has been managed (e51)*". This was because in certain incidents, spectators "*could be invited to abandon the event (e51)*" for being involved in incidents and IS was employed with this goal. Some questions arose related to what crowd movements are considered unusual and why, and what information is considered to locate individuals in context.

### 4.4 Awareness of Individuals

This element was in relation to discover individuals in context and specifically, to be aware of the identity of those individuals (Glaser and Strauss, 1964), the perceptions of their competence (Treurniet et al., 2012) and the definition of their role, confirmed by their uniform. For example, guards were aware of policeman, but they did not want to "*spend the relationship (e21)*" in minor incidents so that they prefer to manage them without their support. In those cases, the guards weighted the support that could be given by policeman so that it would be solicited "*only when it was required (e21)*". Furthermore, individuals also expected that other individuals performed their roles; otherwise, additional individuals would be required to assist them when they failed or required support. For this reason, those individuals were "*located behind of the firemen and policemen (safety and security responders) (e19)*" to back them. Similarly, when individuals solicited support by providing "*oxygen and open(ning-added-) more space (e19)*". Moreover, additional research was suggested to answer the questions what skills and abilities are expected to perform individuals, what roles are principally required, how individuals comprehend that support is required and how it is expected, and to what extent individuals are located near to individuals managing incidents.

## 5. CONCLUSIONS

In this paper, the significance of SA as abstract tool is presented. It serves to enhance and control IS in the routine operation and incident management at major events. This naturalistic context is considered unexplored, dynamic, time constrained and complex and includes the management of both routine and contingent incidents. The findings suggest that individuals employed SA to mediate and control IS towards creating collective SA in context. Individuals obtained information from context including tasks, processes and other individuals (Sonnenwald et al., 2004). This helped to obtain meanings for being immersed in it (Flach, 1995; Gibson, 1983; Gibson, 1986), which also allowed their adaptation to the environment (Smith and Hanckock, 1995). Subsequently, this information was utilized to project future states of the situations (Endsley, 1995) in which other individuals were included providing information to them (Costello et al., 2006; Milham et al., 2000; Cuevas and Bolstad, 2010; Millward, 2008). This was seen when individuals discovered risks and received stimulation from the environment (Hancock and Diaz, 2002) and served to identify other individuals (Glaser and Strauss, 1964) and their competences (Treurniet et al., 2012). For these reasons, the evidence exhibited that SA is likely to mediate and control IS for creating and maintaining collective SA in context.

Referring to the methodological implications, the approach taken is proved to be as a feasible tool to study IS and SA. Specifically, the activity theory helped to uncover the influences of the context by discovering the relevant environmental elements included in the SA demanded. This was confirmed with the activities performed by individuals in strong relation with this context. In addition, the use of three methods to gather data provided enough information to obtain a holistic view of what is happening in the routine operation at major events. This helped on understanding what environmental elements were crucial to trigger IS towards collective SA. Furthermore, the frame employed provided additional factors that were relevant in context. For example, the responsibility implied in the individual SA that triggered IS towards collective SA.

The practical implications uncovered the uses of individual SA in the development of knowledge, abilities and expected performance of the individuals implicated in context. Training is one way to achieve this. Moreover, the comprehension of what environmental environments were mentioned by whom put on manifest the relationships between the organizational goals and the information seeking strategies using the human sensory systems. This can be studied under the information behavior providing additional insights.

To sum up, this research helped on uncovering the significance on how SA enhances and controls IS towards collective SA in context. Findings serve to put on manifest diverse relevant environmental elements included in SA so that this permitted to infer the necessity of projecting those elements for making informed decisions. Here, the use of sensory systems in context was crucial to create SA permitting to include other individuals by sharing information with them. Furthermore, this research presents significant results of SA in a different context as usual (far removed from the military, command and control areas). On the other hand, additional research is needed to explore these issues involving other organizations and their personnel that were excluded in this study and considering other major events in Mexico and alternative countries.

## 6. ACKNOWLEDGMENTS

We would like to acknowledge to the ESRC and 1Spatial for funding this project through the Dorothy Hodgkin Postgraduate Award. Similarly, we would like to bless to the PROMEP and TecNM/Instituto Tecnológico de Tijuana for partially funding the study. We would also like to thank to the participants and their organizations for contributing with this study. The interpretations and views in this paper, however, are solely those of the authors.

## 7. REFERENCES

Allen, D., Karanasios, S., y Slavova, M. (2011). Working with activity theory: Context, technology, and information behavior, Journal of the American Society for Information Science and Technology, Vol. 62, pp. 776-788.

Bedny, G., Seglin, M., y Meister, D. (2000). Activity theory: history, research and application, Theoretical Issues in Ergonomics Science, Vol. 1, pp. 168-206.

Bowdin, G., Allen, J., O'Toole, W., Harris, R., y McDonnell, I. (2006). *Events management* (2nd ed.). Oxford: Elsevier.

Breton, R., & Rousseau, R., "Situation awareness: a review of the concept and its measurement*",* DREV TR-2001-220 Defence Research Establisement Valcartier, 2003.

Endsley, M. "The role of situation awareness in naturalistic decision making". In C. Zsambok, & G. Klein (Eds.), Naturalistic Decision Making, pp. 269-283, Mahwah, USA: Lawrence Earlbaum, 1997.

Endsley, M. "Toward a theory of situational awareness in dynamic systems. Human Factors , 37 (1), pp. 32-64, 1995.

Endsley, M. R., & Jones, W. M. "A model of inter- and intra-team situation awwareness: implications for design, training, and measurement" In M. McNeese, E. Salas, & M. Endsley, New trends in cooperative activities, pp. 46-67. Santa Monica, California, Estados Unidos: Human Factors and Ergonomics Society, 2001.

Estados-Unidos-Mexicanos, C.G.d.l. "Ley general de protección civil". Congreso General de los Estados Unidos Mexicanos, Mexico City, Mexico: Diario de la Federación, p. 29, 6 June 2012, 2012.

Flach, J. M., "Situation awareness: proceed with caution", Human Factors , Vol. 37, pp. 149-157, 1995.

Flanagan, J. C. "The critical incident technique". Psychological Bulletin , 51 (4), pp. 327-358, 1954.

Gibson, J. J., "The senses considered as perceptual systems", Westport, USA: Greenwood Press, 1983.

Hernandez-Escobedo, G.; Allen, D. and Pearman, A., "Comprensión de las situaciones en la prevención de incidentes durante conciertos y partidos de beisbol", Proceedings of the VII Congreso Internacional de Ingeniería Industrial Argos 2014, 22-24 October 2014, Mexicali, Mexico, pp. 241-254, 2014.

Klein, G., "Analysis of situation awareness from critical incident technique reports", In M. R. Endsley and D. J. Garland, Situation awareness analysis and measurement, Lawrence Erlbaum Associates, pp. 51-71, 2000.

Millward, S., "Understanding the Shared Situation Awareness Process: A Communication Framework for Improved Team Performance", Lightning Source Incorporated, 2008.

Mishra, J., Allen, D. and Pearman, A., "Activity Theory as a Methodological and Analytical Framework for Information Practices in Emergency Management", *Information Systems for Crisis Response and Management (ISCRAM)*, Available on: http://www.iscramlive.org/ISCRAM2011/proceedings/papers/140.pdf, 2011.

Richardson, S., & Asthana, S. (2005). Policy and legal influences on inter-organisational information sharing in health and social care services. *Journal of Integrated Care , 13* (3), 3-10.

Rozakis, M. (2007). The cultural contexts of emergencies. Seeking for a(n) holistic approach on disaster management. *Disaster Prevention and Management*, 16 (2), pp. 201-209.

Stake, R., "The art of case study research". London: Sage, 1995.

Strauss, A., and Corbin, J. "Basics of qualitative research: Techniques and procedures for developing grounded theory", Sage: London, 2007.

Wilson, T. D., "A re-examination of information seeking behaviour in the context of activity theory", Information Research, Vol. 11, 2006.

# DESIGN OF AN EDUCATIONAL AND INTERACTIVE GAME TO IMPROVE PERFORMANCE OF MATHEMATICAL SKILLS IN CHILDREN OLDER THAN FIVE AND LESS THAN NINE YEARS OLD EVALUATED WITH NASA-TLX

**Cristian Vinicio López Del Castillo, Penélope Guadalupe Álvarez Vega, Dinora Monroy Meléndez, Jazmín Argelia Quiñónez Ibarra, Yazmín Montaño García.**

Department of Engineering and Technologies
Universidad de la Sierra
Carretera Moctezuma-Cumpas, Km. 2.5
Moctezuma, Sonora, México 84560

div.ingenieria@unisierra.edu.mx, palvarez@unisierra.edu.mx, dmonroy@unisierra.edu.mx, jquininez@uniserra.edu.mx, yazminmg98@gmail.com

**Resumen:** La Ergonomía Cognitiva estudia y aplica los conocimientos en **Psicología Básica** al diseño de entornos de trabajo, tareas, sistemas, etc. En otras palabras, se trata de adaptar tanto objetos, como espacios, sistemas e incluso horarios de trabajo al funcionamiento natural de las habilidades cognitivas de la persona para potenciarlas y evitar su desgaste.

Cuando combinamos los términos *Cognición y Ergonomía* lo hacemos para indicar que nuestro objetivo es estudiar los aspectos cognitivos de la interacción entre las personas, el sistema de trabajo y los artefactos que encontramos en él, con el objeto de diseñarlos para que la interacción sea eficaz. Los procesos cognitivos como percepción, aprendizaje o solución de problemas juegan un papel importante en la interacción y deben ser considerados para explicar tareas cognitivas, tales como la búsqueda de información y su interpretación, la toma de decisiones y la solución de problemas, etc.

El presente proyecto, tuvo como objetivo la elaboración de un material didáctico con un juego interactivo: "Una forma divertida de aprender" que fue basado en las necesidades de los niños mayores de cinco años y menores de nueve años de la Escuela Primaria Benito Juárez de la localidad de Moctezuma, Sonora. Por ende, lo que se buscó con este juego fue contribuir a la disminución de la carga mental de los niños al realizar operaciones matemáticas, reduciendo con esto un porcentaje considerable en el estrés de estos, ya que al sacarlos un poco de la monotonía estos son atraídos a prestar más atención y desarrollan con más facilidad su habilidad mental.

De acuerdo con la metodología utilizada (Método NASA-TLX), se obtuvo un resultado favorable en la evaluación de una muestra de 36 alumnos de la Escuela Primaria, arrojando que dicho juego funcionara de una forma exitosa a la hora de utilizarlo como método de reducción cognitiva.

**Palabras clave:** Ergonomía Cognitiva, diseño, enseñanza-aprendizaje, didáctico.

**Relevancia para la ergonomía:** Diseño de juego interactivo, sobre el aprendizaje cognitivo, para solución de operaciones matemáticas, reduciendo carga mental en el aprendizaje de niños de entre cinco y nueve años.

**Abstract** Cognitive Ergonomics studies and applies knowledge in Basic Psychology to the design of work environments, tasks, systems, etc. In other words, it is about adapting both objects, spaces, systems and even work schedules to the natural functioning of the person's cognitive abilities to enhance them and prevent wear and tear.

When we combine the terms Cognition and Ergonomics, we do so to indicate that our objective is to study the cognitive aspects of the interaction between people, the work system and the artifacts that we find in it, in order to design them so that the interaction is effective. Cognitive processes such as perception, learning or problem solving play an important role in the interaction and must be considered to explain cognitive tasks, such as the search for information and its interpretation, decision making and problem solving, etc.

The objective of this project was to develop a didactic material with an interactive game: "A fun way to learn" that was based on the needs of children over five years of age and under nine years of the Benito Juárez Elementary School in the town of Moctezuma, Sonora. Therefore, what was sought with this game was to contribute to the decrease of the mental load of children when performing mathematical operations, thereby reducing a considerable percentage in their stress, since by taking them out of the monotony these are attracted to pay more attention and develop their mental ability more easily.

According to the methodology used (NASA-TLX Method), a favorable result was obtained in the evaluation of a sample of 36 Primary School students, showing that said game worked successfully when used as a cognitive reduction method.

**Key words:** Cognitive ergonomics, design, teaching-learning, didactic.

**Relevance to Ergonomics:** Interactive game design, about cognitive learning, to solve mathematical operations, reducing mental load in the learning of children between five and nine years old.

## 1. INTRODUCTION

Cognitive ergonomics is defined as the scientific discipline that studies the design of systems interested in mental processes, such as perception, memory, reasoning, and motor response, to the extent that this affect the interactions between human beings and any other elements of a system where people do their work.

A neurological game is being proposed, one that can be played in multiple contexts either at school or at home, which can be useful to any child over five years of age.

This Project was created for children to have interactive learning, which consists of subtracting and adding, as well as allowing the identification of four colors. This Project helps to reinforce children´s knowledge with less difficulty and in a much more fun way.

The interactive game requires a lot of concentration, since its main purpose is for children to learn how to do a subtraction and addition. By knowing the risks that children can suffer from having a high mental load, this interactive game is created that provides cognitive help to mitigate these risks in children over five years old, where children who begin to show frustration when performing mathematical operation will be carried out, mixing an exciting game trying not to collapse, the child is motivated and learns at the same time; the stress that was initially generated over time is lost when through practice the mind speeds up and the response time is shorter.

## 2. OBJECTIVES

- Create an interactive game for the development of mathematical skills in children older than five and younger than nine years of age.
- Apply the NASA-TLX method to evaluate the estimate of mental load before and after evaluating the child through a mathematical operations test and the use of the game.

Delimitation: children between the ages of five and nine years old.

## 3. METHODOLOGY

The first step that was carried out was the creation and design of the interactive game based on the game known worldwide as Jenga.

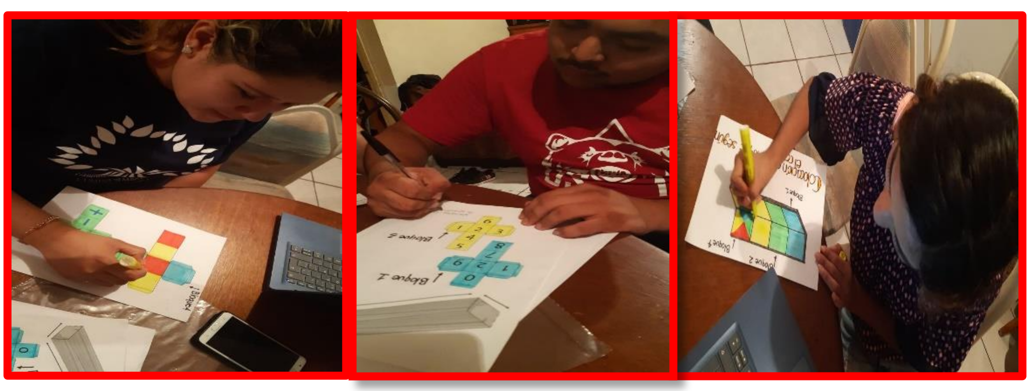


Figure 1. Design of the cubes with numbers and colors.

The next step was to obtain the sample size. The technique was applied to children form the first, second and third grades of an elementary school, from six to nine years old, from the Benito Juárez elementary school from Moctezuma, Sonora.

The following equation was used:

$$n = \frac{N \times Z_a{}^2 \times p \times q}{d^2 \times (N-1) + Z_a{}^2 \times p \times q} \quad (1)$$

Where:
**N =** Total sample size.
**Z =** Confidence level.
**P =** Probability of success or expected proportion.
**Q =** Probability of failure.
**D =** Precision (Maximum permissible error in terms of proportion).

In the third step, the variables to be measured were defined. In the case of this project, it was evaluated with a mathematical operations test; as a whole, it wa evaluated with the NASA-TLX method, where it has as variables the mental demand, physical demand, time demand, performance, effort and frustration at last. The objective of the evaluation with the NASA-TLX method is to know the mental load when carrying out an activity.

In the first test, a set of mathematical operations was designed, including both addition and subtraction, to make it a little more fun and attractive, some illustrations were added where depending on the result of the operations, a color is assigned to the illustration.

In the second evaluation, which would be the NASA-TLX method, its format was redesigned, for easy use and data collection where the behavior and attitude were observed.

At the same time, each student was evaluated with the NASA-TLX method with the help of students from Universidad de la Sierra; the behavior and attitude were observed.

As a fifth step, the results obtained from the Mathematical Operations Test and the NASA-TLX method were analyzed. In this phase of applying the NASA-TLX method to facilitate the annotation of information from each student, a format was designed using a table that contains information such as the full name, age, time in which the mathematical operations test was performed and the last columns are the six criteria that the method evaluates.

**Test de operaciones matemáticas**

**Nombre**______________________________ **Edad** ______

**Fecha** ______________________________ **Tiempo** ______

❖ Realizar los siguientes ejercicios de suma.

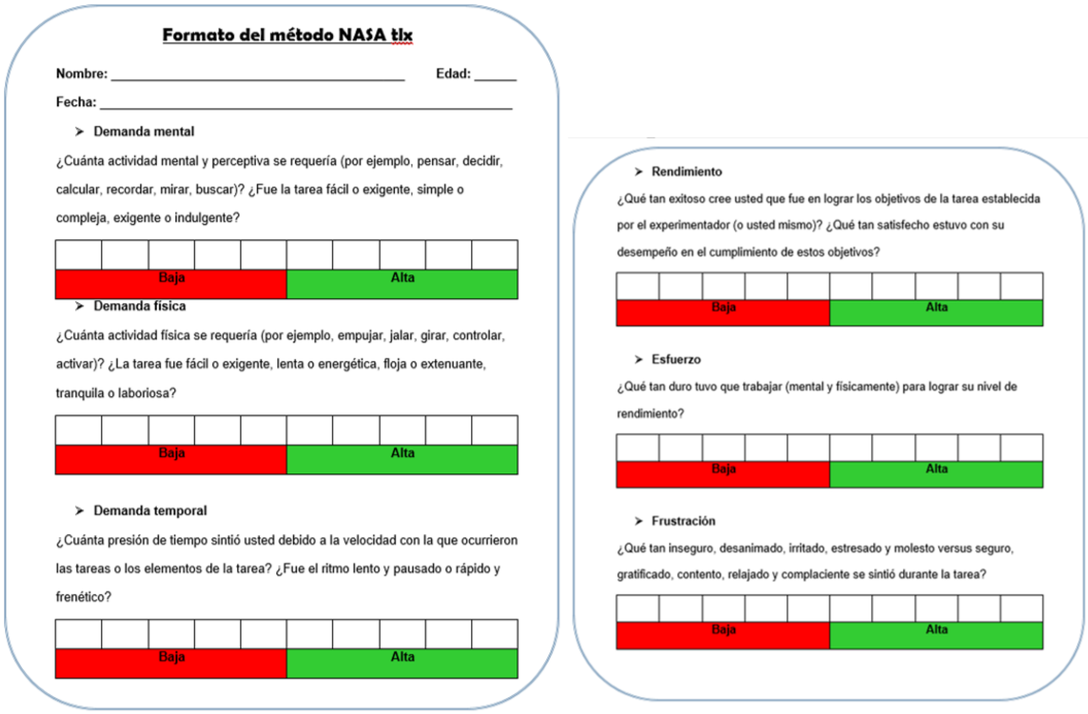
| | | | |
|---|---|---|---|
| 6 + 9 = | | | |
| 7 + 2 = | | | |
| 9 + 5 = | | | |
| 5 + 2 = | | | |
| 8 + 5 = | | | |

❖ Completa y colorea según los resultados

| | | | |
|---|---|---|---|
| **0 = Rojo** | **1 = Verde** | **2 = Azul** | **3 =Amarillo** |

8 - 6 =
4 - 3 =
4 - 2 =
7 - 5 =
4 - 1 =
6 - 4 =
7 - 6 =
5 - 3 =

Figure 2. Test of mathematical operations.



**Formato del método NASA tlx**

Nombre: ______________________________ Edad: ______

Fecha: ______________________________________

➢ Demanda mental

¿Cuánta actividad mental y perceptiva se requería (por ejemplo, pensar, decidir, calcular, recordar, mirar, buscar)? ¿Fue la tarea fácil o exigente, simple o compleja, exigente o indulgente?

Baja | Alta

➢ Demanda física

¿Cuánta actividad física se requería (por ejemplo, empujar, jalar, girar, controlar, activar)? ¿La tarea fue fácil o exigente, lenta o energética, floja o extenuante, tranquila o laboriosa?

Baja | Alta

➢ Demanda temporal

¿Cuánta presión de tiempo sintió usted debido a la velocidad con la que ocurrieron las tareas o los elementos de la tarea? ¿Fue el ritmo lento y pausado o rápido y frenético?

Baja | Alta

➢ Rendimiento

¿Qué tan exitoso cree usted que fue en lograr los objetivos de la tarea establecida por el experimentador (o usted mismo)? ¿Qué tan satisfecho estuvo con su desempeño en el cumplimiento de estos objetivos?

Baja | Alta

➢ Esfuerzo

¿Qué tan duro tuvo que trabajar (mental y físicamente) para lograr su nivel de rendimiento?

Baja | Alta

➢ Frustración

¿Qué tan inseguro, desanimado, irritado, estresado y molesto versus seguro, gratificado, contento, relajado y complaciente se sintió durante la tarea?

Baja | Alta

Figure 3. NASA-TLX method format.

Figure 4. Student of Universidad de la Sierra applying the first test of mathematical operations.

Table 1. Student information gathering format.

| | Student Name | Age | Time | Mental Demand | Physical Demand | Temporary Demand | Performance | Effort | Frustration |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Renata Fimbres Yánez | 8 | 14 11’50’’ | 10 | 3 | 8 | 7 | 4 | 7 |

In the evaluation criteria of the NASA-TLX method, it was evaluated on a scale of 1 to 10 answering the following questions regarding each criterion:

- **Mental demand.** How much mental perceptual activity was required? Was the task easy or demanding, simple or complex, demanding or forgiving?
- **Physical demand.** How much physical activity was required? Was the task easy of demanding, lazy or stenuous, quiet or laborious?
- **Temporary demand.** How much time pressure did you feel with which the tasks or elements of the task occurred? Was the pace slow and leisurely or fast and frantic?
- **Performance .** How successful do you think you were in achieving the objectives of the task set by the experimenter? How satisfied were you with your performance in meeting these goals?
- **Effort.** How hard did you have to work (mentally and physically) to achieve your level of performance?
- **Frustration.** How insecure, discouraged, irritated, stressed, and upset versus confident, gratified, content, relaxed, and complacent did you feel during the task?

These six questions were not applied directly to the students due to the degree of difficulty of understanding for their age, consequently support was obtained from the Elementary School teachers.

## 4. RESULTS

From the applied evaluations, table 2 is presented, which shows the student´s name, age, and the load levels results obtained with the NASA-TLX Method applying the Mathematical Operations Test (which is the average of the results of the qualification of each of the six criteria to be evaluated), of the first evaluation without using the interactive game.

Tables 3 and 4 show the grades of each for the six criteria separately obtained by the students, in the first evaluation that consisted of the Mathematical Operations Test, the grades obtained with the NASA-TLX method on a scale from 1 to 100, the average of the scores for each criterion is also included.

Table 2. Results obtained by NASA-TLX method applying the mathematical Operations Test.

| | Student | Age | Results |
|---|---|---|---|
| 1 | Renata Fimbres Yánez | 8 | 59.666 |
| 2 | María Ximena Vásquez | 8 | 60.336 |
| 3 | Raquel Abigail Gámez Castillo | 8 | 67 |
| 4 | Osvaldo Lara Robles | 9 | 55 |
| 5 | Xavier Zaid Domínguez Franco | 8 | 66.333 |
| 6 | Juan Ángel Sánchez Cruz | 8 | 55.667 |
| 7 | Jorge Mejía Cruz | 7 | 57.664 |
| 8 | Ivanna María Burrola | 6 | 53.667 |
| 9 | Alan Francisco Mungaray | 7 | 62.999 |
| 10 | José C. Bustamante Márquez | 7 | 58.336 |
| 11 | Kevin Saúl Fadeo Paz | 8 | 65.666 |
| 12 | Leonardo Guerrero Pacheco | 7 | 63.667 |
| 13 | Devany Haissier | 6 | 63 |
| 14 | Jerónimo Valencia Sánchez | 7 | 64.333 |
| 15 | Luis Adán Montaño | 6 | 61.664 |
| 16 | Dereck Abraham Espinoza | 8 | 54.333 |
| 17 | Axel Rodrigo Quiñonez Ibarra | 7 | 69.666 |
| 18 | Elissa Diana Yánez | 7 | 57.664 |
| 19 | Mateo Valenzuela Vásquez | 7 | 65 |
| 20 | Roberto Sánchez Montaño | 8 | 53.999 |
| 21 | Sebastián Montaño | 8 | 55.664 |
| 22 | Humberto Guerra Portillo | 8 | 67.666 |
| 23 | Mariel Montaño Nolasco | 8 | 63.664 |
| 24 | Paulett Guadalupe Hurtado | 7 | 63.664 |
| 25 | José Eduardo Lara Madrid | 8 | 56.333 |
| 26 | Abryl Angélica Lares Sánchez | 8 | 71.667 |
| 27 | Valeria Barceló Figueroa | 8 | 57.667 |
| 28 | Marian Montaño Nolasco | 8 | 65.666 |
| 29 | Valentina Carrizosa Barceló | 8 | 59.664 |
| 30 | Jesús Ángel Cárdenas Calles | 9 | 55.664 |
| 31 | Yaideth Quinteros Peinado | 7 | 63 |
| 32 | Vanesa Cárdenas Calles | 8 | 59.664 |
| 33 | Cesar Josué Lares Quintana | 8 | 65.666 |
| 34 | Damián Yoel Cárdenas Ayala | 8 | 63.667 |
| 35 | Dalyna Rodríguez de la Cruz | 6 | 62.336 |
| 36 | Edgar Jaén Sierra Meraz | 6 | 68.333 |
| | | Average | 61.54569 |

Table 3. Grades obtained by NASA-TLX method in the application of the Mathematical Operations Test.

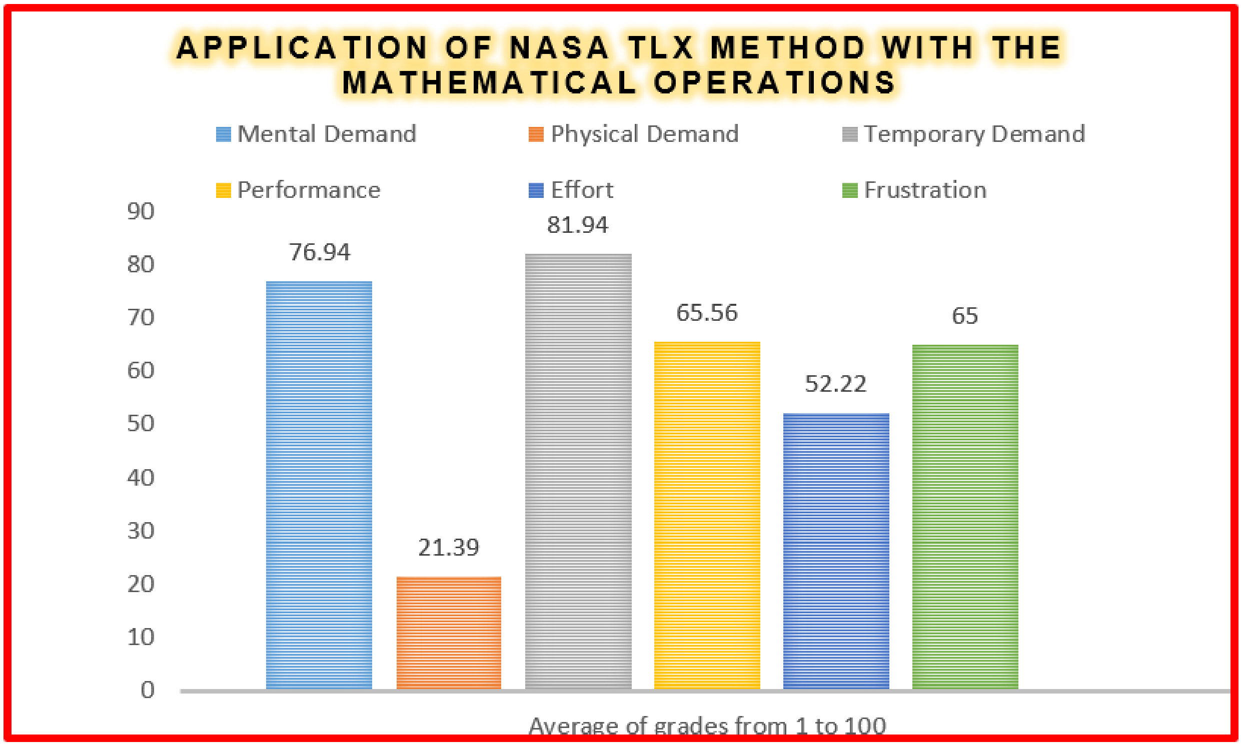
| | Grades of Students from Benito Juárez Elementary School | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Criteria | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| Mental load | 95 | 95 | 85 | 75 | 65 | 85 | 85 | 85 | 75 | 85 | 85 | 85 | 75 | 75 | 85 | 85 | 65 | 85 |
| Physical Demand | 25 | 25 | 15 | 15 | 15 | 15 | 15 | 15 | 25 | 25 | 15 | 15 | 25 | 25 | 15 | 15 | 25 | 15 |
| Temporary Demand | 75 | 55 | 75 | 55 | 75 | 55 | 85 | 75 | 95 | 95 | 95 | 95 | 95 | 85 | 95 | 95 | 95 | 95 |
| Performance | 65 | 65 | 75 | 65 | 75 | 65 | 65 | 55 | 75 | 65 | 45 | 45 | 65 | 75 | 65 | 45 | 75 | 55 |
| Effort | 35 | 35 | 55 | 35 | 45 | 35 | 45 | 35 | 65 | 35 | 35 | 35 | 55 | 55 | 45 | 35 | 65 | 45 |
| Frustration | 65 | 55 | 75 | 75 | 75 | 75 | 75 | 55 | 55 | 65 | 75 | 75 | 55 | 55 | 55 | 75 | 55 | 75 |

| Criteria | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mental load | 65 | 95 | 75 | 65 | 65 | 65 | 75 | 65 | 65 | 65 | 65 | 65 | 75 | 95 | 85 | 65 | 85 | 65 | 76.94444 |
| Physical Demand | 25 | 55 | 15 | 25 | 25 | 25 | 15 | 25 | 25 | 25 | 25 | 15 | 25 | 25 | 15 | 25 | 15 | 25 | 21.38889 |
| Temporary Demand | 95 | 75 | 55 | 85 | 95 | 65 | 65 | 85 | 85 | 75 | 75 | 75 | 85 | 75 | 95 | 85 | 95 | 95 | 81.94444 |
| Performance | 75 | 35 | 65 | 65 | 75 | 75 | 65 | 75 | 75 | 75 | 75 | 75 | 75 | 65 | 45 | 75 | 55 | 75 | 65.55556 |
| Effort | 65 | 35 | 55 | 65 | 75 | 75 | 65 | 75 | 75 | 75 | 75 | 45 | 55 | 35 | 35 | 75 | 45 | 65 | 52.22222 |
| Frustration | 55 | 85 | 55 | 75 | 65 | 65 | 75 | 55 | 55 | 55 | 55 | 75 | 55 | 65 | 75 | 55 | 75 | 55 | 65 |

Table 4. Grades from the NASA-TLX method in the application of the mathematical test.

| AVERAGE SCORE WITH THE NASA-TLX METHOD | | | | | | |
|---|---|---|---|---|---|---|
| | Mental Demand | Physical Demand | Temporary Demand | Performance | Effort | Frustration |
| **Average** | 76.94 | 21.39 | 81.94 | 65.56 | 52.22 | 65 |

Graph 1 shows the averages of the six criteria evaluated for the 36 students with the NASA-TLX method, where it is observed that the highest average scored of the six criteria is the temporary demand with an average of 81.94 on a scale from 1 to 100, therefore this is a high indicator; and the lowest average is found in the physical demand with a 21.39 score that indicates a low physical demand; the other criteria such as the mental demand has an average of 76.94; the performance is medium with an average of 65.56; effort is also medium with 52.22; and lastly, frustration with a general medium score of 65 average.




Graph 1. Average of the criteria scores from the NASA-TLX method in the Mathematical Operations Test.

Table 5 shows the name of the student, the age and the level of load that was evaluated with the test of the interactive game used by the students.

Table 5. Results from NASA-TLX method using the interactive game.

| | Student | Age | Load Level |
|---|---|---|---|
| 1 | Renata Fimbres Yánez | 8 | 51 |
| 2 | María Ximena Vásquez | 8 | 46.33 |
| 3 | Raquel Abigail Gámez Castillo | 8 | 53 |
| 4 | Osvaldo Lara Robles | 9 | 38.33 |
| 5 | Xavier Zaid Domínguez Franco | 8 | 43.66 |
| 6 | Juan Ángel Sánchez Cruz | 8 | 50.99 |
| 7 | Jorge Mejía Cruz | 7 | 45 |
| 8 | Ivanna María Burrola | 6 | 39.66 |
| 9 | Alan Francisco Mungaray | 7 | 49 |
| 10 | José C. Bustamante Márquez | 7 | 55 |
| 11 | Kevin Saúl Fadeo Paz | 8 | 50.99 |
| 12 | Leonardo Guerrero Pacheco | 7 | 42.33 |
| 13 | Devany Haissier | 6 | 51.66 |
| 14 | Jerónimo Valencia Sánchez | 7 | 50.99 |
| 15 | Luis Adán Montaño | 6 | 33.66 |
| 16 | Dereck Abraham Espinoza | 8 | 39 |
| 17 | Axel Rodrigo Quiñonez Ibarra | 7 | 47 |
| 18 | Elissa Diana Yánez | 7 | 40.33 |
| 19 | Mateo Valenzuela Vásquez | 7 | 48.33 |
| 20 | Roberto Sánchez Montaño | 8 | 47.66 |
| 21 | Sebastián Montaño | 8 | 43 |
| 22 | Humberto Guerra Portillo | 8 | 52.33 |
| 23 | Mariel Montaño Nolasco | 8 | 57 |
| 24 | Paulett Guadalupe Hurtado | 7 | 46.99 |
| 25 | José Eduardo Lara Madrid | 8 | 41 |
| 26 | Abryl Angélica Lares Sánchez | 8 | 56.33 |
| 27 | Valeria Barceló Figueroa | 8 | 42.33 |
| 28 | Marian Montaño Nolasco | 8 | 57 |
| 29 | Valentina Carrizosa Barceló | 8 | 49 |
| 30 | Jesús Ángel Cárdenas Calles | 9 | 46.33 |
| 31 | Yaideth Quinteros Peinado | 7 | 43 |
| 32 | Vanesa Cárdenas Calles | 8 | 51.66 |
| 33 | Cesar Josué Lares Quintana | 8 | 50.33 |
| 34 | Damián Yoel Cárdenas Ayala | 8 | 38.33 |
| 35 | Dalyna Rodríguez de la Cruz | 6 | 49.66 |
| 36 | Edgar Jaén Sierra Meraz | 6 | 43.66 |
| | | Average | 46.882 |

In table 6, the scores of each of the six criteria are shown separately that were obtained in the second evaluation using the interactive game, the score that the

NASA-TLX method yielded on a scale from 1 to 100 same as with the first evaluation. Table 7 shows the Average of the scores for each criterion.

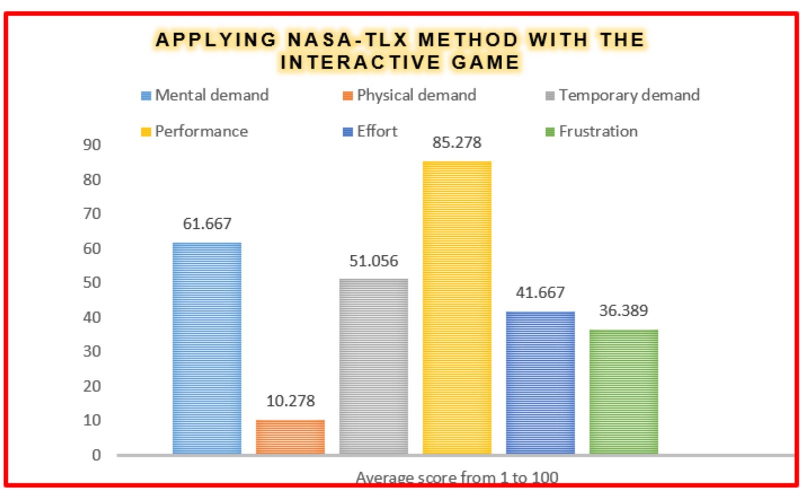
Table 6. Scores from the NASA-TLX method with the use of the interactive game.

| | Grades of Students from Benito Juárez Elementary School | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Criteria | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | Average |
| Mental load | 75 | 55 | 75 | 65 | 55 | 75 | 65 | 75 | 65 | 75 | 65 | 65 | 55 | 55 | 65 | 65 | 55 | 65 | 55 | 75 | 65 | 55 | 55 | 55 | 65 | 55 | 55 | 55 | 55 | 65 | 65 | 55 | 55 | 55 | 55 | 55 | 61.66667 |
| Physical Demand | 15 | 15 | 5 | 5 | 5 | 15 | 5 | 5 | 15 | 15 | 5 | 5 | 15 | 15 | 5 | 5 | 15 | 5 | 15 | 5 | 5 | 15 | 15 | 15 | 5 | 15 | 15 | 15 | 15 | 5 | 5 | 15 | 5 | 5 | 15 | 15 | 10.27778 |
| Temporary Demand | 25 | 45 | 43 | 35 | 45 | 35 | 65 | 55 | 65 | 65 | 65 | 65 | 65 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 35 | 55 | 55 | 45 | 45 | 55 | 55 | 55 | 55 | 45 | 45 | 45 | 55 | 45 | 45 | 45 | 51.05556 |
| Performance | 85 | 85 | 85 | 75 | 85 | 75 | 75 | 75 | 85 | 85 | 75 | 75 | 85 | 85 | 85 | 75 | 85 | 75 | 95 | 85 | 85 | 85 | 95 | 95 | 85 | 95 | 95 | 95 | 95 | 95 | 95 | 85 | 85 | 85 | 85 | 85 | 85.27778 |
| Effort | 25 | 45 | 45 | 25 | 35 | 25 | 35 | 25 | 55 | 25 | 35 | 35 | 45 | 45 | 35 | 25 | 45 | 35 | 55 | 25 | 45 | 45 | 55 | 55 | 45 | 45 | 55 | 55 | 55 | 45 | 45 | 55 | 45 | 45 | 45 | 45 | 41.66667 |
| Frustration | 55 | 35 | 45 | 45 | 35 | 45 | 45 | 35 | 35 | 45 | 45 | 45 | 35 | 35 | 35 | 45 | 35 | 45 | 35 | 35 | 35 | 45 | 25 | 35 | 45 | 25 | 25 | 25 | 25 | 25 | 25 | 35 | 35 | 35 | 25 | 35 | 36.38889 |

Table 7. Average of each criteria by NASA-TLX method and using the interactive game

| AVERAGE SCORE WITH THE NASA-TLX METHOD | | | | | | |
|---|---|---|---|---|---|---|
| | Mental Demand | Physical Demand | Temporary Demand | Performance | Effort | Frustration |
| Average | 61.667 | 10.278 | 51.056 | 85.278 | 41.667 | 36.389 |

Graph 2 shows the average score of the six criteria evaluated for the 36 students with the NASA-TLX method, where it is observed that the highest average of the six criteria is performance, with an average of 85.278 on a scale from 1 to 100 indicating that it is high, and the lowest average is found for physical demand with a score of 10.278 indicating that the physical demand is low; the other criteria such as mental demand scored in average 61.667, which means a medium demand; the effort is low with 41.667; and at last, frustration is low with an average of 36.389.



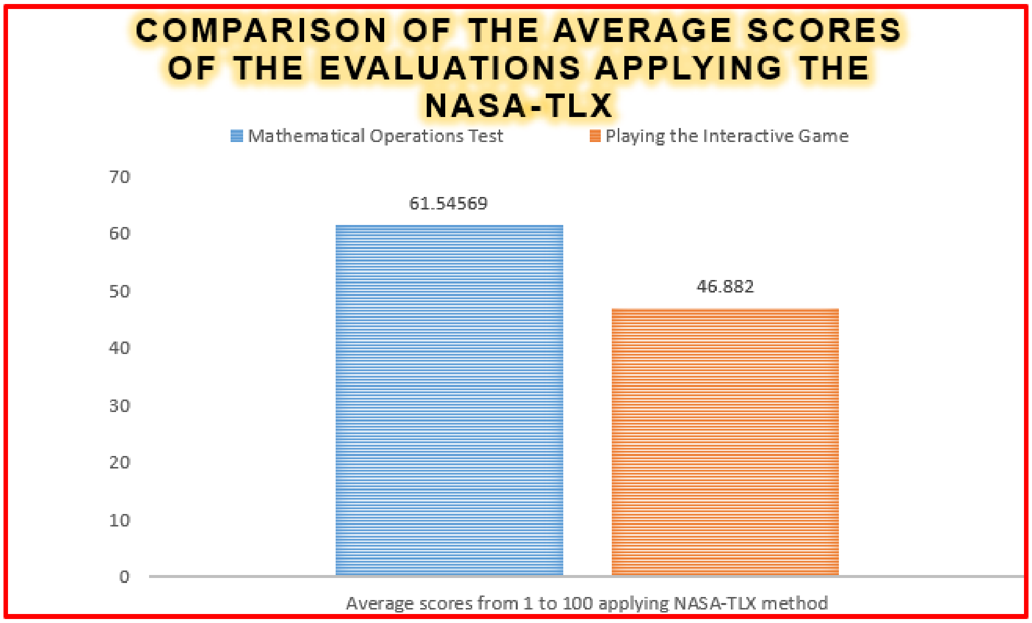

Graph 2. Average of the scores per criterion obtained by the NASA-TLX method in the second evaluation using the interactive game

Table 8 shows the comparison of the results applying the NASA-TLX method on the Mathematical Operations Test and the use of interactive games, as well as the decrease in the level of mental load.

Table 8. Comparison of the level of mental load with the Test of Mathematical Operations and the Interactive Game.

| Student | | Age | Mathematical Operations Test Scores | Interactive Game Scores | Decreased level of mental load |
|---|---|---|---|---|---|
| 1 | Renata Fimbres Yánez | 8 | 59.666 | 51 | 8.666 |
| 2 | María Ximena Vásquez | 8 | 60.336 | 46.33 | 14.006 |
| 3 | Raquel Abigail Gámez Castillo | 8 | 67 | 53 | 14 |
| 4 | Osvaldo Lara Robles | 9 | 55 | 38.33 | 16.67 |
| 5 | Xavier Zaid Domínguez Franco | 8 | 66.333 | 43.66 | 22.673 |
| 6 | Juan Ángel Sánchez Cruz | 8 | 55.667 | 50.99 | 4.677 |
| 7 | Jorge Mejía Cruz | 7 | 57.664 | 45 | 12.664 |
| 8 | Ivanna María Burrola | 6 | 53.667 | 39.66 | 14.007 |
| 9 | Alan Francisco Mungaray | 7 | 62.999 | 49 | 13.999 |
| 10 | José C. Bustamante Márquez | 7 | 58.336 | 55 | 3.336 |
| 11 | Kevin Saúl Fadeo Paz | 8 | 65.666 | 50.99 | 14.676 |
| 12 | Leonardo Guerrero Pacheco | 7 | 63.667 | 42.33 | 21.337 |
| 13 | Devany Haissier | 6 | 63 | 51.66 | 11.34 |
| 14 | Jerónimo Valencia Sánchez | 7 | 64.333 | 50.99 | 13.343 |
| 15 | Luis Adán Montaño | 6 | 61.664 | 33.66 | 28.004 |
| 16 | Dereck Abraham Espinoza | 8 | 54.333 | 39 | 15.333 |
| 17 | Axel Rodrigo Quiñonez Ibarra | 7 | 69.666 | 47 | 22.666 |
| 18 | Elissa Diana Yánez | 7 | 57.664 | 40.33 | 17.334 |
| 19 | Mateo Valenzuela Vásquez | 7 | 65 | 48.33 | 16.67 |
| 20 | Roberto Sánchez Montaño | 8 | 53.999 | 47.66 | 6.339 |
| 21 | Sebastián Montaño | 8 | 55.664 | 43 | 12.664 |
| 22 | Humberto Guerra Portillo | 8 | 67.666 | 52.33 | 15.336 |
| 23 | Mariel Montaño Nolasco | 8 | 63.664 | 57 | 6.664 |
| 24 | Paulett Guadalupe Hurtado | 7 | 63.664 | 46.99 | 16.674 |
| 25 | José Eduardo Lara Madrid | 8 | 56.333 | 41 | 15.333 |
| 26 | Abryl Angélica Lares Sánchez | 8 | 71.667 | 56.33 | 15.337 |
| 27 | Valeria Barceló Figueroa | 8 | 57.667 | 42.33 | 15.337 |
| 28 | Marian Montaño Nolasco | 8 | 65.666 | 57 | 8.666 |
| 29 | Valentina Carrizosa Barceló | 8 | 59.664 | 49 | 10.664 |
| 30 | Jesús Ángel Cárdenas Calles | 9 | 55.664 | 46.33 | 9.334 |
| 31 | Yaideth Quinteros Peinado | 7 | 63 | 43 | 20 |
| 32 | Vanesa Cardenas Calles | 8 | 59.664 | 51.66 | 8.004 |
| 33 | Cesar Josué Lares Quintana | 8 | 65.666 | 50.33 | 15.336 |
| 34 | Damián Yoel Cardenas Ayala | 8 | 63.667 | 38.33 | 25.337 |
| 35 | Dalyna Rodríguez de la Cruz | 6 | 62.336 | 49.66 | 12.676 |
| 36 | Edgar Jaén Sierra Meraz | 6 | 68.333 | 43.66 | 24.673 |
| Average | | | 61.54569 | 46.882 | 14.66369 |

Graph 3 shows both averages of the previously applied evaluations, with the mathematical operations test, scoring an average of 61.546, this average includes the six criteria together; in the second evaluation an average of 46.882 was obtained, reducing a mental load of 14.664 on average from the 26 students on a scale from 1 to 100. It is observed that the load level score obtained by the NASA-TLX method went from having a medium level to having a low level in general.




Graph 3. Comparison of averages of mental load.

## 5. CONCLUSIONS

The mental load in the children evaluated in this study when performing mathematical operations was found to be more favorable when using the interactive game.

Of the six criteria of both evaluations applying NASA-TLX method, from the first to the second evaluation, the mental demand decreased 15.278, the physical demand 11.111, the temporary demand 30.889, the performance increased 19.772, in the case of effort and frustration decreased by 10.556 and 28.661 respectively.

A better educational performance can be obtained when carrying out basic mathematical operations, according to the NASA-TLX method, which by evaluating the before and after of each child gave very satisfactory results, since it manages to reduce the mental load by 14.664; furthermore, the interactive game was designed so that it eases the learning process for children in a more dynamic and less tedious way than the traditional way of solving mathematical operations in school.

## 6. REFERENCES

Águila-Soto, A. D. (2019). *Procedimiento de Evaluación de Riesgos Ergonómicos y Psicosociales.* Carga Mental. Universidad de Almería. Recuperated from https://w3.ual.es/GruposInv/Prevencion/evaluacion/procedimiento/D.%20Carga%20mental.pdf

Edina., D. A. (2004). *Ergonomía Cognitiva y Usabilidad.* Recuperated from https://www.um.es/docencia/agustinr/Tema6-0607a.pdf

Hernandez, P. A. (2000). *Ergonomia Cognitiva Apuntes para su Aplicacion en el Trabajo y Salud.* La Habana, Cuba: Investigador Titular en Ciencias Medicas.

Lopez, A. (2012). *Towi*. Recuperated from https://towi.com.mx/mejorar-la-agilidad-mental-en-los-ninos/

Medina, A. R. (2006). *Ergonomia Cognitiva Yy Usabilidad. Suma Campos Vitrual* .Universidad de Murcia. Recuperated from https://www.um.es/docencia/agustinr/Tema6-0607a.pdf

Monzón, L. M. (2019). Ergonomía Cognitiva. Diseñando un Entorno Seguro, Saludable y Atractivo. Recuperated from https://revistadigital.inesem.es/educacion-sociedad/ergonomia-cognitiva/

Porto, J. P. (2018). *Definicion de jenga.* Definición.DE. Recuperated from de https://definicion.de/jenga/

# IMPLICATIONS FOR USING ABSTRACT AND PHYSICAL TOOLS IN THE MUNICIPAL WORKSHOPS, ACTIVITY THEORY PERSPECTIVE

**Guadalupe Hernández-Escobedo[1], Karina Cecilia Arredondo-Soto[2], Samuel Alvarado-Nangüelu[1], Emilio Bórquez-Rodríguez[1], Ángel Gabriel Robledo-Padilla[1]**

[1]Departmento de Ingeniería Industrial
Tecnológico Nacional de México/Instituto Tecnológico de Tijuana
Calzada Tecnológico s/n, Fraccionamiento Tomás Aquino
Tijuana, Baja California, México 22454
Corresponding author's e-mail: guadalupe.hernandez@tectijuana.edu.mx

[2]Facultad de Ciencias Químicas e Ingeniería
Universidad Autónoma de Baja California
Calzada Universidad No. 14418, Parque Industrial Internacional
Tijuana, Baja California, México 22390

**Resumen:** El propósito de esta ponencia es presentar las implicaciones de uso de las herramientas abstractas y físicas utilizadas en el comportamiento de información exhibido en la operación rutinaria de los talleres municipales. De inicio se definieron los elementos de dicha actividad humana y sus tensiones y contradicciones. Aquí, la teoría de la actividad sirvió como marco conceptual y herramienta de análisis. La revisión de la documentación organizacional, la observación de la operación rutinaria y entrevista con individuos a nivel operativo y administrativo fueron los métodos utilizados para recolectar datos. De esta forma se descubrieron sus elementos, tensiones y contradicciones. Como resultado se generó el sistema de actividad humana que permitiera generar las bases para innovar el uso o diseño de las herramientas abstractas y físicas utilizadas en el comportamiento de información.

**Palabras clave**: Herramientas abstractas, Herramientas físicas, Operación rutinaria, Teoría de la actividad, Talleres Municipales

**Relevancia para la ergonomía**: Las herramientas abstractas y materiales utilizadas en la operación rutinaria en los talleres municipales no han sido estudiadas dentro de la literatura actual. Más aún, cómo éstas pueden ser innovadas en términos de uso o diseño a través de su descubrimiento dentro de su actividad de utilización. Lo anterior tiene implicaciones teóricas, metodológicas y prácticas permitiendo evaluar la eficiencia del uso o diseño en el contexto en estudio.

**Abstract:** The purpose of this paper is to present the implications of use of the abstract and physical tools used in the information behavior exhibited in the routine operation of municipal workshops. Initially, the elements of this human activity and its tensions and contradictions were defined. Here, the activity theory served as a conceptual framework and as an analysis tool. The review of the organizational documentation, the observation of the routine operation and interview with individuals at the operational and administrative level were the methods used to collect data. In this way, its elements, tensions and contradictions were discovered. As a result, the human activity system was generated that would allow to generate the basis to innovate the use or design of the abstract and physical tools used by the information behavior.

**Keywords**. Abstract tools, Physical tool, Routine operation, Activity theory, Municipal workshops.

**Relevance to Ergonomics**: The abstract tools and materials used in routine operation in municipal workshops have not been studied within the current literature. Furthermore, how they can be innovated in terms of use or design through their discovery within their activity of use. The above has theoretical, methodological and practical implications allowing to evaluate the efficiency of the use or design in the context under study.

## 1. INTRODUCTION

The axes of security and public services were considered a priority because they had a significant impact on the life of the city. On the one hand, the municipal government had the obligation to guarantee order and peace so that they can safeguard the integrity of the population in all dimensions. For this, it was necessary to guarantee the public wellness as the basis for a dignified life of the inhabitants, promoting the strengthening of their institutions, giving greater value to prevention and moving towards strategies that respond to the social reality that people live. On the other hand, the priority attention of services as cleaning that contributed with the integral development of a city in current and continuous growth such as Tijuana is. Everything was to find an urban environment that should allow a functional city.

These actions served to implement actions for the benefit of society through an efficient, modern and transparent administration (Ayuntamiento de Tijuana, 2014). The accountability, simplification of government services and decentralization were carried out based on criteria of responsible spending and the modernization of services aimed at a digital government. This was assuming a fundamental infrastructure that allowed the correct path of public institutions and their work was for the benefit of the population it served. Therefore, it was a priority to have security and solid waste collection systems that served the majority of neighborhoods of the city. Hence, the vehicle maintenance and repair system involved in both services were of great importance. Equally relevant was the public expenditure involved in having such a maintenance and repair system. This expense should be responsible for reducing your applied expenses, leaving aside those that did not add public value and had no economic impact on society. Thus, the culture of internal savings was addressed in relation to financial, material, and energy resources, etc.

Therefore, they were defined the urgent social needs and demands and openned a way to opportunities for current and future generations. This was to give answers to public affairs in terms of efficiency, effectiveness, consistency and vision. The actions of the city council were oriented to improve the quality of life and to attend the demands of the population (including the personnel who work in the city council) in accordance with current regulations. On the one hand, its administrative work was oriented to the efficient and effective performance of its responsibilities, seeking to achieve the goals and objectives that strengthen the development of the municipality of Tijuana. It included various activities of the individuals who were part of the council and their behaviors perfoming those activities. Also, the information required to make better decisions. This was implied in the study of information behavior within the administrative apparatus, seeking to obtain the best results in order to achieve the stated objectives. It was because such behavior should have relevant importance within the decision-making process. Its decisions might affect the operation of work centers, the use of public resources, among other results. Moreover, it had been documented in various problems found in various processes involving municipal workshops and personnel from various departments that were closely related to the different activities in these places.

On the other hand, from a theoretical perspective, information behavior has been studied from various approaches and considered a broad concept in various contexts (Savolainen, 2007). Mainly, cognitive and social views have helped on its understanding. The cognitive approach indicated that information behavior is a consequence of products of the mind. Whereas, the social approach has stated that it is the product of interaction between people. However, in this paper it has been considered that both approaches are inclusive, thus giving the opportunity to holistically study the information behavior as well as its tools or means that mediate individuals with the information required in the decision-making process. Therefore, information behavior is defined as the totality of human behavior in relation to information sources and channels, including the active and passive search and use of information (Wilson, 2000). However, this involved the use of various technological tools as mediators. Hence, the current literature has only focused on information and communication technologies (ICTs), considered physical tools, leaving abstract tools on one side, which are equally important within information behavior. This was considered as antecedents to holistically study information behavior and its tools within an environment considered unexplored such as the municipal workshops. Specifically, the study was carried out in the Public Services and Maintenance of Machinery and Equipment workshop, the Municipal Public Security workshop and the firefighters workshop belonging to the Tijuana City Council, as well as other departments with close relationship with those workshops.

The following is a review of the literature associated with the abstract and physical tools used by information behavior. Subsequently, the methodology used is exhibited, followed by the results obtained. It ends with the conclusions.

*Note: For confidential and ethical reasons, some of the information used in this work has been modified.*

## 2. ABSTRACT AND PHYSICAL TOOLS

In the current literature, the tools used into information behavior have been implicitly and explicitly considered. These tools have mediated it directly or indirectly, thus allowing its understanding within the context under study. For example, these tools are classified as abstract and/or physical and serve to discover their cultural elements that helped mediating human activities (Allen et al, 2011); and, in this particular case, information behavior as a synonym of human activity. Hence, the used tools exhibited meanings that shaped the human activities and their use. Likewise, these activities and use shaped those tools by imposing rules and conditions of use, mediating in this way similarly human activities, mainly the abstract (mental or signs) and physical (material) tools (Engestrom, 1987). Physical tools are material and measured the goal orientation of human activity; while abstract tools are signs in the form of language, which mediate social relationship. Consequently, it has been relatively easy to investigate physical tools or ICTs leaving an opportunity to investigate abstract tools in various contexts, such as the treaty here that is unexplored.

On the one hand, physical tools have been mainly represented by information and communication technologies. This has allowed to study and know in depth how the objective of information behavior is exhibited by individuals in different contexts. Mainly, the benefits of these have helped on manage the information that is generated in these contexts (Cosgrave, 1996). There are other physical tools such as command and control centers, which, although they are generally made up of the aforementioned technologies, include other tools such as closed-circuit video cameras, radios, maps, notes, blackboards, etc. However, it is relevant to know its effectiveness and efficiency by mediating this behavior within its context under study and their impact. This gives the opportunity to study them in an unexplored context such as the mentioned workshops.

On the other hand, abstract tools are represented mainly by the language used in contexts and within social interactions between individuals and mainly face-to-face (Wilson, 1997). However, the effectiveness and efficiency of such interactions are generally not studied. This is done by contextualizing it in such a way that it is downplayed as an impact factor. Another tool not considered is development and training for the performance of human activities. Also, this leads to the exclusion of experience. In addition, the information culture, the interdependence between individuals and their organizations, their interdepartmental ideologies are examples of abstract tools that are overlooked or not considered relevant. This opens the opportunity to investigate them in the context addressed in this study.

In general, the knowledge of the abstract and physical tools used in the routine operation in this unexplored context allowed to delve into the knowledge of information behavior and the implications of its use within the context treated here. That is, the discernment of the implications in the use of tools should allow to know the effectiveness and efficiency of the information behavior observed as a primary human activity within the municipal workshops. For this reason, it is important to note that in this document only the main tools used in the workshops are presented, leaving aside their evaluation in terms of effectiveness and efficiency. This should allow future research in this area.

## 3. METHODOLOGY

### 3.1 Municipal Workshops

The present investigation was carried out in the workshops of Public Services and Maintenance of Machinery and Equipment, Municipal Public Security and Firefighters of the City Council of Tijuana. This was carried out with the consent of the Secretary of Administration and Finance and with the special permission of the Director of the Department of General Services, Maintenance of Buildings and Municipal Workshops of the Mayor's Office. This involved all the operational and administrative areas in each of the workshops and the personnel at the operational and tactical level and the intra- and inter-departmental relations.

In these workshops, various preventive and corrective maintenance services were carried out on the various vehicles that the council had. Vehicles can be garbage collection trucks and vans, trucks used in garbage transfers, street sweepers, dump trucks, patrol cars, motorcycles, bicycles, armored trucks, fire engines, ambulances, haul trucks, etc. These vehicles were used by the various departments; hence, in order to perform any preventive or corrective maintenance service, they must be requested by personnel from those departments. Once with the authorized work order, the vehicles entered one of these workshops to receive the requested services. Once completed, the vehicles were delivered to their respective departments, which subsequently authorized the release of payment for mentioned services. This was because the services were provided by external individuals and private companies. Otherwise, if the service was performed by personnel from the workshops, the payment to suppliers of used materials and supplies was authorized.

### 3.2 Activity Theory

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

These assumptions helped to understand the motivations of that behavior, which can be cognitive (internally generated) and social (externally generated). These motivations determine the goals that should be achieved and are similarly affected by the existing conditions of the environment. The activities, in turn, are composed of actions resulting from the goals. Similarly, actions are carried out by operations performed automatically or routinely under stable environmental conditions. Otherwise, if conditions are unstable, the operations become actions until the point where conditions become stable again and actions are converted on operations once again. This is a cycle of human activity that repeats itself in direct relation to environmental conditions, but capturing its essence is a challenge carried out in routine operation in workshops.

Furthermore, the theory suggests that all activities are governed by the following principles: all human activities are collective, mediate by artifacts or tools, and goal-oriented; there are multiple opinions; it has a history resulting from transformations carried out over time; tensions and contradictions are the origin of these changes developing this activity; and this can have various expansion transformations resulting in changes and innovations as a consequence of the accumulation of tensions and contradictions. The latter can be located in each element of the activity (primaries); related to each other (secondary); related between motives/objects of a central element of a system and motives/objects of a more culturally advanced element (tertiary); and related between the central activity and other nearby activities (quaternary) (Engestrom, 1987). Figure 1 presents the human activity system in general.

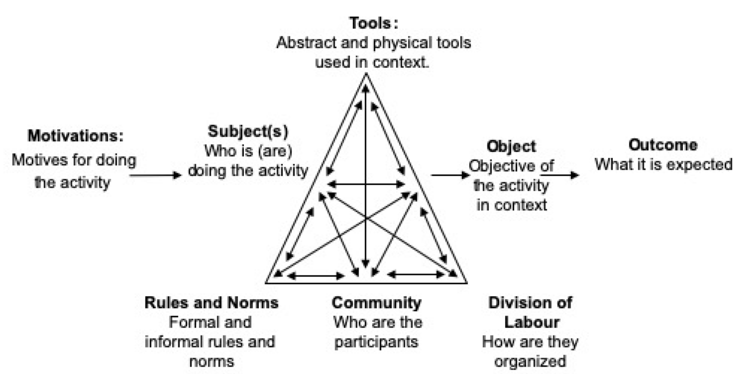



Figura 1. Human activity system

Likewise, the theory gives the basis for finding and using each element of the human activity system under study. These are: what subject (s) carry out the activities, what are their object, what tools (mental and/or physical) they use to mediate the activity, which community is involved, what rules and norms of interaction they follow, how they divide the work and what is the expected result (Engestrom, 1987). In the same way, this theory helped to make sense and understand the information collected, this is why activities must be understood through what people do and why they do it (Kaptelinin, 2005). Additionally, its understanding was holistic based on its dynamism and complexity closely related to its context, providing conditions to interpret and study activities in its natural environment (Denzin and Lincoln, 2000). This was through the support of methodological strategies for the collective case study (Stake, 1995), increasing its knowledge with analytical and non-statistical generalizations (Yin, 2009).

### 3.3 Methods to Collect Data

The methods used helped to examine the unique and routine events that happen (critical incidents) in the routine operation of the municipal workshops; contemplate the individuals and the physical and intellectual tools used; inspect the processes, activities, actions and operations carried out; and explore the subsystems, systems and supra-system in which the municipal workshops and the intra- and inter-departmental relationships are immersed. Also, the resources, supplies, products, processes and procedures available to the department to carry out routine operations.

The organizational information review aimed to discover the administrative procedures that were carried out in the municipal workshops and related departments. Also, this allowed to discover the main physical and intellectual tools used in these processes; the rules and norms that regulate routine work and interpersonal relationships, and the division of labor through the various existing organization charts. It also helped to identify the various activities, actions and operations required in routine workshop work. Approximately 95 documents were reviewed and these included regulations, laws, procedures, petition documents, budgets, requests for services, etc.

The observation of routine operations was aimed at verifying and understanding how services were attended; how they used the various physical and intellectual tools; how they followed existing rules and norms of behavior; how the work was divided, who participates in the routine operation; what are the working conditions; how the organizational objective is verified; how the relationships were between the various individuals participating in the workshops and the department and with individuals from other departments. Likewise, it served to corroborate the work environment in the workshops. Approximately 150 hours of observation were invested in the three participating workshops.

The interviews with the staff served to access the reality in which the individuals who worked in the various areas that made up the municipal workshops were immersed. In this way, the part corresponding to the tasks carried out in the workshops in the achievement of organizational objectives was accessed. Also, these were focused to uncover critical incidents within the routine operation. Therefore, only the personnel who had attended these were involved. Critical incidents were those unusual situations that affected the performance in the routine work causing individual and group tensions. On the other hand, the number of interviews was in relation to the saturation of the responses. That is, the interviews were conducted until the responses were repeated in order to weigh and assess those contradictions and tensions that emerged when there were critical incidents. 19 interviews were conducted, two at the managerial level (Director of the department and Senior Officer) and 17 at the operational level.

It was necessary to emphasize that the academic work was carried out in adherence to ethics and good customs in the handling of the data and information generated by it, everything was codified, thus ensuring its confidentiality during the process of obtaining and analysis. Also, the personnel who agreed to participate in the research were interviewed and a procedure was developed for that purpose, where they were also coded.

### 3.4 Analysis Methods

The human activity system made it possible to decompose information behavior into its elements, described in section 3.2. In addition, it allowed to know its object (ivo), its actions in the achievement of goals and the operations carried out routinely in direct relation to its context. This is a characteristic of unstable systems and, therefore, the activity theory helped to obtain knowledge of these through understanding the human system and its dynamic nature. Also, this theory allowed to know the activity in depth and its scope within its study context.

Thus, its elements were sought and once discovered, the existing tensions and contradictions within the system and in relation to other departments were found. These were at the primary level (each element of the system); secondary (between the elements of the system); tertiary (between the objectives of this system and a culturally advanced system) and finally, the quaternary (are those between close systems).

Subsequently, the department positioned itself in relation to other departments, its position within the council and its close relationship with the community through the impact of its activities on the provision of services and those relationships with its external suppliers. That is, the specific and general considerations were made in direct relation to other systems or subsystems. Here, the contradictions and tensions discussed above and the impact on routine operation were considered. For example, the delay in the corrective maintenance service of a garbage truck due to lack of spare parts increases the cost of garbage collection and increases the social cost of not attending the collection services. These were two indicators used to measure the efficiency of routine operation in workshops.

Finally, each individual who participated in this work was contextually analyzed and the importance of their activities within the system was understood. The same was done for each document and observation made. Also, it was performed on every element of the human activity system. This provided additional information to propose improvements in the routine operation of the municipal workshops, presented in relation to the practical implications of section 5.

# 4. FINDINGS

## 4.1 Information Behavior Activity System

Figure 2 shows the information behavior human activity system that was developed from the analysis performed.

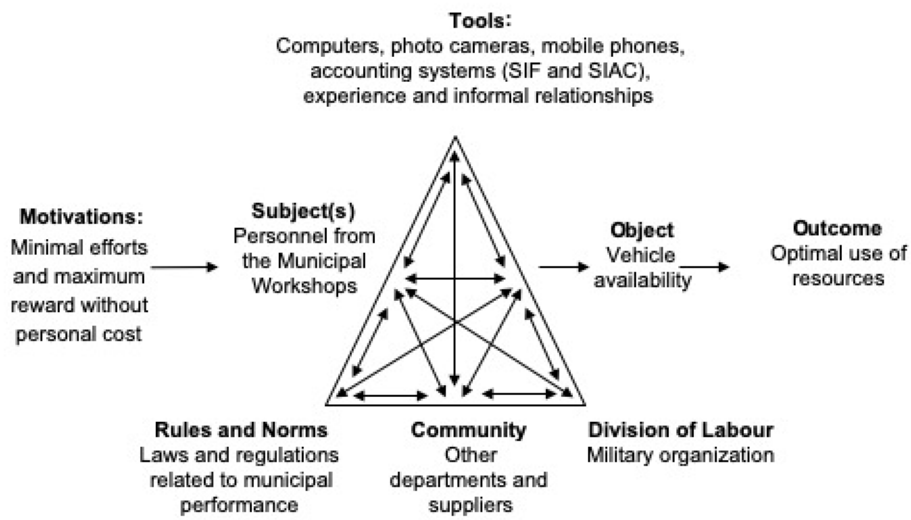



Figura 2. Human Activity System of Information Behavior

## 4.2 Tensions and Contradictions

It was found that a primary contradiction was the administrative procedure followed to grant preventive maintenance services. This was because excessive resources were required to do an oil change in municipal workshops. A secondary contradiction was the lack of training to carry out diagnoses that revealed the problem of vehicles. This delayed preventive and corrective maintenance services. A tertiary contradiction was the change in preventive maintenance plans by the departments involved. This decreased the useful life of the vehicles. A quaternary contradiction was the existing friction between departments of the same administrative level where the departmental objectives must be aligned with the objectives of the Municipal Development Plan. This generated tensions between departments resulting in changes in administrative processes requiring additional resources to be able to satisfy them.

## 4.3 Departmental Relations

Regarding these, for example, the delay in the corrective maintenance service of a garbage truck due to lack of spare parts increased the cost of garbage collection and increased the social cost of not attending the collection services. These were indicators used to measure the efficiency of routine operation in workshops. On the other hand, regarding individual relationships with the context, it was commented that the detail in the handling and request of spare parts was too rigorous. This entailed an excessive investment of money, time and resources to be able and to control the inventories of spare parts and supplies. Others were the procedures used to carry out preventive and corrective maintenance requiring excessive resources. This was observed in the documents used to perform preventive and corrective maintenance services, where it was found that at least eight authorizations were required, displayed in the same number of signatures made by people located in different buildings into the city.

## 5. CONCLUSIONS

In this presentation, the abstract and physical tools used in the behavior of information and their methodological, theoretical and practical implications exhibited within the municipal workshops were discovered. The results suggested that abstract and physical tools were of great value to perform routine work within workshops. In addition, these tools were in direct and indirect relationship to establish communication with other departments that made up the administrative apparatus of the city council.

Regarding the methodological implications, the activity theory and the research strategy were consistent with the study of said human activity within the context treated here. This allowed an objective access to the elements that made up the mentioned activity. It also helped to clarify those tensions and contradictions that had an impact on the practical implications, discussed later in this section.

Regarding the theoretical implications, these showed that it was necessary to rethink and study in detail the theories regarding the types of tools used in the behavior of information. Although it was true that technology helped on carrying out the actions and operations of the mentioned human activity efficiently, new theories must emerge that should explain in detail to what extent these technologies increase efficiency. This was in order to be able to use or generate other tools that migh change the sense of behavior through new explanations in the efficient use of those techonologies.

Finally, the practical implications revealed various areas of opportunity, being able to classify them in relation to: lack of resources to develop better service strategies for other departments; lack of training for the operative personnel of the workshops, mainly unionized personnel; the profiles of the personnel who enter did not correspond to the profile required by the department to carry out the activities of the department, and the excellent use of the existing resources in the workshops.

Along the same lines, the discovery of the tools suggests the primary need for three main aspects. First, the lack of staff skills in the use of abstract tools during the requested services denoted a need of training to develop these. Second, the use of physical tools showed the lack of those tools since it was found that several types of them were owned by the staff and not by the council. In other words, the city council had a shortage of tools that staff remedied through the use of their personal tools in their workplace. Third, the use of computer equipment and accounting systems highlighted the need to update these tools since it was found that they were slow and generally needed internal repairs.

Finally, this paper has showed various tools used by the information behavior within the context of municipal workshops. This highlighted various technologies that were used and that were exhibited in the existing relationships within the administrative apparatus and intra- and inter-departmental relationships. There were implications that should be exploited in such a way that the efficiency of mentioned behavior might be increased with the reordering and consideration of the tools used and/or generating others according to the needs found.

## 6. ACKNOWLEDGMENTS

We would like to acknowledge to the TecNM/Instituto Tecnológico de Tijuana and H. Ayuntamiento de Tijuana for partially funding this study. We would also like to thank to the operative and administrative participants and their organization for contributing with this study. The interpretations and views in this paper, however, are solely those of the authors.

## 7. REFERENCES

Ayuntamiento de Tijuana (2014). *Plan Municipal de Desarrollo 2014-2016*. H. Ayuntamiento de Tijuana. Tijuana, México.

Allen et al. (2011). *Working with activity theory: Context, technology, and information behavior.* Journal of the American Society for Information Science and Technology. 62(4), pp.776-788.

Benton, T., y Craib, I. (2011). *Philosophy of social science: The philosophical foundations of social thought* (2nd ed.): Nueva York, Estados Unidos: Palgrave.

Cosgrave, J. (1996). *Decision making in emergencies*. Disaster Prevention and Management. 5 (4), pp.28-34.

Denzin and Lincoln, Y. (2000). *The discipline and practice of qualitative research*. Handbook of qualitative research. 2, pp.1-28.

Engeström, Y. (1987). *Learning by expanding: an activity theoretical approach to developmental research.* Helsinki: Orienta-Konsultit.

Kaptelinin and Nardi, B. (2006). *Acting with Technology: Activity Theory and Interaction Design.* Cambridge, MA: MIT Press.

Kaptelinin, V. (2005). *The object of activity: making sense of the sense-maker*. Mind, Culture, and Activity. **12**(1), pp.4-18.

Mwanza, D. (2002). *Towards an Activity-Oriented Design Method for HCI Research and Practice*. Thesis, The Open University.

Savolainen, R. (2007). *Information behavior and information practice: reviewing the "umbrella concepts" of information-seeking studies.* Library Quaterly. **77**(2), pp.109-132.

Stake, R. (1995). The art of case study research. Londres: Sage.

Wilson, T. D. (1997). *Information behaviour: An interdisciplinary perspective*. Information Processing & Management. 33 (4), pp.551-572.

Wilson, T. D. (2000). *Human Information Behavior.* Informing Science. **3**(2), pp.49-56.

Wilson, T.D. (2006). *A re-examination of information seeking behaviour in the context of activity theory*. Information Research. 11((4) paper 260).

Wilson, T. D. (2008). *Activity theory and information seeking.* Annual Review of Information Science and Technology. (42), pp.119-161.

Yin, R.K. 2009. *Case study research: design and methods.* Londres: Sage.

# WORKING CONDITIONS OF PERSONNEL THAT COLLABORATE DURING THE CONSTRUCTION OF CUSTOM-MADE DISPLAYS AND COMMERCIAL EXHIBITIONS IN MEXICO.

**Ma. Fernanda Gutiérrez Torres**

Department of Industrial Design
Universidad Nacional Autónoma de México
Facultad de Estudios Superiores Aragón
Av. Rancho Seco s/n, Impulsora Avícola.
57130 Nezahualcóyotl, Estado de México.
México.
gutierrez.mafernanda@gmail.com

**Resumen:** La investigación se desarrolla con el objetivo de preparar los contenidos que puedan integrarse a los programas de diferentes asignaturas del Plan de Estudios de Diseño Industrial tiene como propósito explorar las posibilidades en las que el diseñador puede aplicar conocimientos de ergonomía para ofrecer mejores soluciones en sus proyectos de diseño. En la asignatura *Diseño de Exhibiciones y espacios comerciales* se presenta una gran oportunidad ya que al planear un espacio, se trabaja con un equipo que desempeña diferentes oficios para resolver todos los aspectos técnicos que se requieren para transformar un local. En estas circunstancias, varios trabajadores llevan a cabo su tareas simultáneamente, bajo presiones de tiempo y sin consideraciones ergonómicas.

El objetivo general de la investigación es conocer los diferentes oficios para proponer la intervención ergonómica en cada uno de ellos para evitar los riesgos, lesiones y repercusiones en la salud del personal.

En este artículo se presenta la descripción del oficio conocido como colocador de alfombras, que desempeña sus actividades en el entorno de los espacios que pueden ubicarse en centros comerciales o en recintos feriales. Los colocadores se contratan temporalmente, por obra determinada o periodo más amplio.

Se eligió este oficio porque ofrece una buena oportunidad para el análisis ya que en este trabajo son evidentes los problemas posturales, cargas excesivas, movimientos forzados, repetitivos y lesiones. Al realizar la investigación, se encontró información útil desarrollada en Estados Unidos ya que sus registros indican que hay un número considerable de demandas por incapacidad por lesiones en las rodillas como consecuencia de este trabajo, en relación con el total de la población laboral activa.

Esta parte de la investigación servirá como muestra para describir y analizar cada uno de los oficios que se han propuesto e implementar las intervenciones ergonómicas pertinentes fundamentadas en conocimientos para proponer herramientas y técnicas que ayuden a prevenir los problemas de salud inherentes a cada oficio.

**Palabras clave:** Diseño, riesgos ergonómicos, condiciones, trabajo.

**Relevancia para la ergonomía:** La investigación aporta información y advierte sobre los riesgos ergonómicos de los técnicos que desempeñan su trabajo en empresas del ramo de la industria de las exposiciones que prestan sus servicios en recintos feriales, con repercusiones negativas para su salud. que laboran bajo presiones y exigencias de tiempo,

Es importante destacar que el análisis se lleva a cabo con una visión integral, ya que se incluyen los componentes de cada tarea, las actividades derivadas de ella, la organización de trabajo, los factores tecnológicos y ambientales. Las situaciones analizadas en este ámbito, han sido poco exploradas por la Ergonomía, por lo que se prevé que puede ser un tema novedoso que debe incluirse en el ámbito académico, en particular en alguna asignatura del plan de estudios de diseño industrial. De igual manera, se pretende atraer la atención y despertar la conciencia tanto en el ámbito académico de la investigación, como en el campo profesional de los ergonomistas, de los diseñadores, de los empresarios y de las autoridades para que se atiendan las condiciones de trabajo de este gremio.

**Abstract:** The research carried out with the objective of preparing the contents that can be integrated into the programs of different subjects of the Industrial Design Study Plan aims to explore the possibilities in which the designer can apply ergonomic expertise to offer better solutions in their design projects. In the subject called *Design Exhibitions and Commercial Spaces,* a great opportunity opens since the beginning of planning a space, a designer works within a team of workers that perform different trades to solve all the technical aspects that are required to transform a certain space. In these circumstances, the different workers vary out their tasks simultaneously, under time pressure and without ergonomic considerations.

The general objective of the research is to comprehend the characteristics of the trades in order to propose ergonomic intervention in each of them to avoid risks, injuries and negative consequences on their health.

This paper presents the description of a representative case that deals with the trade known as carpet layer, who carries out activities in the environment of spaces that can be located in shopping centers or fairgrounds. Carpet layers work as free lance or with an established company.

This trade was chosen because it offers a great opportunity for analysis, since postural problems, excessive loads, forced and repetitive movements, and knee injuries are evident in this task. In conducting the research, we found useful information developed in the United States of America as their records indicate that there are considerable number of disability claims for knee injuries arising from this job relative to the total workforce.

This part of the research will serve as a sample to describe and analyze each of the trades that have been proposed and therefore implement the relevant knowledge-based ergonomic interventions to propose tools and techniques that help prevent health problems inherent to each trade.

**Key words:** Design, ergonomics, risks, working conditions.

**Relevance to Ergonomics**: The research contributes to provide information and warns about the ergonomic risks of working conditions of the technicians who perform their tasks with general contractors that design and build commercial spaces in trade fairs, exhibitions and shopping malls with potential negative consequences for their health because they work under pressure of time.

It is Important to acknowledge that this analysis includes effects on human performance, environmental and technological factors, issues of organization and work management.

The circumstances analyzed in this area, have been little explored, so we assume that it can be a novel topic that can attract the attention of academics in universities related to industrial design program, ergonomics research conducted to comprehend it, designers, entrepreneurs and authorities dedicated to this well-known commercial activity in Mexico.

## 1. INTRODUCTION

Based on several years of personal expertise as designer as well as teaching in the University, we propose the contents for the program of the subject called *Design of Exhibitions and Commercial Spaces* of the Study Plan of the Undergraduate In Industrial Design (FES Aragon UNAM). This program is important because in Mexico there are some outstanding companies designing and building trade fairs, exhibitions and commercial buildings, as well as designers employed in this area or working as free lance. Everybody is concerned with technical topics but rarely discuss ergonomic issues as risks that can be identified and prevented during the production, assembly or disassembly of the exhibitions, events or commercial spaces.

It is important that design programs in universities should develop critical awareness of major issues applying ergonomics to prevent risks, injuries and other malfunctions of people who work in this special area.

## 2. OBJECTIVES

Describe the working conditions of different tasks to identify the ergonomic risks to which technical personnel are exposed: carpenters, carpet layers, blacksmiths, electricians, painters, among others, during the assembly and disassembly of consumer exhibitions, commercial spaces in fairgrounds and shopping malls.

This paper is concerned on *carpet layers working conditions* as an example to introduce the case study and to be aware of the measures to prevent health problems, to conduct research to develop tools to reduce physical stress and trauma regarding this task.

### 2.1. Academic objectives

The aim of this paper is to present a complete thematic unit that includes the prevention and correction of the situation where ergonomic risks are identified and described thoroughly to be included in the program of the subject *Design of exhibitions and commercial areas* of the Curriculum of the Degree in Industrial Design. FES Aragón UNAM; conduct research that further could reduce the physical stress and trauma suffered by different workers by offering new tools and techniques.

### 2.2. Delimitation

In this paper, the description of the task called carpet layer will be identified within the scope of custom type stand or tailored events, commercial spaces that are commonly installed in fairgrounds or shopping malls in Mexico City and in the main large towns of the country.

The description of the task, tools and different conditions of this job in which risk will be identified to be able to evaluate and implement ergonomic intervention to existing conditions to prevent and correct the effects of body posture or muscular effort. This description and analysis will serve as an example to be applied in other jobs as carpenters, electrical and technician or other situations, which will serve as an example within case study.

It is important to mention that the conditions are deferent in other countries and may even vary from one company to another.

## 3. METHODOLOGY

3.1. Method: case study

3.2. Theoretical framework:

- Definition of terms.
- Description of the tasks selected within the different stages of assembly of Exhibitions.
- Identification of ergonomic risks and their relationship with activities.

3.3. Topics:

- The environment and context.
- Environment: temperature. Effects of heat and cold. Humidity. Working strenuously in heat and cold.
- Skilled versus unskilled workers.
- Touching. The cutaneous senses.
- Smelling. Working in polluted air. Aerosols. Effects on breathing and on the skin.
- Hearing. Sound, noise and vibration caused by noisy machines: woodworking tools, metal cutting tools, welding and cutting, etc. Noise and stress surveys.
- Manual work, repeated, in stress situations.
- Work shifts, hours of work per day, continuous schedules. Poor feeding.
- Teamwork, shared responsibilities, lack of clarity in work orders, limited time to

develop.
Manual handling of loads: carriers and accommodation of materials and Equipment in the exhibition area. No training for lifting loads.
Use stairs, work at considerable heights, forklift cranes, "heck".
Staff turnover.
Description of the personnel and their tasks:
Carpenters, carpet layers, blacksmiths, electricians, apprentices, painters, large format print setters, texts and logos.

## 4. RESULTS

### 4.1. Case study: Carpet layer or carpet installer. Working conditions. Theoretical framework.

Working postures: this job habitually requires bent, stooped, crawling and twisted working positions, like loading and unloading heavy weights as the carpet and underlay rolls; kneeling all the time, working in restricted and opened spaces. (Kroemer, 2001).

Forceful exertions with both hands, arms, shoulder muscles and the back. Force to push with knee, leg and thigh.

Manually driven tools needed for carpet installation:

Hammer, scissors, pliers, carpet knife, knee kicker, power stretcher,
With manual tools the operator generates all the energy and therefore is always in full control of the energy exerted.

These tools can be classified as follows:

Table 1. Classification of manually driven tools.

| | | |
|---|---|---|
| 1 | Percussive: hammer | Human task: swing and hold a handle |
| 2 | Scraping: saw, chisel | Human task: push or pull. |
| 3 | Rotating or boring: borer, drill, screwdriver | Human task: push, pull or turn and hold a handle. |
| 4 | Squeezing: pliers | Human task: press and hold a handle. |
| 5 | Cutting: scissors | Human task: pull and hold a handle |
| 6 | Cutting: knife | Human task: pull or push and hold a handle |

Source: Fraser, 1980 cited by Kroemer (2001).

Table 2 includes a short description of the manual tools and the knee kicker used by these workers. Also the knee pads recommended by NIOSH publication Number 90-104 (May 1990).

In Table 3 a brief description of the job is mentioned to visualize and help to understand the “Skills and abilities” mentioned in Table 4. All this information may help to know this occupation that has been ignored in our country.

Table 2. Tools needed for carpet installation.

| | | |
|---|---|---|
| 1 |  | Knee kicker apply tension using a **kick** of the **knee** to the back of the tool. They are used to tension carpet in smaller spaces, such as closets, staircases, and rooms up to 10 feet (3.0 m) square.<br>Notice that this tool is pushed with the knee.<br>Percussive tool. |
| 2 |  | Carpet knife<br>Cutting knife. Pull using a handle. |
| 3 |  | Carpet stretcher tool or power stretcher prevents the carpet from wrinkling or bowing up in spots.<br>Notice that this tool is pushed with the knee.<br>Percussive tool. |
| 4 |  | Carpet row cutter<br>Cutting knife. Push using a handle. |
| 5 |  | Carpet tucker is designed to snug carpet in the gap between the floor and the wall.<br>Percussive tool. |
| 6 |  | Knee pads for flooring works |

| | | |
|---|---|---|
| 7 |  | Knee pads for flooring works |

Source: homedepot.com/howto/DiscussionDetail/12-Tools-Needed-for-Carpet-Installation-

Table 3. Description of the job.

| | | |
|---|---|---|
| 1 | Carpet installers: | Floor and carpet layers install carpet, linoleum, and other floor coverings in homes or buildings. |
| 2 | Floor and carpet layers install different products. | Their methods are different but they share many similar tasks. Floor and carpet layers first measure the room and plan the layout. They consider traffic patterns and where to place seams. They inspect the surface of the floor. If it has imperfections that might show through, they patch holes or replace worn subflooring. |
| 3 | Cut and install either carpet padding or foundation material. | These materials provide cushioning and soundproofing. Floor and carpet layers roll out, measure, and mark the floor covering. They cut the floor covering, allowing a few extra inches for the final fitting. |
| 4 | Floor and carpet layers have several tasks that are unique to the floor covering they install. | Carpet layers nail tack strips to hold the carpet in place near walls and thresholds. They join carpet seams by sewing, or by using heat-tape and a carpet iron. Carpet layers stretch the carpet with a **knee kicker** tool and cut off the excess.<br><br>They use a power stretcher to hook the carpet to the tack strips along walls and thresholds. They finish the carpet edges with a wall trimmer.<br><br>They also install metal treads or thresholds at doorways. In special areas, such as stairways, carpet |

| | | |
|---|---|---|
| | | layers may use staples or other methods to install carpet.<br><br>In commercial buildings, they often use special glues. |

Table 4. Skills and abilities.

| | | |
|---|---|---|
| 1 | Communicate | Understand spoken information.<br>Speak clearly so listeners can understand.<br>Listen to others and ask questions. |
| 2 | Reason and problem solve | Notice when something is wrong or is likely to go wrong.<br>Use reasoning to discover answers to problems.<br>Follow guidelines to arrange objects or actions in a certain order. |
| 3 | Work with people | Change behavior in relation to others' actions |
| 4 | Perceive and visualize | Imagine how something will look if it is moved around or its parts are rearranged. |

Source: Illinois Career Information System.

## 4.2. Identification of ergonomic risks.

The carpet layer task is carried out mainly by male workers because it requires strength and high energy to transmit between the tools and the hands and between the tools and the knee. The carpet layer generates all the energy while using the different tools listed in Table 2. In Table 5 some images were chosen to explain the risks of working in this way during a typical installation.

Table 5. Recording and observing postures at work.

| | | |
|---|---|---|
| 1 |  | Carpet layer first prepares the floor by nailing tack strips along the perimeter of the room. |
| 2 |  | Carpet layers kneel on hard surface, without shoes, exposed to find nails and sharp razors.<br><br>Carpet layers spend about 75% of the time on their hands and knees. |

| | | |
|---|---|---|
| | | Knees are in direct contact with hard and cold surfaces. |
| 3 |   | The carpet layer uses the knee kicker to engage an edge of the carpet onto the tack strips. Very strong kicks are applied when the carpet is stretched from wall to wall. According to a biomechanical study, the average impact of such kicks exceeds 3,000 newtons (675 pounds)–about three to five times the body weight. During a typical installation these strong knee kicks are repeated 120 to 140 times per hour [Bhattacharya et al. 1985]. NIOSH. |
| 4 |  | They cut the floor covering, allowing a few extra inches for the final fitting. |

Source: https://www.youtube.com/watch?v=-yf3-9HyvWo

## 5. CONCLUSIONS

As this research develops important and well-founded data has been obtained about the job of the carpet layer. It is important to mention, that nowadays, little attention has been paid to the problems that may arise with the personnel who carry out this task., which is highly requested in shopping centers and fairgrounds, in addition to new buildings and hotels, among others.

In other countries, which are at the forefront of laws and regulations to protect their workers; surgeons and engineers have actively participated in issuing recommendations and suggestions to prevent workers from being affected in their health due to carelessness and ignorance of the effects of daily activities.

Following NIOSH recommendations, research in universities and other centers should be conducted to develop methods and techniques that further reduce the physical stress and trauma suffered by men and women, workers, users, artisans, etc. in daily tasks.

Hopefully more ergonomists, surgeons, engineers and designers are interested in the prevention of risks and occupational diseases and, above all the results of academic investigations should be discussed publicly.

## 6. REFERENCES

CONMASA. Grupo SCH. Corporate brochure, PDF. https://conmasa.mx/en/about-us/ October, 2020.

E.J. Krause & Associates, Inc. http://www.ejkrause.com/events.html

Hernández Sampieri, R., Fernández Collado, R. Baptista Lucio, M:P. (2014). *Metodología de la investigación,* Mc Graw-Hill/Interamericana Editores, México.

Home Depot http://community.homedepot.com/howto/DiscussionDetail/12-Tools-Needed-for-Carpet-Installation-90650000000L9Rh

Illinois Worknet Center. American job center. Carpet installers. https://apps.illinoisworknet.com/cis/Clusters/OccupationDetails/100321?parentId=110200&section=skills&sectionTitle=Skills%20and%20Abilities October, 2020.

Kapandji, A.I. (2006). *Fisiología articular. Esquemas comentados de mecánica humana.* Médica Panamericana, Madrid.

Kroemer, K., Kroemer, H. and Kroemer-Elbert, K. (2001). *Ergonomics. How to design for ease and efficiency.* Prentice Hall International Series, Upper Saddle River, N.J.

Llaneza Alvarez, F.J. (2012). *La ergonomía forense y el papel de los ergónomos como peritos judiciales.* Tesis doctoral. Universidad de Oviedo, España.

Maya, E. (2014). *Métodos y técnicas de investigación.* Facultad de Arquitectura. Universidad Nacional Autónoma de México.

Mital, A., Nicholson, A.S., and Ayoub, M.M. (1993). *A Guide to Manual Materials Handling*. Taylor & Francis, Ltd., London, United Kingdom.

NIOSH (1990). *Preventing Knee Injuries and Disorders in Carpet Layers.* (DHHS NIOSH Publication 90-104), US Government Printing Office, Washington, D.C. https://www.cdc.gov/niosh/docs/90-104/default.html

*Proyecto de modificación del Plan de Estudios de la Licenciatura en Diseño Industrial.* (2020). Facultad de Estudios Superiores Aragón. Universidad Nacional Autónoma de México. PDF.

Youtube videos: https://www.youtube.com/watch?v=-yf3-9HyvWo

# ERGONOMIC DESIGN OF AN ARMCHAIR FOR STUDENTS OF MECHANICAL ENGINEERING OF THE SUPERIOR TECHNOLOGICAL INSTITUTE OF GUASAVE

**Litzy Jaqueline Gutiérrez Vázquez, Ana Isabel Ramos Cortez, Xóchitl Patricia Flores Gutérrez, Yuridia Belén Cota Pardini**

Department of Industrial Engineering
Instituto Tecnológico Superior de Guasave
Carretera a Brecha S/N, Ej. Burrioncito
Guasave, Sinaloa, CP. 81149
Ing.belencota@gmail.com

**Resumen** Los alumnos del Instituto Tecnológico Superior de Guasave se encuentran en las aulas y laboratorios del campus aproximadamente 7 horas diarias. Utilizar sillones que no han sido diseñados ergonómicamente y que les obligan a adoptar posturas incorrectas durante la jornada escolar. Sabiendo que un sillón ergonómico supone problemas de salud, mayor comodidad y, por tanto, mucha energía y motivación, en esta investigación el objetivo fue el diseño ergonómico de un sillón para estudiantes específicamente de la carrera de Ingeniería Mecánica del Instituto Tecnológico Superior de Guasave. Para el diseño del sillón, se desarrolló un estudio antropométrico a los alumnos de la carrera con edades comprendidas entre los 18 y los 22 años, y se confeccionó una gráfica antropométrica con las dimensiones requeridas. Considerando una población de 100 estudiantes de la carrera, se determinó el tamaño ideal de la muestra para incluir un percentil del 95%. Las dimensiones estructurales de los diferentes segmentos corporales se tomaron en individuos con posturas estáticas de pie o sentado.

**Palabras clave:** Ergonomía, Antropometría, percentil, dimensión, postura.

**Relevancia para la ergonomía:** Cuando se habla del diseño de un sillón ergonómico para estudiantes, estamos hablando directamente del tema de la salud, que es un aspecto muy relevante dentro del área de interés de la ergonomía. Gracias a que el diseño del sillón se ajusta a las características antropométricas de sus usuarios, se pueden evitar los efectos nocivos de las horas extras mantenidas en una postura incorrecta. Incrementar la calidad en el servicio, la productividad en el proceso de enseñanza-aprendizaje y el cuidado de la salud, son aspectos muy relevantes para todas las instituciones educativas.

**Abstract** The students of the Superior Technological Institute of Guasave are in the campus classrooms and laboratories for approximately 7 hours every day. Utilizing armchairs that have not been ergonomically designed and which forces them to adopt incorrect postures during the school day. Knowing that an ergonomic armchair supposes health issues, greater comfort, and therefore, much energy and motivation, in this research, the aim was the ergonomic design of an armchair for students specifically from Mechanical Engineering career of the Superior Technological Institute of Guasave. To design the armchair, developed an anthropometric study to the students of the career with ages between 18 and 22 years, and an anthropometric chart was made with the required dimensions. Considering a population of 100 students of the career, it was determined the ideal size of the sample to include a percentile of 95%. The structural dimensions of the different body segments were taken on individuals with standing or seated static postures.

**Keywords**: Ergonomics, Anthropometric, percentile, dimension, posture

**Relevance for the ergonomics**: When talking about the design of an ergonomic armchair for students, we are speaking directly about the health topic, which is a very relevant aspect within the ergonomics area of interest. Thanks to the fact that the armchair design adjusts to the anthropometric characteristics of its users, the harmful effects of incorrect posture-maintained overtime can be avoided. Increasing the quality in the service, productivity in the teaching-learning process, and taking care of the health, are very relevant aspects for all the educational institutions.

## 1. INTRODUCTION

The ergonomics is defined as the multidisciplinary knowledge field that studies the human characteristics with the objective of adapting the works and products to their capacities and needs (Vergara & Agost, 2015). The ergonomics application has as aim adapting, products, tools, field areas, with the purpose of improving the wellbeing of the users.

In university institutions, it is common to observe students that cannot get to sustain their feet to the surface due to their short height, or well those whose inferior extremities dimensions keep them from adopting a good posture, due to the available space is not enough. Definitely, the discomfort of the students is a variable that has an impact on the development of educational activities, since inadequate furniture prevents the execution of tasks from being favorable to them.

Medina (2011) mentions that countries such as Brazil, Colombia, the United States, and Venezuela have carried out research on the dysergonomic conditions in the classrooms in different national universities.

In this sense, Rodriguez and Gonzales (2011) compile the school furniture evolution to evaluate if this is following the ergonomic parameters and indicate that the adaptation of the scholar furniture to the anthropometrics or the physical needs of the children is the main purpose of the most relevant progress; however, they explain that this evolution has not always been positive, from the ergonomics point of view. Rodriguez and Gonzales conclude that one of the concerns that arise nowadays is the need for furniture adaptation and the discomfort that it can generate and that the characteristics of traditional scholar furniture force the students to adopt anti-physiological positions, which over time can cause serious health problems

Anthropometrics is fundamental in making an adequate ergonomic design. The term anthropometrics comes from the Greek Anthropos (man) and Metrikos (measure), and it is about the quantitative study of the man's physical characteristics. Many authors describe anthropometry as a group of techniques derived from physical anthropology. Anthropometry is the science that studies the dimensions and proportions of the human body. The anthropometric data are necessary to establish the dimensions of the products and working areas. It applies in all areas of the industrial design. (Vergara & Agost, 2015)

Since the anthropometry applied to the design is the use of the different validated methods and instruments of physical measurements from a specific population, the result of the measurements aids to dimension the prototype desired to design and helps to establish strategies to know how it will adjust to the population's dimensions.

The anthropometric dimensions from each population denominate by measurements and are defined as percentiles, which are values that divide a group of statistical data in percentage that is lower than the different values obtained. This research begins from collecting the measures of the user's population, in this case, the student population from Mechanical Engineering of the Superior Technological Institute of Guasave to make an armchair design that adapts to their characteristics. There are many factors that intervene significantly in the body dimensions of human beings, such as sex, age, race, etc. One of the most significant differences is found between men and women, due to in general people of the male sex tend to have larger body dimensions than people of the female sex.

The measurements taken must be as precise as possible so that the study has the necessary reliability for its application to the design of objects or elements of common use. (Ruiz, 2008)

## 2. OBJECTIVES

Design an ergonomic armchair for the students of Mechanical Engineering of the Superior Technological Institute of Guasave considering their anthropometric characteristics.

- Record the anthropometric data of the selected students' sample to help to dimension the prototype.
- Calculate 95% and 5% percentiles.
- Design an ergonomic armchair that adjusts to the students' dimensions.

## 3. METHODOLOGY

### 3.1 Design of the anthropometric chart

An anthropometric study was conducted in the Study of Work and Ergonomics laboratory of Industrial Engineering of the Superior Technological Institute of Guasave with a students' sample of the career of mechanical engineering with the intention of calculating the 95% and 5% percentile to design an ergonomic armchair for the current population of the mentioned career.

To perform the sample, determined the measures that needed to be considered for the mentioned design and codified to identify them in each one of the subjects. (See figure 1 and table 1).

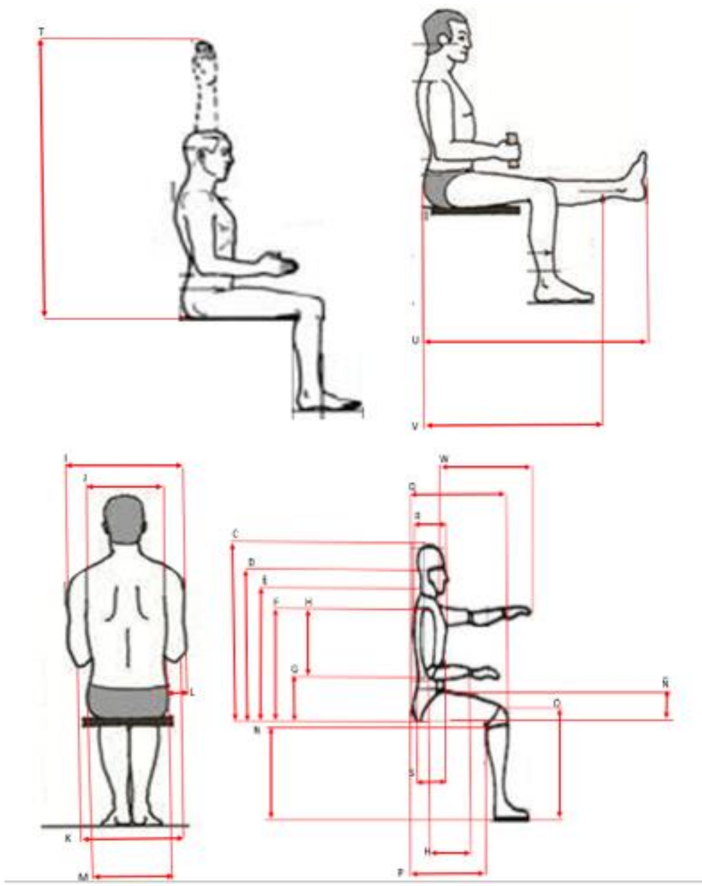


Figure 1. Anthropometric chart

Table 1. Dimensions selected and their codes

| DIMENSION | CODE |
|---|---|
| Weight | A |
| Height standing | B |
| Height seated | C |
| Height of the eyes | D |
| Height of the nape | E |
| Height of the shoulders | F |
| Height of the elbow | G |
| Length shoulder-elbow | |

| | |
|---|---|
| Length elbow-wrist | H |
| Width of shoulders 2 | I |
| Width of shoulders | J |
| Width between elbows | K |
| Width of elbow | L |
| Width of hips | M |
| Height of popliteal | N |
| Thickness of thigh | Ñ |
| Height of the knee | O |
| Length of the back popliteal | P |
| Length of back knee | Q |
| Thickness of chest P. | R |
| Thickness abdominal | S |
| Height reach vertical | T |
| Distance buttock-tiptoe | U |
| Distance buttock-leg | V |
| Reach tiptoe | W |

## 3.2 Calculation of the sample size.

To determine the sample size, a population of 100 students of the career of mechanical engineering was considered and the sample size was calculated, obtaining a total of 43 students that were chosen randomly.

$$n = \frac{z^2 * p * q * N}{e^2(N-1) + z^2 * p * q} \quad (1)$$

Where:
- N = Total population
- Z2 = 1.962 (if the reliability is 95%)
- p and q= expected proportion 0.5, for a maximum probability of each subject if considered.
- e = precision

$$n = \frac{196^2 * 0.95 * 0.05 * 100}{0.05^2(100-1) + (1.96^2 * 0.95 * 0.05)} = 42.44 \approx 43$$

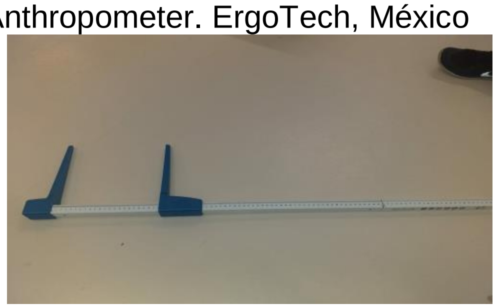
## 3.3 Taking anthropometric measurements

The measures were taken inside the laboratory facilities, where the students attended during 4 consecutive days considering the following:

1) The space has conditions of adequate comfort, good lighting, large space, and comfortable temperature.
2) The subjects studied were barefoot and with light clothes.
3) Considering that the body weight and height have variations during the day, the measures were taken at the first time of the day between 7 and 9 A.M., with previous food recommendations.
4) The instruments were calibrated and confirmed their accuracy before taking the measures.
5) The anatomical and reference points were previously marked on the anthropometric chart.

To take the measures, the instruments available in the laboratory of the Superior Technological Institute of Guasave were used. That is the case of the: Flexometer, tallimeter, anthropometer, and a digital scale (see table 2).

Table 2. Instruments used in the measurements

| | |
|---|---|
| Digital flexometer. ErgoTech México  | Tallimeter. Seca 2.10 meters  |
| Anthropometer. ErgoTech, México  | Digital scale. Weightcare, 180 kg maximum  |

The data obtained from the measurements were stored and processed in Microsoft Excel spreadsheets to determine the percentiles. With the objective that a larger number of individuals locates within a body dimension equal to or less than those determined in the study, a 95% percentile was chosen.

### 3.4 Ergonomic armchair design

With the data obtained from the measurements, the 95% and 5% percentiles were calculated in the Excel program to determine the adequate measures for the design of an ergonomic armchair for the students of the mechanical engineering career. SolidWorks 2014 was used to design the armchair.

## 4. RESULTS

As already mentioned, the aim of this research was the design of an armchair that complies with the appropriate dimensions to the 95% of the students of the Mechanical Engineering career from the Superior Technological Institute of Guasave have an adequate posture that allows them to take care of their health and maintain the academic performance. It is important to mention that currently, the institution has a classic armchair that does not comply with the required ergonomic standards. Following, table 3 shows the registry of the 25 measurements taken to 43 students of the campus, and table 4 illustrates the 95% and 5% percentiles calculations.

One of the principal functions of the ergonomics is the adaptation of working spaces. With the completion of this work, an ergonomic analysis was carried out aimed at the elaboration of the ergonomic armchairs, using anthropometry, in order to determine the influencing factors and which should be the ideal values to get the comfort and at the same time the efficiency of the work performed.

As it is known, the postures and those natural movements are indispensable to achieve an efficient work, considering that the working area adapts to the body dimensions of the students of the career, not leaving aside the diverse varieties that exist among the students' sizes to evaluate, to get the ergonomic chair.

In order to achieve the ideal working area design, it is more logical and correct to consider the individuals with greater height to be able to narrow down the dimensions, a clear example would be the distance between the legs underneath the armchair. On the other hand, also considering the individuals with a lower height, to narrow down the reach zones dimensions. The ideal percentiles would be 95% and 5%.

Due to the 5% percentile adequates as the population value in which has dimensions of equal or lower value. In the same way, the 95% percentile indicates that this value is equal or lower. In a normal distribution, these two points are symmetric in regard to the mean, which means that the two measures are at the same distance as the mean.

## Table 3. Registry of measurements

| SUJ. | WEIGHT | HEIGHT STANDING | HEIGHT SEATED | HEIGHT OF THE EYES | HEIGHT OF THE NAPE | HEIGHT OF THE SHOULDERS | HEIGHT OF THE ELBOW | LENGTH SHOULDER ELBOW | LENGTH ELBOW WRIST | WIDTH OF SHOULDERS | WIDTH OF SHOULDERS 2 | WIDTH BETWEEN ELBOWS | WIDTH OF ELBOW | WIDTH OF HIPS | HEIGHT OF POPLITEAL | THICKNESS OF THIGH | HEIGHT OF THE KNEE | LENGTH OF THE BACK POPLITEAL | LENGTH OF BACK KNEE | THICKNESS OF CHEST P. | THICKNESS ABDOMINAL | HEIGHT VERTICAL REACH | DISTANCE BUTTOCK TIP TOE | DISTANCE BUTTOCK LEG | REACH TIP TOE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1 | 60 | 174 | 90 | 80 | 73 | 60 | 27 | 36 | 30 | 44 | 45 | 44 | 7 | 36 | 43 | 16 | 52 | 38 | 52 | 20 | 22 | 139 | 62 | 98 | 79 |
| 2 | 73 | 163 | 88 | 75 | 74 | 56 | 27 | 34 | 27 | 44 | 50 | 50 | 9 | 41 | 44 | 17 | 51 | 42 | 53 | 24 | 25 | 130 | 63 | 97 | 74 |
| 3 | 82 | 179 | 90 | 81 | 73 | 64 | 30 | 36 | 32 | 45 | 51 | 52 | 8 | 40 | 45 | 15 | 56 | 48 | 61 | 24 | 22 | 115 | 71 | 104 | 51 |
| 4 | 74 | 164 | 86 | 73 | 67 | 8 | 24 | 36 | 28 | 41 | 49 | 49 | 8 | 37 | 42 | 17 | 53 | 44 | 55 | 22 | 24 | 131 | 65 | 98 | 124 |
| 5 | 60 | 174 | 86 | 73 | 63 | 55 | 20 | 37 | 30 | 41 | 46 | 47 | 7 | 33 | 43 | 15 | 54 | 47 | 56 | 20 | 20 | 130 | 66 | 103 | 75 |
| 6 | 75 | 173 | 86 | 77 | 69 | 59 | 24 | 36 | 29 | 45 | 51 | 49 | 6 | 38 | 40 | 15 | 50 | 52 | 60 | 23 | 23 | 134 | 70 | 105 | 75 |
| 7 | 74 | 167 | 86 | 71 | 65 | 58 | 20 | 36 | 28 | 44 | 54 | 54 | 7 | 36 | 41 | 15 | 52 | 47 | 55 | 26 | 23 | 129 | 65 | 103 | 71 |
| 8 | 68 | 174 | 89 | 80 | 69 | 62 | 25 | 37 | 23 | 29 | 47 | 43 | 10 | 34 | 44 | 19 | 56 | 43 | 56 | 21 | 21 | 135 | 66 | 98 | 73 |
| 9 | 95 | 183 | 93 | 80 | 70 | 61 | 23 | 34 | 29 | 33 | 53 | 53 | 12 | 40 | 48 | 22 | 58 | 46 | 59 | 35 | 27 | 131 | 69 | 104 | 70 |
| 10 | 75 | 177 | 90 | 85 | 73 | 64 | 26 | 36 | 29 | 29 | 46 | 46 | 10 | 36 | 47 | 18 | 46 | 43 | 59 | 21 | 21 | 123 | 69 | 105 | 59 |
| 11 | 77 | 173 | 91 | 85 | 71 | 62 | 26 | 33 | 31 | 29 | 47 | 50 | 10 | 35 | 45 | 20 | 58 | 42 | 55 | 21 | 23 | 132 | 65 | 102 | 70 |
| 12 | 69 | 183 | 90 | 80 | 70 | 63 | 29 | 35 | 30 | 33 | 46 | 48 | 8 | 33 | 46 | 17 | 53 | 41 | 52 | 21 | 20 | 137 | 62 | 99 | 74 |
| 13 | 65 | 173 | 90 | 79 | 70 | 61 | 20 | 36 | 31 | 29 | 45 | 43 | 9 | 31 | 50 | 16 | 60 | 44 | 54 | 22 | 21 | 131 | 64 | 104 | 70 |
| 14 | 82 | 166 | 85 | 75 | 65 | 58 | 24 | 35 | 30 | 27 | 48 | 53 | 10 | 37 | 46 | 18 | 56 | 40 | 55 | 24 | 23 | 120 | 65 | 96 | 62 |
| 15 | 95 | 183 | 95 | 86 | 64 | 66 | 27 | 36 | 30 | 31 | 50 | 50 | 10 | 37 | 41 | 21 | 62 | 45 | 59 | 24 | 25 | 135 | 69 | 109 | 69 |
| 16 | 63 | 171 | 92 | 80 | 68 | 61 | 28 | 34 | 30 | 26 | 42 | 39 | 9 | 33 | 41 | 17 | 53 | 42 | 49 | 18 | 19 | 124 | 59 | 94 | 63 |
| 17 | 98 | 175 | 94 | 82 | 76 | 64 | 30 | 35 | 28 | 31 | 47 | 52 | 8 | 39 | 47 | 17 | 58 | 46 | 57 | 26 | 26 | 139 | 67 | 100 | 75 |
| 18 | 74 | 173 | 79 | 73 | 65 | 58 | 27 | 34 | 29 | 30 | 44 | 47 | 9 | 38 | 46 | 18 | 58 | 43 | 54 | 22 | 21 | 120 | 64 | 103 | 62 |
| 19 | 79 | 181 | 88 | 73 | 66 | 58 | 22 | 38 | 32 | 46 | 39 | 48 | 8 | 40 | 56 | 16 | 46 | 56 | 60 | 24 | 22 | 137 | 70 | 110 | 79 |
| 20 | 88 | 172 | 84 | 72 | 67 | 56 | 27 | 36 | 39 | 44 | 56 | 46 | 9 | 42 | 40 | 16 | 54 | 42 | 55 | 27 | 27 | 129 | 65 | 99 | 73 |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 81 | 175 | 78 | 73 | 64 | 58 | 23 | 38 | 31 | 43 | 49 | 47 | 10 | 38 | 46 | 15 | 59 | 44 | 54 | 25 | 26 | 140 | 64 | 108 | 81 |
| 22 | 72 | 170 | 87 | 75 | 65 | 59 | 24 | 33 | 28 | 27 | 46 | 48 | 8 | 36 | 48 | 16 | 56 | 44 | 51 | 22 | 23 | 128 | 61 | 100 | 69 |
| 23 | 98 | 185 | 96 | 79 | 75 | 66 | 24 | 37 | 30 | 30 | 48 | 49 | 9 | 40 | 50 | 19 | 63 | 44 | 58 | 28 | 26 | 141 | 68 | 110 | 75 |
| 24 | 101 | 179 | 90 | 82 | 71 | 64 | 25 | 36 | 27 | 30 | 52 | 59 | 10 | 42 | 47 | 22 | 50 | 49 | 59 | 22 | 24 | 147 | 69 | 105 | 83 |
| 25 | 67 | 177 | 92 | 79 | 70 | 62 | 25 | 35 | 30 | 30 | 42 | 48 | 7 | 57 | 47 | 16 | 57 | 49 | 60 | 25 | 20 | 133 | 70 | 107 | 71 |
| 26 | 81 | 183 | 90 | 77 | 72 | 63 | 26 | 37 | 31 | 32 | 46 | 47 | 10 | 37 | 43 | 13 | 56 | 47 | 55 | 23 | 20 | 141 | 65 | 105 | 78 |
| 27 | 80 | 181 | 88 | 78 | 79 | 59 | 25 | 37 | 31 | 36 | 39 | 48 | 10 | 37 | 44 | 15 | 57 | 43 | 54 | 20 | 22 | 141 | 64 | 104 | 82 |
| 28 | 70 | 181 | 91 | 76 | 66 | 60 | 24 | 35 | 30 | 24 | 44 | 47 | 10 | 34 | 48 | 14 | 54 | 36 | 48 | 21 | 21 | 138 | 58 | 109 | 78 |
| 29 | 51 | 166 | 86 | 73 | 67 | 58 | 25 | 33 | 26 | 27 | 41 | 41 | 8 | 39 | 45 | 15 | 53 | 44 | 52 | 19 | 15 | 122 | 62 | 94 | 64 |
| 30 | 62 | 179 | 86 | 77 | 66 | 59 | 24 | 35 | 29 | 34 | 42 | 37.5 | 8 | 33 | 43 | 13 | 55 | 42 | 54 | 21 | 19 | 134 | 64 | 94 | 75 |
| 31 | 55 | 161 | 88 | 77 | 69 | 61 | 30 | 31 | 26 | 27 | 42 | 38 | 7 | 38 | 41 | 12 | 49 | 43 | 54 | 25 | 18 | 128 | 64 | 93 | 67 |
| 32 | 94 | 188 | 89 | 76 | 67 | 59 | 24 | 36 | 30 | 36 | 49 | 53 | 10 | 41 | 47 | 16 | 61 | 50 | 61 | 24 | 27 | 145 | 71 | 117 | 86 |
| 33 | 64 | 168 | 83 | 73 | 61 | 54 | 25 | 30 | 29 | 27 | 46 | 45 | 9 | 32 | 44 | 14 | 54 | 33 | 46 | 20 | 19 | 127 | 56 | 93 | 73 |
| 34 | 56 | 189 | 80 | 74 | 62 | 58 | 23 | 37 | 27 | 24 | 44 | 47 | 8 | 33 | 49 | 15 | 58 | 41 | 56 | 20 | 18 | 141 | 66 | 105 | 83 |
| 35 | 76 | 169 | 86 | 71 | 62 | 54 | 29 | 32 | 26 | 26 | 42 | 46 | 9 | 38 | 47 | 17 | 55 | 39 | 55 | 21 | 22 | 124 | 65 | 98 | 70 |
| 36 | 65 | 165 | 78 | 65 | 54 | 47 | 26 | 31 | 25 | 25 | 45 | 43 | 9 | 35 | 43 | 14 | 54 | 39 | 49 | 21 | 20 | 126 | 59 | 96 | 79 |
| 37 | 73 | 159 | 81 | 71 | 63 | 56 | 25 | 31 | 23 | 42 | 48 | 55 | 11 | 39 | 42 | 15 | 50 | 42 | 50 | 25 | 26 | 117 | 60 | 94 | 61 |
| 38 | 60 | 173 | 80 | 74 | 65 | 60 | 26 | 34 | 30 | 32 | 43 | 48 | 9 | 40 | 50 | 18 | 57 | 45 | 56 | 21 | 20 | 140 | 66 | 100 | 80 |
| 39 | 59 | 172 | 88 | 77 | 64 | 59 | 25 | 19 | 28 | 29 | 43 | 43 | 9 | 37 | 53 | 16 | 54 | 44 | 50 | 19 | 20 | 135 | 60 | 95 | 76 |
| 40 | 60 | 170 | 92 | 76 | 69 | 57 | 23 | 34 | 29 | 29 | 43 | 39 | 8 | 36 | 50 | 13 | 52 | 38 | 46 | 20 | 19 | 130 | 56 | 89 | 73 |
| 41 | 77 | 172 | 88 | 78 | 73 | 61 | 28 | 35 | 26 | 23 | 47 | 50 | 9 | 38 | 44 | 16 | 55 | 40 | 52 | 22 | 23 | 129 | 62 | 92 | 68 |
| 42 | 94 | 175 | 90 | 82 | 76 | 65 | 28 | 33 | 28 | 26 | 47 | 56 | 9 | 40 | 55 | 20 | 57 | 40 | 55 | 25 | 26 | 136 | 65 | 97 | 71 |
| 43 | 58 | 168 | 90 | 80 | 73 | 61 | 25 | 33 | 30 | 27 | 43 | 41 | 9 | 32 | 41 | 14 | 52 | 42 | 54 | 19 | 19 | 136 | 64 | 94 | 75 |
| 44 | 80 | 170 | 86 | 77 | 70 | 66 | 28 | 34 | 28 | 24 | 48 | 51 | 9 | 41 | 43 | 16 | 54 | 44 | 56 | 24 | 22 | 135 | 66 | 99 | 69 |

Table 4. Percentiles calculation

| | WEIGHT | HEIGHT STANDING | HEIGHT SEATED | HEIGHT OF THE EYES | HEIGHT OF THE NAPE | HEIGHT OF THE SHOULDERS | HEIGHT OF THE ELBOW | LENGTH SHOULDER ELBOW | LENGTH ELBOW WRIST | WIDTH OF SHOULDERS | WIDTH OF SHOULDERS 2 | WIDTH BETWEEN ELBOWS | WIDTH OF ELBOW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| **PERCENTIL 5%** | 55.1 | 161.4 | 78.52 | 70.68 | 61.46 | 47.92 | 20 | 30.1 | 23.58 | 23.6 | 39.3 | 38.575 | 6.7 |
| **PERCENTIL 95%** | 97.53 | 184.8 | 93.9 | 84.7 | 75.9 | 64.93 | 29.46 | 37 | 31.9 | 44.9 | 52.45 | 54.925 | 10 |

| | WIDTH OF HIPS | HEIGHT OF POPLITEAL | THICKNESS OF THIGH | HEIGHT OF THE KNEE | LENGTH OF THE BACK POPLITEAL | LENGTH OF BACK KNEE | THICKNESS OF CHEST P. | THICKNESS ABDOMINAL | HEIGHT VERTICAL REACH | DISTANCE BUTTOCK TIPTOE | DISTANCE BUTTOCK LEG | REACH TIPTOE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| **PERCENTIL 5%** | 32 | 40.1 | 12.76 | 46.52 | 36.64 | 46.4 | 18.6 | 17.68 | 117.92 | 56.4 | 92.22 | 73.2 |
| **PERCENTIL 95%** | 41.9 | 52.7 | 20.9 | 60.45 | 49.57 | 60 | 27.26 | 26.9 | 141.19 | 70 | 109.73 | 82.87 |

In the figures 2,3,4,5,6,7 and 8 the ergonomic armchair design can be observed.

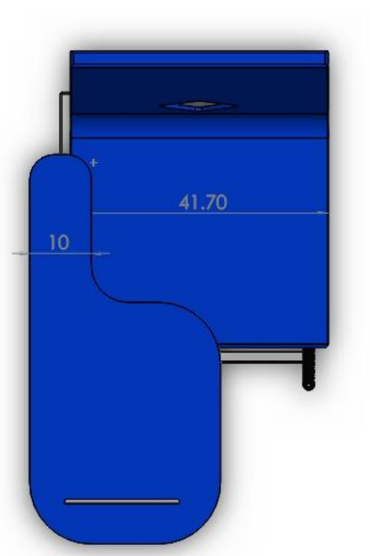
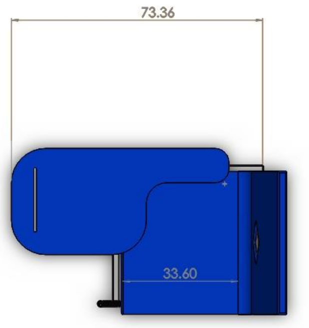



Figure 2. Ergonomic design of the armchair

Figure 3. Seat width



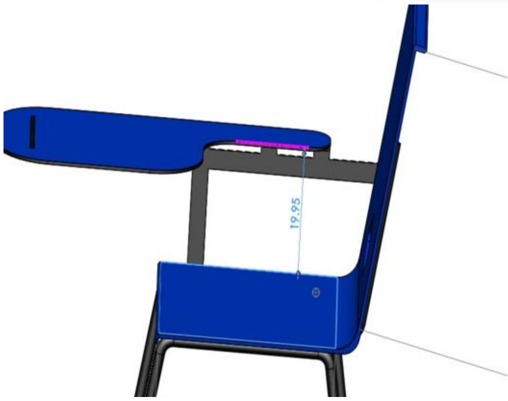




Figure 4. Back-arm length

Figure 5. Arm-seat height

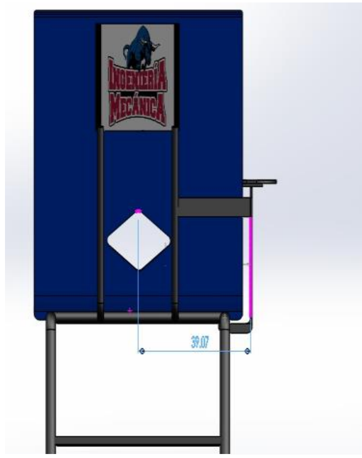



Figure 6. Arm width Figure 7. Seat and back length


Figure 8. Seat height

## 5. DISCUSSION/CONCLUSIONS

The correct design of the classroom armchair is a very important factor that will contribute not only to the students maintaining an adequate posture during the school day and with this reduce the fatigue and backache, but also to provide comfort if it is adapted to the users' physical dimensions.

Cervantes et al (2019) developed a low back pain diagnosis in university students from the health area in Tepic, Nayarit where 90 students of BSc Nutrition and Physiotherapy participated (45 of each career). The nutrition students were the ones who presented the biggest problem, 77.77% manifested back pain. Although inadequate postures were a predominant factor in suffering from low back pain, Cervantes et al point out that the pain perception in the lower back was due to poor ergonomic measurements of furniture and armchairs, which do not adapt to the complexion of most students.

Whilst, Parraga (2014) identified the factors that influence in the discomfort of the university student of the faculty of Industrial Engineering of the Mayor National University of San Marcos (UNMSM), indicating that the ergonomic aspect that influences the most in the university students discomfort is the furniture, principally the carpet’s seat due to the material hardness.

This causes that, at the end of the day, the students manifest discomfort in the buttocks and to a lesser extent, in the thighs and middle back. Parraga concludes that definitely, the measures of the classroom furniture do not keep relation with the anthropometric measures of the students.

This research considered the elements that cause discomfort in the students of Mechanical Engineering of the Superior Technological Institute of Guasave to suggest a design that overcomes those causes. Adequate the armchairs to the students help to decrease musculoskeletal stress and fatigue, having a good posture and also facilitates the development of activities since it allows to provide comfort to the students and at the same time, helps in their academic performance.

## 6. REFERENCES

Cervantes, A. (2019). Diagnóstico de lumbalgia en estudiantes universitarios del área de salud en Tepic, Nayarit. México: Med. Leg.Cista Rica vol. 36. https://www.scielo.sa.cr/scielo.php?script=sci_arttext&pid=S1409-00152019000100043

Medina, E (2011). Problemas disergonómicos asociados al mobiliario escolar y al manejo de cargas en escolares de educación básica en planteles públicos y privados. Valencia, Venezuela. Maracay: Comunidad y Salud vol. 9. http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S1690-32932011000100008

Párraga, M. (2014). Diseño ergonómico de aulas universitarias que permitan optimizar el confort y reducir la fatiga de estudiantes y docentes. Link: http://cybertesis.unmsm.edu.pe/bitstream/handle/cybertesis/3618/Parraga_vm.pdf;jsessionid=F5F502B13B34436159FE15E781986CC7?sequence=1

Rodríguez, L., Gonzales, P. (2011). Evolución del mobiliario escolar. Revista Técnica Industrial, 295, 64-69.
Ruiz, O. M. (2008). Tablas antropométricas infantiles. Bogotá: Universidad Nacional de Colombia. Facultad de Artes.
Vergara, M., & Agost, M. J. (2015). Antropometría aplicada al diseño del producto. Castelló de la Plana: Universitat Jaume.

# ERGONOMIC REDESIGN OF THE COPY CENTER IN AN INSTITUTION OF HIGHER EDUCATION

**María Yolanda Frausto Villegas, Mónica Gabriela Gutiérrez Hernández, Alexis Quiroz Frausto, Alberto Morales Vazquez, Eduardo Sarmiento**

Department of Industrial Engineer
Ciudad Juarez Technological Institute
Technological Ave. # 1340, Development “The Crucero”
Heroica Ciudad Juárez, Chihuahua 32500
fraustoyol@hotmail.com

**Resumen:** En una institución de educación superior se cuenta con un centro de copiado, que atiende a más de 7000 alumnos. El espacio y el servicio resultan insuficientes pues constantemente algunos alumnos optan por evitar el tiempo de espera y retirarse sin recibir el servicio. Aunado a esto las computadoras con que cuenta son obsoletas y estas dispuestas de tal manera que resulta incómodo para el usuario utilizarlas. A través del presente estudio se determinaron las siguientes áreas de oportunidad: Como primer punto utilizando una simulación en ProModel® se calculó que cada hora se pierden aproximadamente 25 clientes. Se realizó una propuesta de reacomodo para optimizar el espacio. Se hizo un análisis del equipo con el que se cuenta y el disponible en el mercado para obtener una propuesta factible de adquirir equipo más eficiente. Se analizaron las condiciones ambientales de iluminación y ruido de acuerdo a lo establecido en las respectivas normas. Y finalmente a través de un estudio EPR (evaluación de postura rápida) se determinó que la posición no implicaba algún problema.

**Palabras clave**: Centro de Copiado, EPR (evaluación Postural Rápida), rediseño, evaluaciones ambientales.

**Relevancia para la ergonomía**: El análisis de los procesos de servicios son poco estudiados en relación a los procesos productivos. Por lo que el presente proyecto analiza diversos aspectos enfocados en mejorar la ergonomía de un lugar donde se presta servicio a más de 7000 usuarios. En el proyecto se presentan múltiples mejoras que se pueden realizar en un espacio de servicios, tales como las condiciones ambientales, la interacción hombre-máquina y una distribución del equipo y mobiliario más apropiada al espacio disponible. Se demuestra de esta forma como los procesos de servicios no quedan exentos de mejoras ergonómicas y como la ergonomía puede ser aplicada desde diversos enfoques para optimizar tanto los procesos productivos como de servicios.

**Abstract:** In a higher education institution, there is a copy center, which serves more than 7000 students. Space and service are insufficient because some students constantly choose to avoid waiting time and withdraw without receiving service. In addition to this, the computers with the account are obsolete and are arranged in such a way that it is uncomfortable for the user to use them. Through the present study, the following areas of opportunity will be determined: As a first point, using a simulation in ProModel®, it will be calculated every hour that approximately 26 clients are lost. A rearrangement proposal was made to optimize the space. An analysis was made of the equipment it has and the one available in the market to obtain a feasible proposal to obtain more efficient equipment. Analyze the ambient lighting and noise conditions in accordance with the provisions of the respective standards. And finally through an EPR study (rapid position evaluation) it was determined that the position did not involve any problem.

**Keywords**. Copy Center, EPR (rapid postural evaluation), redesign, environmental evaluations.

**Relevance for ergonomics:** The analysis of service processes is little studied in relation to production processes. So this project analyzes various aspects focused on improving the ergonomics of a place where more than 7,000 users are served. The project presents multiple improvements that can be made in a service space, such as environmental conditions, human-machine interaction and a distribution of equipment and furniture more appropriate to the available space. This demonstrates how service processes are not exempt from ergonomic improvements and how ergonomics can be applied from various approaches to optimize both production and service processes.

## 1. INTRODUCTION

One of the main objectives of the Industrial Engineer is the optimization of processes, that focus on productive and services, including tools used in industrial engineering that contribute to this purpose. An ergonomic approach is one of the leading industrial engineering analysis that can improve among other factors, quality services and comfort for the users.

This project carries out an analysis of the environment in a Copy Center with more than 7,000 students. In that place, a crowd of students is generated at the end of every class hour (that is usually when most students request the services offered at the Copy Center).

Approximately 10 users observed are served by two dependents within 20 minutes, but around 25 students leave the place because of the long wait to finally use the services of the Copy Center.

It addition to this, it is observed that the position taken by users during the use on the available computers is uncomfortable and also the equipment is outdated and slow. The proyect make a good suggestion to replace the existing equipment (computers) in this place to new ones that can provide a better service for the users.

A study of the environmental conditions or noise and lighting in relation to the corresponding standards is also included, finding areas of opportunity in these factors.

### 1.1 General Objetive

Propose a redesign of the space distribution in the Copy Center of ITCJ, optimizing the available area, upgrading equipment and stations, based on EPR (rapid postural evaluation) ergonomic evaluations.

### 1.2 Specific objectives:

1. Assess environmental conditions of the Copy Center and identify sources of risk that affect the proper functioning of this place.
2. Register current information about the distribution of the Copy Center and make a proposal to optimize the space.
3. Analyze existing equipment and compare their characteristics with the specifications of the equipment of the current market.
4. Apply the ergonomic methodology EPR (rapid postural evaluation), to evaluate the positions taken by the customer at the moment of using it.

### 1.2 Delimitation:

The development of this project has a period of time of two months. It focuses only in the ITCJ population (Campus 1), it is important to mention that the investigators do not have the authority to make the suggested changes, that's why they are only going to make a new proposal to improve this place. This project is focused only to study the area of the Copy Center.

The investigators will only use the available equipment of the laboratory to make the ergonomic evaluations.

## 2. METHODOLOGY

The EPR methodology was used to evaluate the position of the user at the time of using the computer in the present study also focused various analyzes were performed to find areas of opportunity in the copy center.

As a first point through a technique observation and recording the number of people attending the copy center in peak hours was determined.

Dimensions of the place were taken for the current plans and proposed site in order to give greater mobility space to customers and improve the capacity of the site.

Lighting and noise: the evaluation of the most significant environmental conditions for the site was subsequently performed.

There was also an analysis of the conditions of computer equipment, later to raise a feasible proposal and according to the needs of the site.

## 3. RESULTS

### 3.1Taking Times

It was necessary to take times of the arrival of users to determine the number of students who receive services at peak periods and the number of students who don't receive the service. According to the simulation ProModel® of Figure 1, it was found that a 20 minute period 35 students arrive which are served 6, 4 remain in row 25 are out of service due to insufficient capacity of the local.

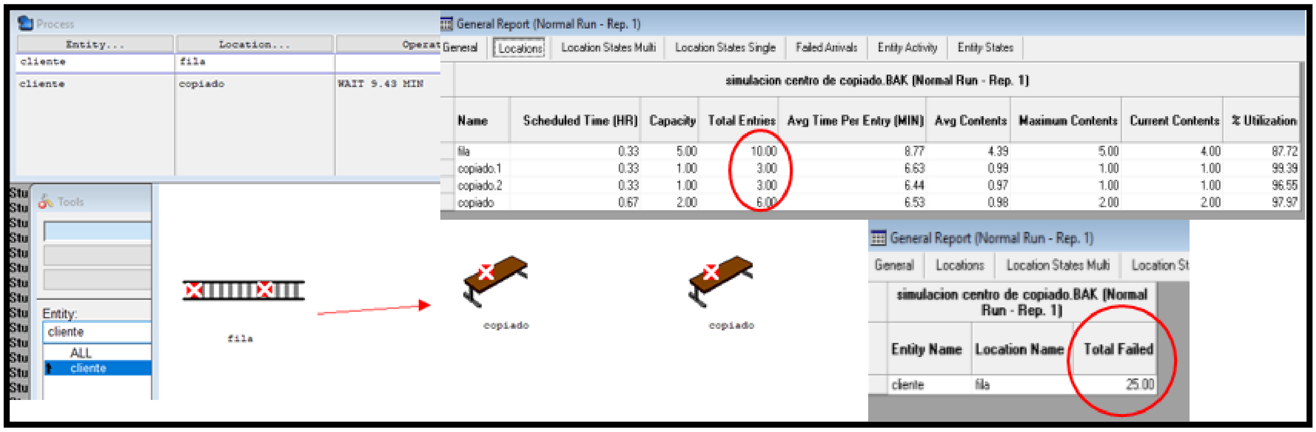



Figure 1. Results in ProModel Simulation

### 3.2 Perform the layout of the place

Using AutoCAD® software. This tool will be used to redesign the Copy Center area, taking advantage of each of the spaces that are part of the place, solving the poor distribution of the furniture in general.

In the figure 2 it shows the original distribution of the copy center, with 15.20m$^2$ total surface of the area. The yellow arrows show the users flow in the place.

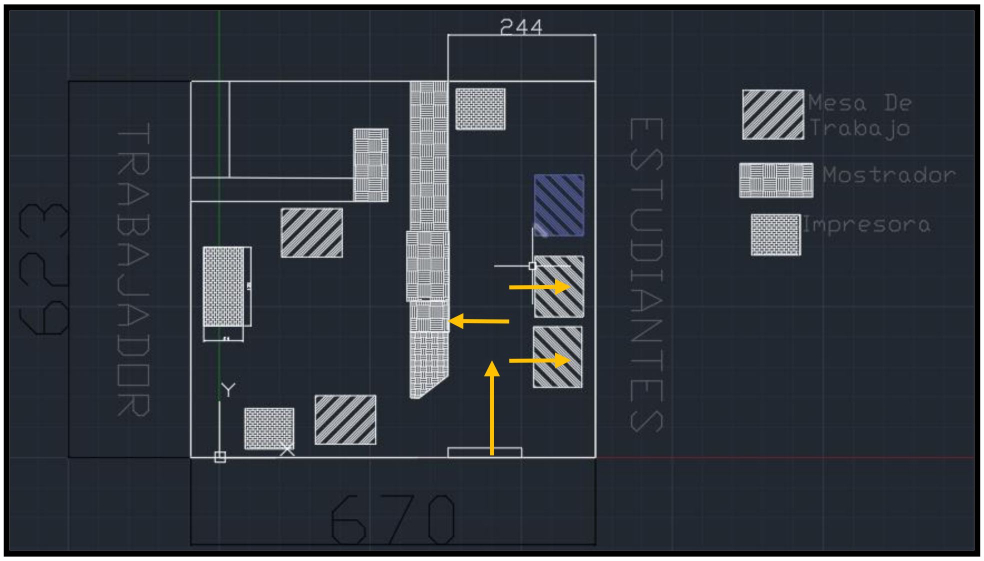



Figure 2. current distribution of the copy center

The proposed distribution that it is shown in Figure 3. Now has an area of 20.87 square meters for students.

Among the factors that were critical to this area highlights, the elimination of counters that have no functionality rather than separate dependent worker on the client as well as the eradication of a definite division between client and dependent and replacing an area where both can utilize space to the maximum, making the proper flow for customers.


Figure 3. Proposed distribution of the copy center

**3.3** Make an assessment of the physical condition of the place

Through measurements of noise, and light to make sure that the results match with the corresponding standards.

3.3.1 Studio Lighting

The Official Mexican Standards NOM-025-STPS-2008 aims to establish lighting requirements in the areas of workplaces, to have obtained the amount of lighting required for each visual activity in order to provide a safe environment and healthy in the tasks to develop workers.

In Table 1 it is shown according to this standard index area in relation to the number of measurement zones.

Table 1. Relation between the index area and the number of places measured

| **Index area** | **a) Minimum number of zones evaluated** | **b) Number of zones to consider by the limitation** |
|---|---|---|
| IC < 1 | 4 | 6 |
| 1 ≤ IC < 2 | 9 | 12 |
| 2 ≤ IC < 3 | 16 | 20 |
| 3 ≤ IC | 25 | 30 |

The value of the index area, to set the number of areas to be evaluated, is given by the following equation:

$$IC = \frac{(x)(y)}{h(x+y)}$$

Where:

IC = index area.

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

h = height of the luminaire relative to the work plane, in meters.

$$IC = \frac{(\,6.23\ mts)(\,6.70\ mts)}{3.02\ mts\ (\,6.23\ mts +\ 6.70\ mts)} = 1.0689$$

| **Index area** | **a) Minimum number of zones evaluated** | **b) Number of zones to consider by the imitation** |
|---|---|---|
| 1 ≤ IC ≤ 2 | 9 | 12 |

In the figure 4 it is shown the areas that were evaluated by the ilumanitation study.

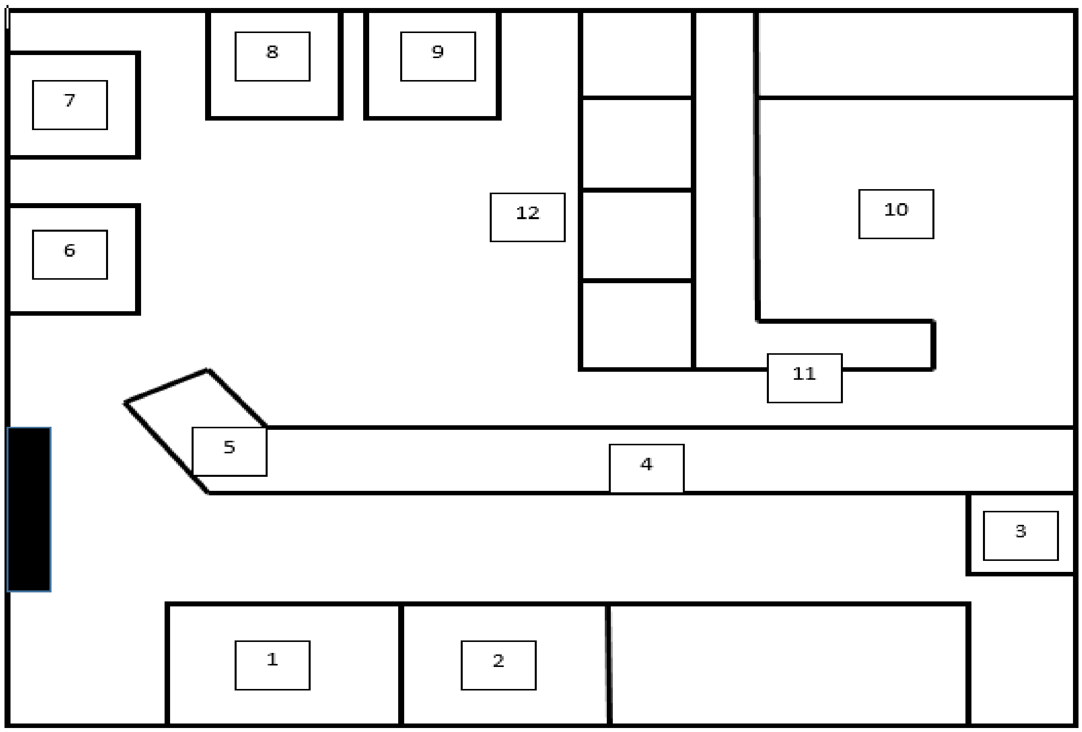



Figure 4. Areas that were evaluated by the illumination study

In the table 2 it is shown the results of the evaluated areas

Table 2. Results of the ilumination and reflex study

| No. | Reflejos ($E_1$) | Iluminación ($E_2$) |
|---|---|---|
| **1** | 71 | 168 |
| **2** | 11 | 73 |
| **3** | 22 | 41 |
| **4** | 9 | 62 |
| **5** | 42 | 214 |
| **6** | 128 | 261 |
| **7** | 111 | 358 |
| **8** | 89 | 282 |
| **9** | 78 | 187 |
| **10** | 31 | 228 |
| **11** | 9 | 16 |
| **12** | 100 | 269 |
| | | $\sum$ **$E_2$ =** 2,159 |

Average ilumination determination (Ep)

The calculation of the average lighting level for the room constant method is performed with the following expression:

$$E_p = 1 / N ( \sum E_i)$$

Where:
Ep = average lux level.
Ei = level measured in lux illumination at each point.
N = Number of measurements.

$$E_p = \frac{1\,(2{,}159)}{12} = 179.916$$

Evaluation of the reflector reflection

The reflection factor of the surface (Kf) is determined with the following equation:

$$K_f = \frac{E_1}{E_2}(100)$$

Where:
E1 = first measurement with the photocell placed lightmeter face surface with a distance of 10 cm ± 2 cm.
E2 = second measurement with photocell oriented in the opposite direction and supported on the surface, in order to measure incident light.
Table 3 shows the results of the calculation are shown in the reflection factor

Table 3. Results of the reflection factor

| No. | Reflejos ($E_1$) | Iluminación ($E_2$) | $K_f$ |
|---|---|---|---|
| 1 | 71 | 168 | 42.26 |
| 2 | 11 | 73 | 15.06 |
| 3 | 22 | 41 | 53.65 |
| 4 | 9 | 62 | 14.51 |
| 5 | 42 | 214 | 19.62 |
| 6 | 128 | 261 | 49.04 |
| 7 | 111 | 358 | 31.00 |
| 8 | 89 | 282 | 31.56 |
| 9 | 78 | 187 | 41.71 |
| 10 | 31 | 228 | 13.59 |
| 11 | 9 | 16 | 56.25 |
| 12 | 100 | 269 | 37.17 |

$$K_f = \frac{71}{168}(100) = 42.26$$

$$K_f = \frac{11}{73}(100) = 15.06$$

$$K_f = \frac{22}{41}(100) = 53.65$$

$$K_f = \frac{9}{62}(100) = 14.51$$

$$K_f = \frac{42}{214}(100) = 19.62$$

$$K_f = \frac{128}{261}(100) = 49.04$$

$$K_f = \frac{111}{358}(100) = 31.00$$

$$K_f = \frac{89}{282}(100) = 31.56$$

$$K_f = \frac{78}{187}(100) = 41.71$$

$$K_f = \frac{31}{228}(100) = 13.59$$

$$K_f = \frac{9}{16}(100) = 56.25$$

$$K_f = \frac{100}{269}(100) = 37.17$$

Finally in Table 4 comparing the results obtained in the study is performed lighting and set by the standard 025.

Table 4. Comparison of results obtained with parameters of the NOM 025.

| **Visual task of the workplace** | **Work area** | **Minimum lighting levels (luxes)** |
|---|---|---|
| Indoor | Circulation areas and hallways, waiting rooms, rest rooms, warehouse rooms, platforms, boiler rooms. | 100 |
| Simple visual requirement: Visual inspection, parts counting, bench and machine work. | Personnel services: rough storage, reception and dispatch, security booths, compressor rooms and pailer. | 200 |
| **Average illumination obtained at the copying center** | | 179.916 |

As can be seen, the copy center has an average lighting 179,916 luxes, so enters the appropriate range that is set by NOM-025-STPS-2008 is focused on this area in which there are a type of reception / waiting room, storage, and use of machinery to provide the service that is being done.

### 3.3.2 Noise Study

Mexican official standard 011 aims to establish the conditions of safety and health in the workplace where noise is generated, which by their characteristic or action level may be able to harm the health of workers. It also aims to determine target levels and maximum permissible exposure time to noise in a working day. This rule applies in all workplaces where there is exposure of the worker to noise in the country.

Maximum Permissible Exposure Limits. According to the World Health Organization (WHO) human ear can tolerate 55 decibels without any harm to health, and depending on the exposure time, noise greater than 60 decibels can cause us discomfort physical as headache, tachycardia, agitation breathing, rapid blinking and muscles may become tense. The maximum exposure times depending on the perceived decibels are shown in Table 5

Table 5. Maximum noise exposure times in decibels

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

Figure 5 shows the areas that were considered for the study shows noise


Figure 5. Areas that were evaluated by the noise study

NSA calculation. First calculations Table B1 of each period were recorded in Excel. After formula in Excel (= power (10, cell / 10)), this in order to get used to:

$$\sum_{j=1}^{150} 10^{Nj/10}$$

With the next formula get the NSA in each point.

| Excel (=10*LOG(1/150* final sum of each point) | $NSAi = 10log \frac{1}{150} \sum_{j=1}^{150} 10^{\frac{Nj}{10}}$ |
|---|---|

| NSA POINT 1 | NSA POINT 2 | NSA POINT 3 | NSA POINT 4 |
|---|---|---|---|
| 58.31578361 | 64.03710673 | 65.77079164 | 63.82881976 |

NER calculation. We calculate the NER using the following formula:

$$NER = 10log \sum_{i=1}^{n} ti_{10}\frac{NSAi}{10} - 10logTe$$

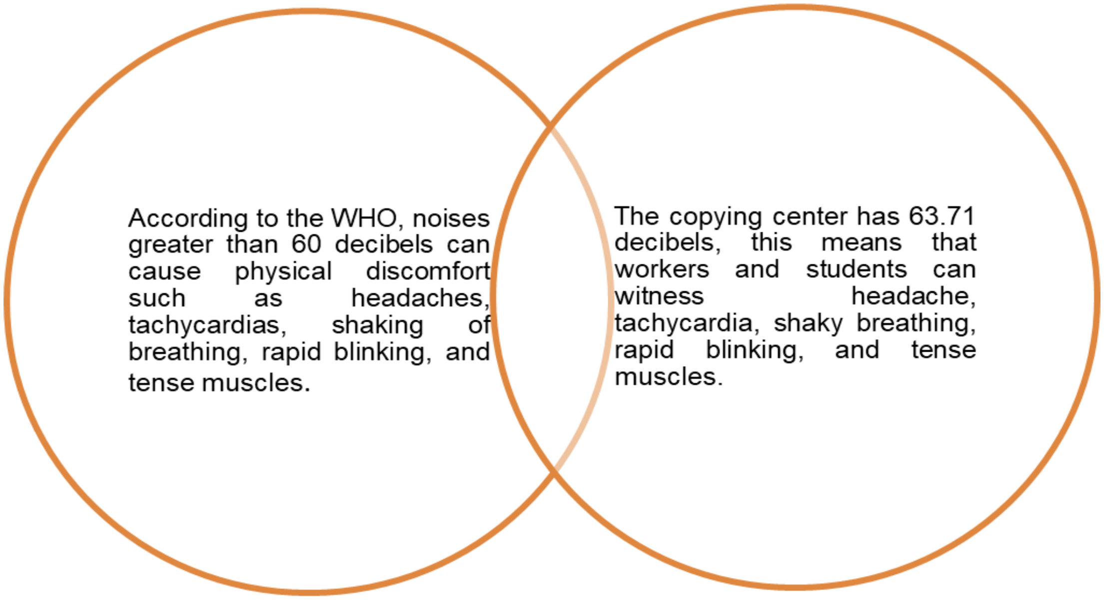
We do calculations in Excel with the following formula and perform the sum of the results generated:

=0.25*POTENCY(10,NSA of each point/10)

| POINT 1 | POINT 2 | POINT 3 | POINT 4 | SUMMARY |
|---|---|---|---|---|
| 169636.1352 | 633360.0718 | 944102.5534 | 603701.1239 | 2350799.884 |

We then use the formula = 10 * LOG (total sum) -10 * LOG (1) to get the NER.

| POINT 1 | POINT 2 | POINT 3 | POINT 4 | SUMMARY | NER |
|---|---|---|---|---|---|
| 169636.1352 | 633360.0718 | 944102.5534 | 603701.1239 | 2350799.884 | **63.7121566** |




## 3.4 Keep a record of the characteristics and conditions of the present equipment

Using Solid State Drives SSD speed issue has become indispensable in recent years, as they offer speeds of writing and reading higher than traditional hard drives HDD and other features that allow this to be much more reliable to the save time, manage information and open files. When you are looking for speed storage component no better than this, because according to the needs of a copy shop, the ability to perform multi task, opening programs as quickly as possible, and relatively minor file transfer time is needed.

With a SDD drive priced at $ 467 mxn lot of benefits and solutions to the main problems of the teams which currently account in the copy center are obtained. Some benefits are shown in the following comparative table.

Comparison SSD HDD

Hard disk (HDD)

80GB Solid State Disk (SSD) 120GB

Start Time Operating System Average start time of 10 to 13 seconds. Average start time of 30 to 60 seconds.

Writing and reading speed 80 MB / s 545 MB / s

Opening speed file I regularly performance below a SSD Performance 48% higher than that of an HDD Hard Drive

Resistance 300G average resistance, an element very sensitive to impacts 1,500G resistance average, five times higher than that of a HDD

Multitask reliable operations likely to "freeze" a program while another opens. It is able to open applications 2.5 times faster than a HDD. Ideal for multitasking.

With the implementation of an additional RAM module to manage to have the 4GB required for Windows 10 will perform properly, you can have benefits by decreasing delays between processes and multitasking on current computers. Priced at $ 579 mxn, you can get the following benefits as shown in the following comparative table.

Comparison of SDRAM

| | 2048 MB RAM | 4096 MB RAM (Modulo ADATA) |
|---|---|---|
| Channel Type | DDR2 SDRAM | DDR2 SDRAM |
| Clock Speed | 667 MHz | 800 MHz |
| Wide bandwidth | 10.7 GB / s | 12.8 GB / s |
| dual channel | Do not | Yes |

It has the ability to work with two memory modules RAM so the wide bandwidth increases compared to if only the current module is used. The module has acquired higher clock speed which can handle information more quickly.

With the implementation of the above two components increase performance dramatically, giving users the ability to multitask to make your process while using the equipment is fluid without any extra time for delays and load times of applications and files.

### 3.5 Apply the EPR (Evaluation rapid postural) method

To the positions adopted by the student during the use of the Copy Center equipment (see figure 6)

The study of the positions taken in the copy center at the time of printing activity, this study was performed with the EPR (Postural Rapid Assessment) method was performed as it is a method to see how this work at the time of such action in a general manner taking into account the time needed to carry out the printing process (Diego-Mas, 2015).

Figure 6. Picture to evaluation rapid Postural (EPR)

The study was positive about the positions taken in relation to the time that students are exposed to these positions, however, some factors may be considered, for example, the waiting time varies depending on the number of people who have the copy center, another important factor is the backpack, since having her back for a considerable time can cause fatigue.

The positions of the figure 7 were considered for the preparation of this study and for each position taken time.

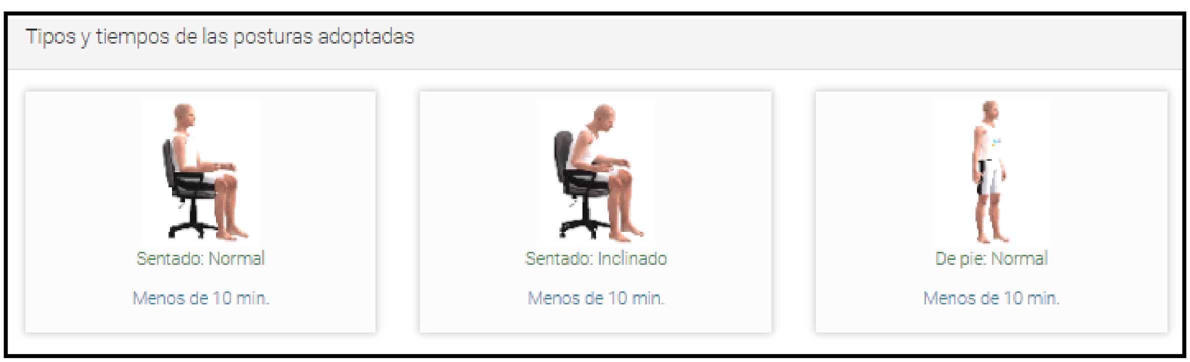



Figure 7. Position considered to the study

The evaluation obtained by this method was 1 and evaluated in the table of performance levels RPA can conclude that the ergonomic situation regarding the positions obtained is satisfactory (see figure 8).

| Color/Puntuación | Valoración |
|---|---|
| 0,1,2 | Situación satisfactoria. |
| 3,4,5 | Débiles molestias. Algunas mejoras podrían aportar más comodidad al trabajador. |
| 6,7 | Molestias medias. Existe riesgo de fatiga. |
| 8,9 | Molestias fuertes. Fatiga. |
| 10 | Nocividad. |

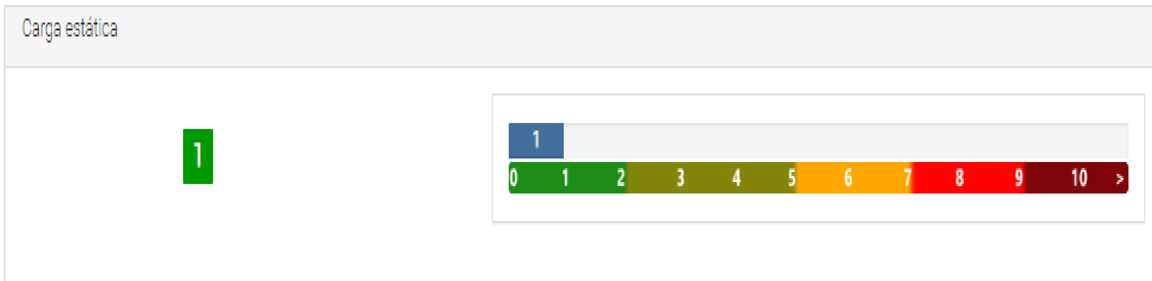



Figure 8. EPR (Postural Rapid Assessment) results

## 4. DISCUSSION/CONCLUSIONS

In relation to the results obtained with the analysis of waiting times, service and failed arrivals, it was found that the service is deficient in critical periods. About 25 potential clients stop being served in this period, this is when the students finish their class hours and require the service. Under this scheme, it would be worth considering modifying the Lay out according to the proposal presented in this project as it provides more space so that more customers can expect the service.

In addition to this, it would be worth considering including one more dependent to expand attention at critical hours, since it is not convenient for any business that customers leave without receiving the service.

In relation to studies of environmental factors, it is concluded that lighting is adequate for the type of activity carried out there. However, the noise exceeds the parameters established by the standard by almost four decibels, so it would be worth considering a countermeasure.

The team's study shows that there is another option on the market that does not imply great cost but that will help to make the service more efficient.

Finally, the EPR Rapid Posture evaluation was satisfactory because, although it is an uncomfortable posture, the student only uses less than 10 minutes to use the computer. However, the longest time is waiting and can be very uncomfortable if you consider that you carry a backpack all that time so it would be worth evaluating this situation.

## 5. REFERENCES

NOM-011-STPS-2001. (2001). Norma Oficial Mexicana NOM-011-STPS-2001, Condiciones de seguridad e higiene en los centros de trabajo donde se genere ruido. Diario Oficial, secretaria de Trabajo y Previsión Social

NOM-025-STPS-2008. (2008). Norma Oficial Mexicana NOM-025-STPS-2008, Condiciones de iluminación en los centros de trabajo. Diario Oficial, secretaria de Trabajo y Previsión Social

Diego-Mas, José Antonio. EPR - Evaluación postural rápida. Ergonautas, Universidad Politécnica de Valencia, 2015. [Consulta 17-03-2020]. Disponible online: http://www.ergonautas.upv.es/metodos/epr/epr-ayuda.php

# ERGONOMIC DESIGN OF PERSONAL PROTECTIVE EQUIPMENT TO PREVENT INJURIES TO WORKERS IN MANUFACTURING INDUSTRIES OF ELECTRONIC COMPONENTS.

**Edith Patricia Lara Verdugo, Eleydi Velázquez Rivera, Angélica María Clemente Pérez.**

Department of Industrial engineering
Tecnológico Nacional de México/Instituto Tecnológico de Nogales.
Av. Instituto Tecnológico
Colonia Granja
Nogales, Sonora 84065

Corresponding author's e-mail: edithlara684@gmail.com, eleydiv@gmail.com, aclemente28@gmail.com

**Resumen** Esta investigación se realizó en una industria manufacturera en la cual se trabaja en la inserción de componentes electrónicos, el estudio se realizó a mujeres que operan en el área de ensamble, en esta área las actividades laborales se realizan de forma repetitiva por tiempos prolongados, por lo que las trabajadoras están propensas a molestias y/o lesiones en la piel de los dedos de las manos, debido a la fricción generada al insertar los componentes. Actualmente, el método de protección personal utilizado son gasas colocadas de forma que envuelven los dedos, sin embargo, podrían ser poco eficientes, puesto que no protegen de manera adecuada y pueden incluso causarles molestia o incomodidad a las trabajadoras, para comprobar esto se les realizó una encuesta y así conocer la situación existente.

Con esta investigación se busca proporcionar el diseño de un equipo de protección personal más adecuado para las operadoras, a raíz de esto se realizó una recolección de medidas antropométricas referenciadas en percentiles de la población de interés laboral de la región donde se realiza la actividad.

Es de suma importancia tomar en cuenta la antropometría de las operadoras para el diseño correcto, siendo estas medidas las características principales para la creación del diseño del equipo de protección personal (dedales).

Es relevante destacar que este proyecto consta de dos etapas, la primera constara solo de presentar el diseño de acuerdo con los resultados obtenidos de las medidas antropométricas y encuestas realizadas. En la segunda etapa se mostrará el proyecto en físico y la aceptación del diseño en el campo laboral con las trabajadoras.

**Palabras clave**: Repetitividad, equipo de protección personal, lesiones.

**Relevancia para la ergonomía**: Se debe de contar con el equipo de protección personal adecuado para realizar las actividades laborales. Por lo que se aporta un diseño ergonómico para las trabajadoras que ensamblan componentes electrónicos.

**Abstract:** This research was carried out in a manufacturing industry in which the insertion of electronic components is worked, the study was carried out on women who operate in the assembly area, in this area work activities are carried out repetitively for long periods of time, for which workers are prone to discomfort and / or injury to the skin of the fingers of the hands, due to the friction generated when inserting the components. Currently, the personal protection method used is gauze, placed in a way that wraps the fingers, however, they are not very efficient, since they do not protect adequately and may even cause discomfort or discomfort to the workers. a survey and thus know the existing situation.

Therefore, this research seeks to provide the design of the most suitable personal protection equipment for the operators, as a result of this, a collection of anthropometric measurements referenced in percentiles of the population of labor interest in the region where the exercise.

It is of utmost importance to take into account the anthropometry of the operators for the correct design, these measures being the main characteristics for creating the design of personal protective equipment (thimbles).

It is relevant to note that this project consists of two stages, the first consisting only of presenting the design in accordance with the results obtained from anthropometric measurements and surveys carried out. In the second stage, the physical project and the acceptance of the design in the workplace with the workers will be shown.

**Keywords**: Repetitiveness, Injuries, Personal Protective Equipment

**Relevance to Ergonomics**: This investigation contributes to Ergonomics the reduction of possible ergonomic risks that, if this problem is not addressed, physical risks can cause musculoskeletal disorders due to the repetitiveness of operations without personal protective equipment.

## 1. INTRODUCTION

In an electronic components company, in the assembly area, repetitive movements for long periods without adequate personal protective equipment generate a negative impact on the workers, since they can cause physical injuries, which is the problem to be addressed. "A pressure injury begins with a red area on the skin. This red area may feel hard and/or hot. For those with dark skin, the area may appear shiny. At this stage, the progression is reversible. The skin will return to its normal color if the pressure is removed. If the pressure is not removed, a blister or scab may form, meaning that the tissue underneath is dying. (Reeve C; Reeve d, 2016).

According to an article published in 2003 on the investigation of accidents involving injuries to the hands and fingers of the state of Aragua, Venezuela. Of the 623 reported and declared accidents, 294 reported injuries to workers' hands and fingers, which represents a 47.19% frequency of accidents with injuries. This allows us to point out how hand indemnity is frequently committed to work activity, coinciding with other authors who have investigated the problem of occupational accidents. (Rojo, 2002; Martinez, 1998; Mutua E., 2002).

The most common physical demands are: repeating the same movements of hands or arms (59%) and adopting painful and fatiguing postures (36%). In both cases, the frequency of exposure is higher for women than for men. The physical workload is analyzed in relation to two indicators: the physical effort made by the worker when performing his task, physical demand of the work, and on the other, the musculoskeletal disorders that the worker attributes to postures and efforts derived from his work (vii national survey of working conditions, 2011). In the physical demands of work: the most common are repetitive movements of hands and/or arms (59%), in manufacturing, storage, driving and transport activities, according to «Guía Práctica de Salud Laboral para la valoración de: APTITUD EN TRABAJADORES CON RIESGO DE EXPOSICIÓN A CARGA FÍSICA». Escuela Nacional de Medicina del Trabajo (ENMT).

As part of the methodology, a survey was conducted to determine if operators had any problems performing their tasks. To carry out the design it is necessary to take anthropometric measurements because, although it will be adjustable, the measurements of the 5 and 95 percentiles are needed, in this way to be able to present a design that can be used by the majority of the workers, the results will be presented later.

## 1.1 Justification

The skin is a vital organ, which is exposed to multiple risks in the workplace. To avoid work-related skin diseases, it is necessary to adopt specific measures to protect it before starting the day and to seek systematic care at the end of work. Technical protection measures are the first measure to avoid skin diseases. (Wolfang, 2000, p.25).

According to Nom-017-STPS-2008, the employer must select, acquire and provide its workers with the corresponding personal protective equipment to protect them from agents of the work environment that may harm their physical integrity and health.

For this reason, an ergonomic personal protective equipment was designed, made up of three thimbles joined in the shape of a glove, with which it seeks to avoid friction, relieve pressure and irritation generated by the repetitiveness of the activity and the exposure time that it entails to this type of additional discomfort and injury, which affect workers in manufacturing industries of electronic components.

## 1.2 Delimitation

This project is focused on the population of female workers working in manufacturing industries of assembly with electronic components of the city of Nogales, Sonora.

## 2. OBJECTIVE

Design an innovative product as personal protection for electrical component assembly operators, which can reduce toe injuries (hands), generated by repetitiveness, friction and exposure time.

### 2.1. Specific objectives

- Identify a functional and comfortable form of protection when assembling electronic components.
- Provide the way to give the best fit of the personal protective equipment devised.
- Conduct a survey to identify the need for adequate personal protective equipment.

## 3. METHODOLOGY

The present investigation will follow a set of activities for its development, being divided as follows:

The first activity was to carry out a study to determine the real situation or condition in which women workers are found after your work day, this was done by applying 40 surveys a maquiladora workers of assembling electronic components, in order to know the problem or need.

The second activity of the methodology consisted of establishing an anthropometric measurement procedure, which maintained a statistical support with high significance for each segment defined in the study and design of the thimbles. To take measurements, the help of an analog Vernier caliper and an ergonomic measuring tape was required.

With the measures obtained it was possible to determine the 5th and 95th percentile, necessary for the ergonomic design of the thimbles. Due to the variations in the anthropometric and morphological characteristics of each person, it is very important to take samples from the population of interest or the area where you want to implement.

As it is sought that the thimbles have the best fit, a size system was also created, for anthropometric adaptation. With the information obtained, the design was done in 3D format, for this, SolidWorks software was used.

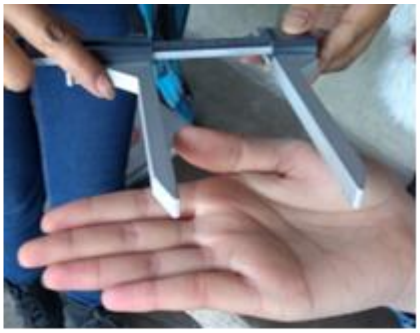



Figure 1. Thumb lenght

Figure 2. Wrist circumference

Figure 3. Palm width

## 4. RESULTS

Below is the design of the ergonomic personal protective equipment, as well as a compendium of the information collected with the surveys conducted, in addition, a table of sizes was made, based on the percentiles obtained.

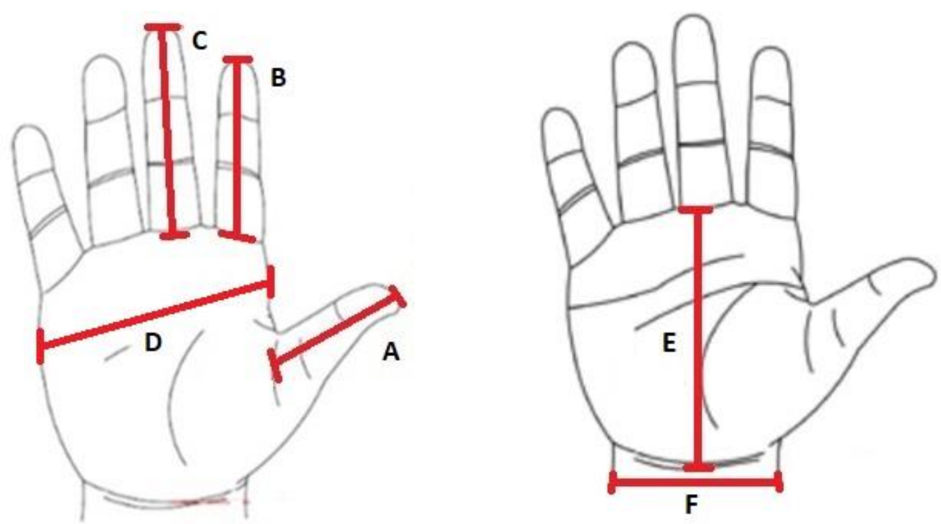



Figure 4. Hand segments that were measured

Table 1. Percentiles obtained

| Code | Measurements | 5 Percentile | 95 Percentile |
|---|---|---|---|
| A | Thumb length | 4.595 cm | 6.6 cm |
| B | Index length | 6 | 7.205 |
| C | Middle finger length | 6.595 | 7.905 |
| D | Palm width | 8.795 | 10.32 |
| E | Palm length | 7 | 8.405 |
| F | Wrist circumference | 14.175 | 17.025 |

Table 2. Size chart

| Size | S | M | L | XL | XXL |
|---|---|---|---|---|---|
| Thimbles size. | 6 | 7 | 7 | 8 | 8.5 |
| Hand length | 14 | 15 | 16 | 17 | 18 |
| Hand width | 7 | 7 | 8 | 8.5 | 9 |
| Wrist circumference | 13 | 14 | 15 | 16 | 17 |

Once the results of the surveys have been analyzed, it can be seen that 87.5% have suffered hand injuries such as calluses, blisters, irritation or discomfort when carrying out their work activity, 6.5% consider that it is suitable for the activities they perform and 82.5 % believes that the proposed product would be very helpful to prevent or lessen the inconvenience they present and that 92.5% would be willing to use it.

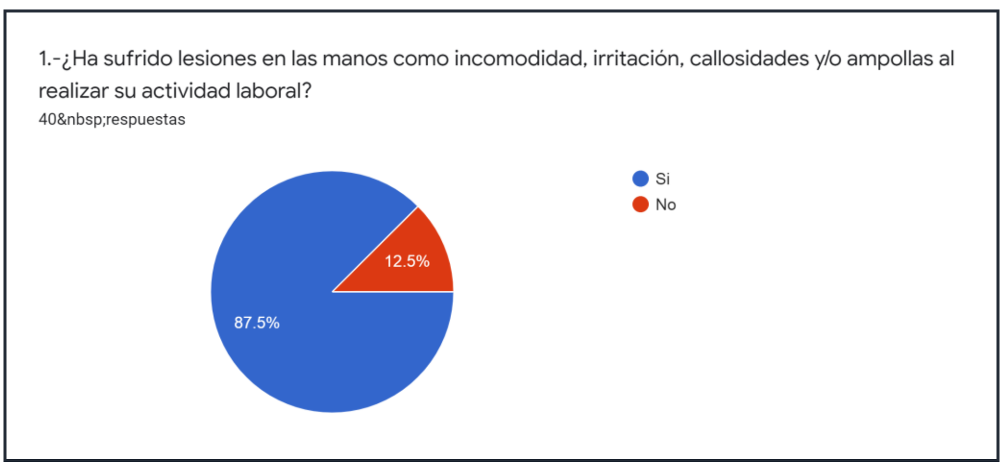



Figure 5. Results obtained from question 1

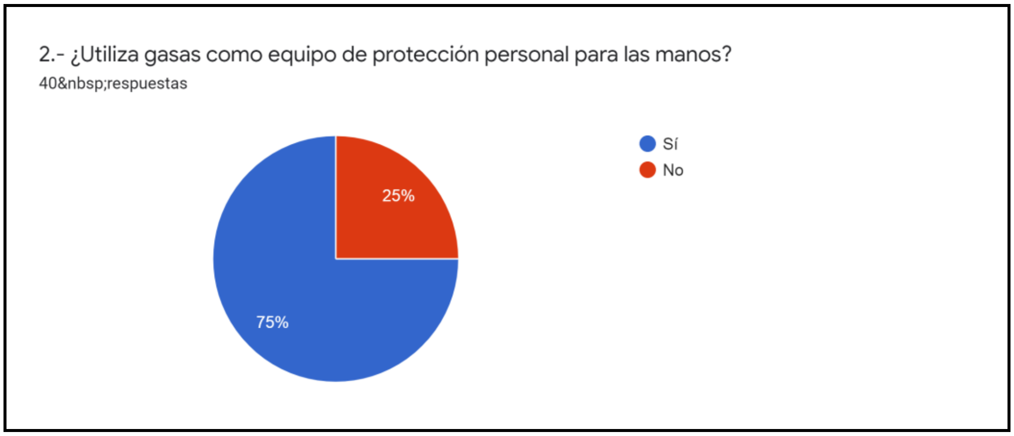



Figure 6. Results obtained from question 2

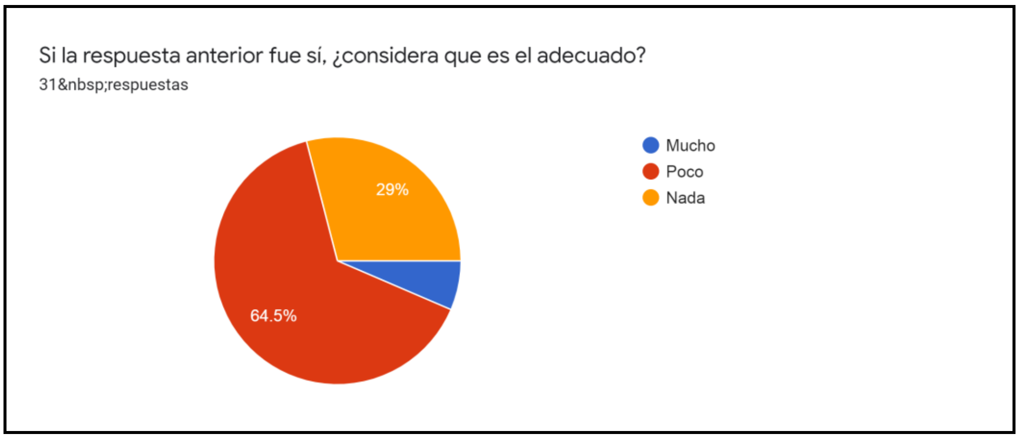



Figure 7. Results obtained from question 2


Figure 8. Results obtained from question 3

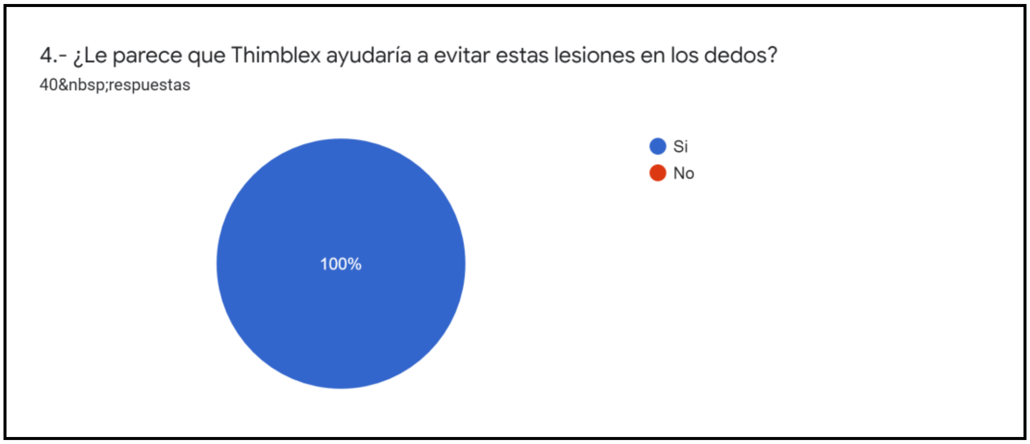



Figure 9. Results obtained from question 4

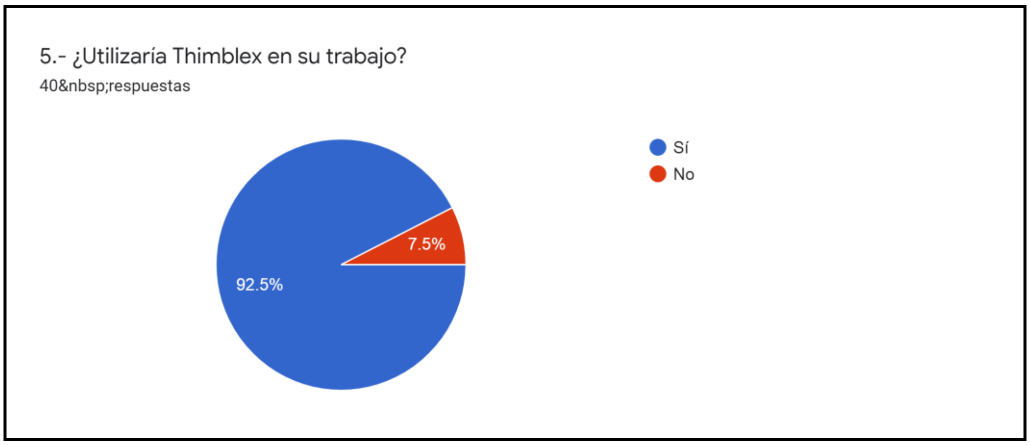



Figure 10. Results obtained from question 5

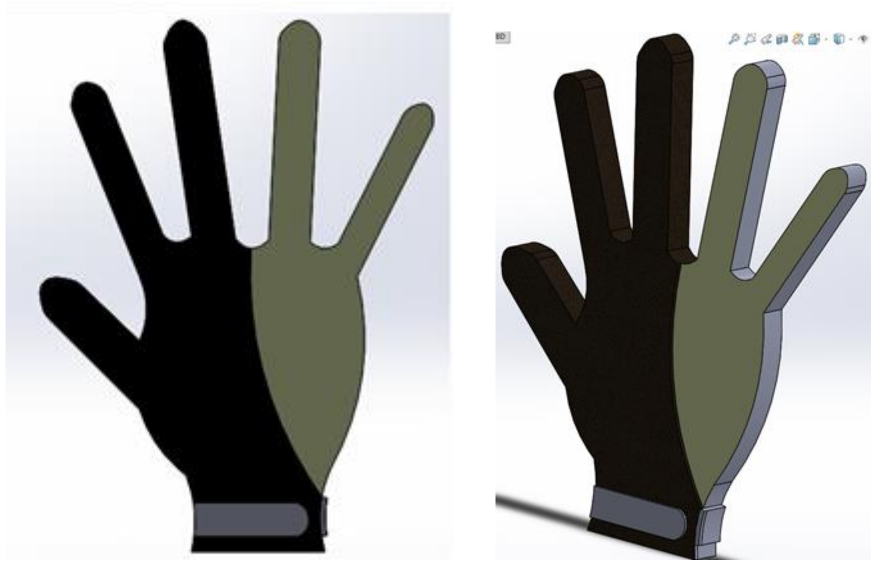


Figure 11. Thimbles design

## 5. CONCLUSIONS

The results provided the design of an innovative personal protective equipment, reiterating that this seeks to avoid discomfort and/or injury in women workers, caused by friction at the time of their work activities, which require repetitive and long-term periods.

Therefore, the objectives were met, since it was possible to identify with the help of a survey, the need for adequate protective equipment for the workers who assemble electronic components, in addition, with the measurements obtained, the size chart was made, which It will provide the best adjustment of the thimbles to the workers, specifically not only protection, but also functionality and comfort.

With the help of all the information collected, as a second stage, it is planned to present the product physically, in addition, that the workers try the thimbles, in this way to be able to verify or determine the magnitude in the reduction of physical risks.

## 6. REFERENCES

Escuela Nacional de Medicina del Trabajo Instituto de Salud Carlos III. (diciembre de 2015).

*Guía Práctica de Salud Laboral para la valoración de: APTITUD EN TRABAJADORES CON RIESGO DE EXPOSICIÓN A CARGA FÍSICA.* Diciembre 2019, de Asociación Española de Especialistas en Medicina del Trabajo Sitio web: file:///C:/Users/HP/Downloads/CITA%20%233.pdf

Grupo nacional para el estudio y asesoramiento en ulceras por presión y heridas crónicas.
(mayo, 2014). *Clasificación de las lesiones relacionadas con la dependencia*. Enero, 2020, de EEA UPP Sitio web: file:///C:/Users/HP/Downloads/clasificacion-categorizacion-de-las-lesiones-relacionadas-con-la-dependencia-segunda-edicion.pdf

Martín, M., Jonny F, & Nancy Nava, R.. (Julio 2003). *Investigación de Accidentes Laborales con lesiones de las manos y los dedos.* Estado Aragua. Venezuela.. Enero, 2020, de Salud de los Trabajadores Sitio web: file:///C:/Users/HP/Downloads/Dialnet-InvestigacionDeAccidentesLaboralesConLesionesDeLas-2938684.pdf

Reeve, D., & Reeve, C. (2016, 16 marzo). *Cuidado de la piel - International*. Recuperado 21 enero, 2020, de https://www.christopherreeve.org/es/international/top-paralysis-topics-in-spanish/skin-care.

# HAND TOOL REDESIGN – ERGONOMIC BRUSH

**Alberto Ramírez, Juan Santos, Luis Bueno, Betzy Puente y Mónica García**

Industrial Engineering Department
Tecnológico Nacional de México / IT de Los Mochis
Blvd. Juan de Dios Batiz y 20 de Noviembre
Los Mochis, Sinaloa 81259
juansanthos12@gmail.com

**Resumen:** A simple vista la realización de una actividad resulta ser inofensiva para un trabajador, sin embargo, una vez que se realizan estudios y aplican métodos nos damos cuenta que la actividad impacta en gran medida el bienestar del trabajador, tal es el caso de los pintores de casa, quienes para realizar su trabajo hacen uso de una herramienta de mano, la brocha, y consideran que no se corre algún riesgo por utilizarla. Es por eso que en la presente investigación se evaluará el grado de fatiga de dicha actividad utilizando el cuestionario Yoshitake, se aplicará el método Rapid Upper Limb Assesment (RULA) para determinar si existen Desordenes de Trauma Acumulado (DTA's) debido a la repetitividad de la acción por largas jornadas de trabajo, y por último se propondrá un rediseño de la herramienta de mano el cual será evaluada mediante una guía proporcionada por el Instituto Nacional de Salud y Seguridad Ocupacional (NIOSH).

**Palabras clave:** RULA, Yoshitake, Pintores de casa, movimiento repetitivo, NIOSH.

**Relevancia para la ergonomía**: Aportamos a la ergonomía una investigación objetiva de la herramienta de trabajo del pintor de casa, con el fin de dar a conocer los riesgos ergonómicos a los que están sujetos los trabajadores para poder presentar una propuesta de rediseño ergonómico para evitar o disminuir los riesgos en la mayor medida posible.

**Abstract:** At first glance, the performance of an activity turns out to be harmless for a worker, however, once studies are carried out and methods are applied, it is noted that the activity highly impacts the worker's well-being, such is the case of housepainters, who to carry out their work make use of a hand tool, the brush, and consider that there is no risk to use it. That is why in this research will be evaluated the degree of fatigue in the painting activity by using the Yoshitake questionnaire; the Rapid Upper Limb Assessment method (RULA) will be applied to determine if there are Cumulative Trauma Disorders (CTD's) due to the repeatability of the action for long hours of work, and finally a redesign of the hand tool will be proposed which will be evaluated through a guide provided by the National Institute for Occupational Safety and Health (NIOSH).

**Key words:** RULA, Yoshitake, Housepainters, repetitive movement, NIOSH.

**Relevance for ergonomics:** We provide to ergonomics an objective investigation of a painters work tool, in order to show the ergonomic risks which workers are subject and present a proposal for ergonomic redesign to avoid or reduce risks to the greatest extent possible.

# 1 INTRODUCTION

Day by day workers and professionals carry out a series of activities that their work or position demands them and the big risk they suffer while carrying them out goes unnoticed due that at first glance it seems that they are harmless tasks; this is the case of painters, who are in charge of painting different surfaces such as walls, fences, etc. to glamourize or maintenance that part of the building, house or any other location. Its main work tool is the brush, which is an instrument that consists of a set of bristles attached to a handle that is used for painting.

In order to make a proper use of the brush, the painter needs to make a precision grip with his hand so that in this way he can have control over it and not stain the surface that he does not want to paint or is on another color. While performing this precision grip there is pressure on the nerves on the hand and wrist, that if it continues for prolonged and routine periods of time it causes an injury or even disease in the wrist such as carpal tunnel syndrome or tendinitis, that is why the purpose of this research is to find the possible redesign of this hand tool so that it can be ergonomic and thus obtain a well-being for the painter or anyone else who uses a brush. Once the prototype is done, the next step would be to study, analyze and verify by different methods that the redesign is really helping the painter to avoid these problems without affecting the performance and precision of his work.

To achieve a really functional redesign of this tool, it will be necessary to apply fatigue and hand tool evaluation methods, as well as material composition to make the correct decisions on its design.

## 1.1 Justification

In the article "Development of a flower cutting tool, using ergonomic design requirements" written by Rodriguez, J., Maradei, F., and Martinez, J. and published in the UIS Ingenierías magazine in 2018, stated that hand strength and wrist posture are risk factors for development Carpal Tunnel Syndrome; problem presented in housepainters work.

Another article published in the Europe PMC journal by S L Johnson in 1993 titled “Ergonomic hand tool design” establishes that the use of an ergonomic design and the appropriate selection of hand tools is able to reduce the cumulative exposure of trauma, in addition to that, the appropriate tool design, job rotation work and exercise programs improve productivity and promote human well-being.

## 1.2 General objective:

- Propose a redesign of the hand tool for housepainters in the city of Los Mochis, Sinaloa.

#### 1.2.1. Specific objectives:

- Determine possible injuries to the worker with the hand tool in the specific activity of painting details and corners on surfaces.
- Establish the measures of the possible redesign of the tool.

### 1.3. Delimitation

The ergonomic brush is aimed to people who work as a housepainter, because they are who use this tool for long periods of time and are the most likely to develop possible injuries or musculoskeletal diseases in the wrists due to use of the conventional brush.

## 2 METHODOLOGY

In the first place, before proposing a redesign, it is necessary to verify, if indeed, there is a workload with such a degree that causes fatigue, tiredness or pain in the painter while carrying out his task. For this we implemented the Yoshitake questionnaire, which is responsible for providing information about the type of demand that the activity requires, physical demands (Type 3), mental demands (Type 2) and mixed demands (Type 1).We asked workers, after their workday to provide us the information on how they felt physically and mentally, by filling in the questionnaire. At the end of the questionnaire application, the data were interpreted to later graph the results.

As a second step, we decided to implement the RULA method so that it is feasible to evaluate the position of the painters through a score that goes from 1 to 7, depending on the angles obtained in the different postures and their repeatability, as well as determining if it is necessary to redesign immediately the tool, in this case, the conventional brush.

To carry out this study, an investigation was developed to collect data by taking photographs, with the purpose of highlighting the inconveniences or difficulties that painters may have when using a conventional brush, since this activity it may involve CTD´s due to the high repeatability of the action performed.

The RULA method was applied to painters in an age range of 35 - 45 years, with experience in the field, with a sample size of 3, where 100% were men. The method is responsible for analyzing the movements of the painter focused on the upper limbs, neck, trunk and legs.

To arrive at the result of the action level of change in the activity, the following angles were taken. In figure 1 we can observe the score that will be considered depending on the posture´s angle, then locate it in the corresponding table to the extremity (neck, wrist, back, arm, and forearm) which is studied.

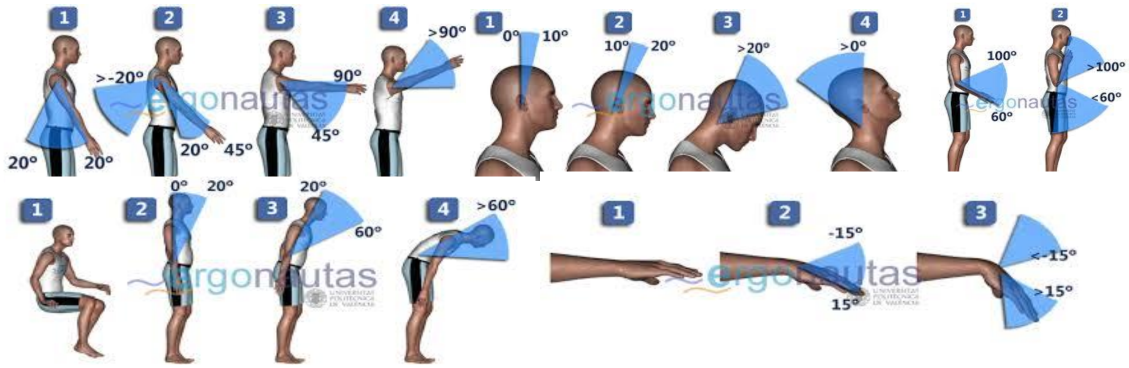



Figure 1 - Score and angles of the postures in the RULA method


Figure 2 Angles in Group A postures using the Conventional Brush

Analyzing Figure 2 we can assign the scores to the different parts of group A while using the conventional brush. The Arm obtained a score of 3, while the Forearm obtained 2 points and finally the wrist has a score of 3 but due to a cubital deviation we will add 1 more point so the final score of the wrist is 4 while its turning score is 2 due to extreme supination.

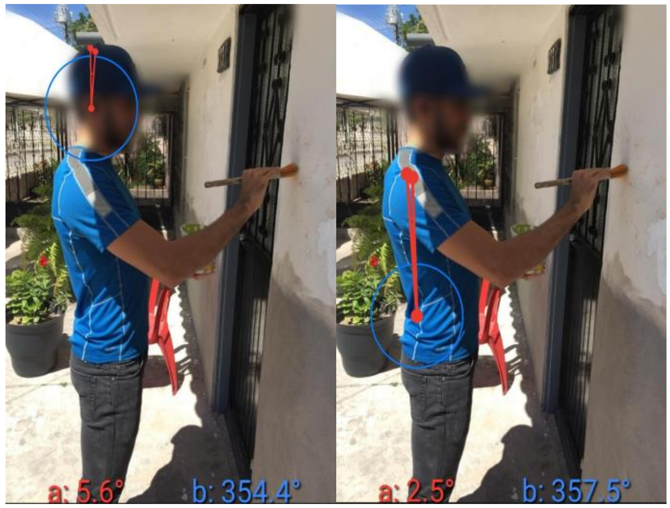



**Figure 3** Angles in Group B postures using the Conventional Brush

Observing the angles from figure 3 we will give the score to the parts of Group B, the neck got 1 point, while the trunk got 2 points and the legs 1.

Table1 Group A Score Using the Conventional Brush

| GROUP A Using Conventional Brush | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Arm | Forearm | WRIST | | | | | | | |
| | | 1 | | 2 | | 3 | | **4** | |
| | | Wrist Twist | | Wrist Twist | | Wrist Twist | | Wrist Twist | |
| | | 1 | 2 | 1 | 2 | 1 | 2 | 1 | **2** |
| 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 |
| 2 | 1 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 |
| **3** | 1 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 5 |
| | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | **5** |
| | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| 4 | 1 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| | 2 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 6 | 6 |
| 5 | 1 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 7 |
| | 2 | 5 | 6 | 6 | 6 | 6 | 7 | 7 | 7 |
| | 3 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 8 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 1 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 9 |
| | 2 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 |
| | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |

After placing the scores obtained in the previous figure within table 1 we can see the score obtained by Group A when using the Conventional Brush.

Table 2 Group B Score Using the Conventional Brush

| GROUP B Using Conventional Brush | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NECK | TRUNK | | | | | | | | | | | |
| | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
| | LEGS | | LEGS | | LEGS | | LEGS | | LEGS | | LEGS | |
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| 1 | 1 | 3 | **2** | 3 | 3 | 4 | 5 | 5 | 6 | 6 | 7 | 7 |
| 2 | 2 | 3 | 2 | 3 | 4 | 5 | 5 | 5 | 6 | 7 | 7 | 7 |
| 3 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 7 |
| 4 | 5 | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 8 | 8 |
| 5 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 |

In table 2 we can see the score of Group B when using the Conventional brush, this score corresponds to 2, but taking into account the repeatability of the activity when using this tool increased by one point the score of both groups so that Group A would have a score of 6 and Group B would have a final score of 3.

Table 3 Final score obtained using the Conventional Brush

| | TABLA F Final score Using the conventional Brush | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Score D (Neck , Trunk, Legs) | | | | | | | |
| Score C (Uper Members) | | 1 | 2 | 3 | 4 | 5 | 6 | 7+ |
| | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 |
| | 2 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| | 3 | 3 | 3 | 3 | 4 | 4 | 5 | 6 |
| | 4 | 3 | 3 | 3 | 4 | 5 | 6 | 6 |
| | 5 | 4 | 4 | 4 | 5 | 6 | 7 | 7 |
| | 6 | 4 | 4 | 5 | 6 | 6 | 7 | 7 |
| | 7 | 5 | 5 | 6 | 6 | 7 | 7 | 7 |
| | 8+ | 5 | 5 | 6 | 7 | 7 | 7 | 7 |

In Table 3 we see the final score obtained by the conventional brush and we realize that it has a high score so it is urgent to redesign the tool to minimize the problems that it can generate. In figure 4 we can see the angles needed to qualify each of the parts of group A when using the Ergonomic Brush. The scores were as follows: Arm 1 point, Forearm 1, Wrist 3 without any modification and a score of 2 in the wrist rotation by extreme supination.


**Figure 4** Angles of Group A postures using the Ergonomic Brush


**Figure 5** Angles of Group B postures using the Ergonomic Brush

With the data we have in Figure 5 it is possible to assign the score to the parts that make up group B. Taking a look it is possible to see that the neck has a score of 1, the trunk 1 point and finally the legs have a score of 2.

Table 4 Group A Score Using the Ergonomic Brush

| GROUP A Using The Ergonomic Brush | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Arm | Forearm | WRIST | | | | | | | |
| | | 1 | | 2 | | 3 | | 4 | |
| | | Wrist Twist | | Wrist Twist | | Wrist Twist | | Wrist Twist | |
| | | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 |
| 2 | 1 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 |
| 3 | 1 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 5 |
| | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 |
| | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| 4 | 1 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| | 2 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 6 | 6 |
| 5 | 1 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 7 |
| | 2 | 5 | 6 | 6 | 6 | 6 | 7 | 7 | 7 |
| | 3 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 8 |
| 6 | 1 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 9 |
| | 2 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 |
| | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |

In Table 4 the data of the previous figure were emptied in order to obtain the score of group A while using the ergonomic brush, giving us a score of 3.

**Table 5** Group B Scoring Using the Ergonomic Brush

| GROUP B Using The Ergonomic Brush | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NECK | TRUNK | | | | | | | | | | | |
| | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
| | LEGS | | LEGS | | LEGS | | LEGS | | LEGS | | LEGS | |
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| 1 | 1 | 3 | 2 | 3 | 3 | 4 | 5 | 5 | 6 | 6 | 7 | 7 |
| 2 | 2 | 3 | 2 | 3 | 4 | 5 | 5 | 5 | 6 | 7 | 7 | 7 |
| 3 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 7 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 5 | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 8 | 8 |
| 5 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 |

In table 5 we observe the score obtained by Group B while using the Ergonomic Brush and this is 3 points, but due to the repeatability of the activity when the tool is used it will increase 1 point the same as the one of Group A, giving us a total of 4 points in both cases.

Tabla 6 Final Score Obtained Using the Ergonomic Brush

| | TABLA F Final Score obtained using the Ergonomic Brush | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Score D (Neck, Trunk , Legs) | | | | | | | |
| Score C (Uper Members) | | 1 | 2 | 3 | 4 | 5 | 6 | 7+ |
| | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 |
| | 2 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| | 3 | 3 | 3 | 3 | 4 | 4 | 5 | 6 |
| | 4 | 3 | 3 | 3 | 4 | 5 | 6 | 6 |
| | 5 | 4 | 4 | 4 | 5 | 6 | 7 | 7 |
| | 6 | 4 | 4 | 5 | 6 | 6 | 7 | 7 |
| | 7 | 5 | 5 | 6 | 6 | 7 | 7 | 7 |
| | 8+ | 5 | 5 | 6 | 7 | 7 | 7 | 7 |

When we see the table 6 we realize that the final score of the RULA method for the postures using the Ergonomic Brush is 4.

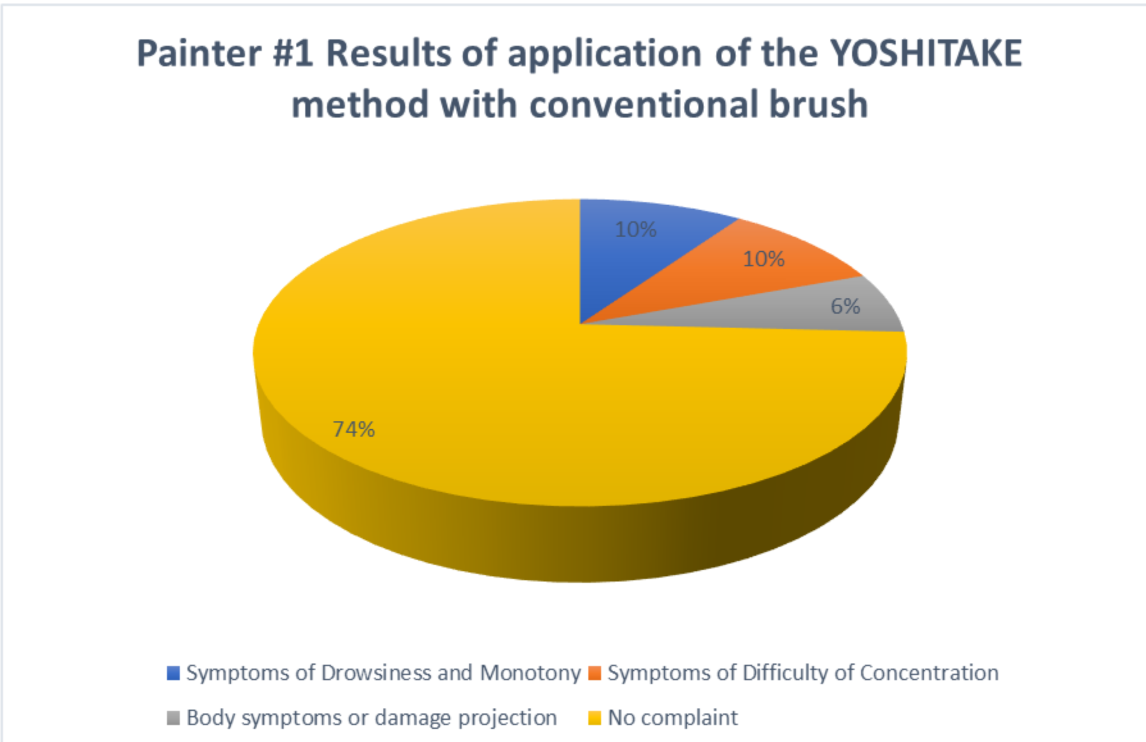
Not compliant with a fatigue and posture assessment, our tool was also assessed using a guideline provided by the National Institute for Occupational Safety and Health (NIOSH). The purpose of this guide is to simplify this process and help employers and workers to identify non-energized hand tools which are less likely to cause injury to those who use them; those that can be used effectively with less force, less repetitive movements and fewer postures that cause muscle tension to the body.

To do this, it was enough to compare both tools, conventional brush and brush with an ergonomic redesign proposal, in every point where the tool was applied, having to count at the end the score obtained by each of them.

## 3 RESULTS

Using the Yoshitake questionnaire in a range of 1 week, for 3 days surveyed it was obtained that with conventional brush the worker suffers from strong physical demand, according to the positions he performs to paint. While with an ergonomic brush, the physical demand is reduced.

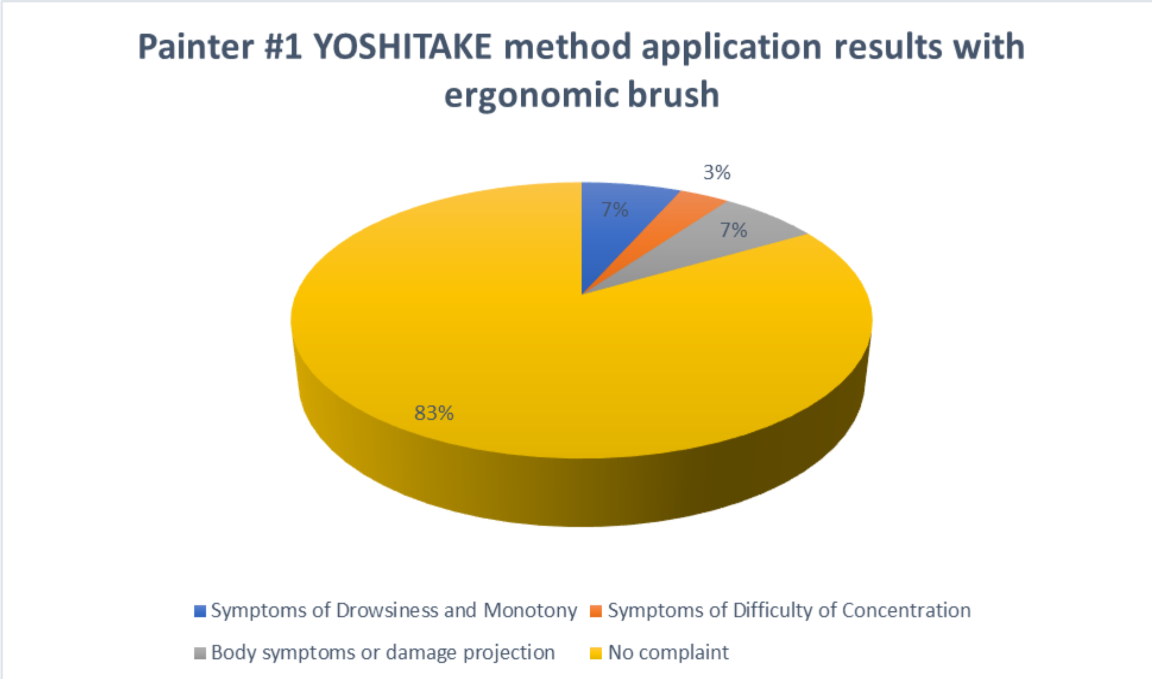
We can conclude that the handle of the conventional brush does not have a favorable design for the continuous use given by professional painters, since it has a high impact on their hands due to the type of grip they use when handling the brush. The type of grip they use when handling detail brushes is known as precision grip, which is used to have better control of the tool, but it requires putting the hand in a not very comfortable position where it is forcing certain nerves and ligaments, so maintaining that position for a long period of time can cause diseases in the long run.




Graphic 1 YOSHITAKE method results in painter #1

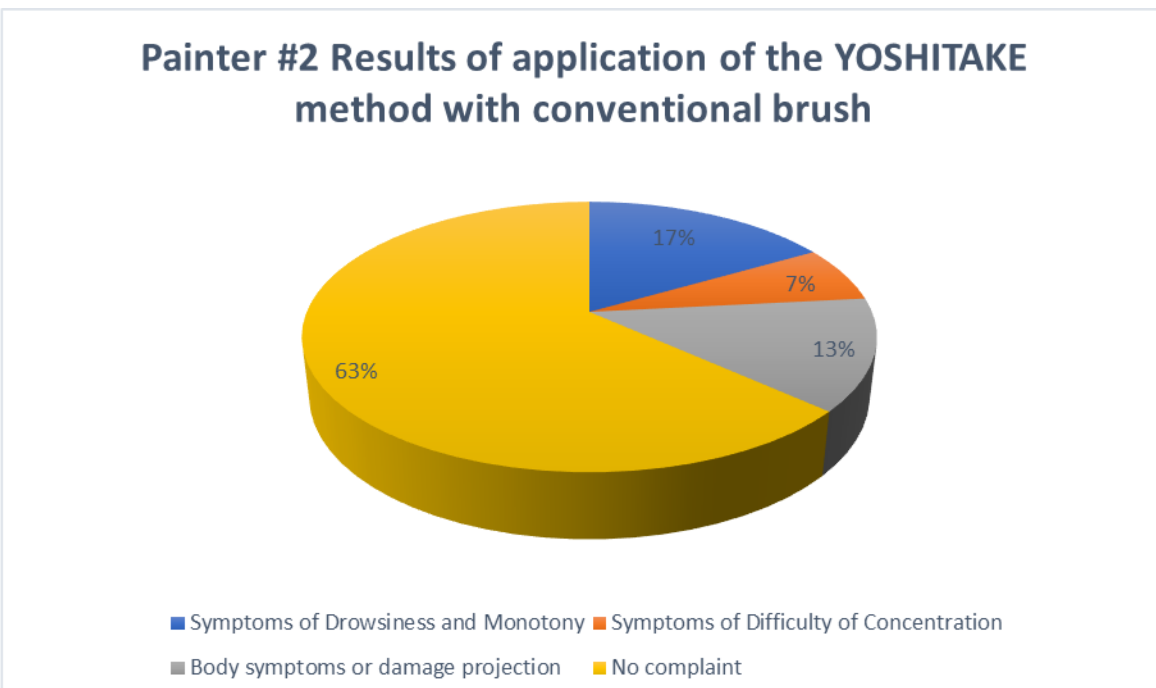
The results of the application of the ergonomic brush method are as follows:

It is

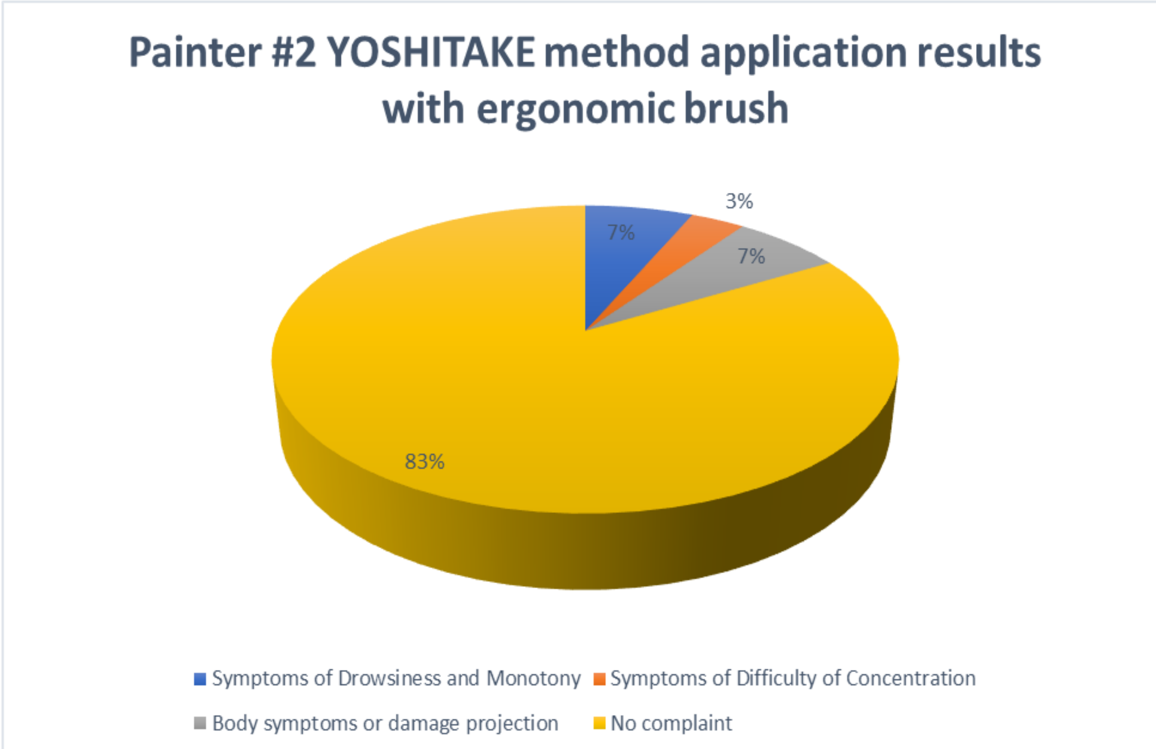



Graphic 2 YOSHITAKE method results in painter #1

observed that the type of work requirement falls into the category of physical requirement in both applications, nevertheless, in the use of the ergonomic brush decrease the symptoms of drowsiness and monotony, difficulty in concentration and body symptoms or projection of damage.

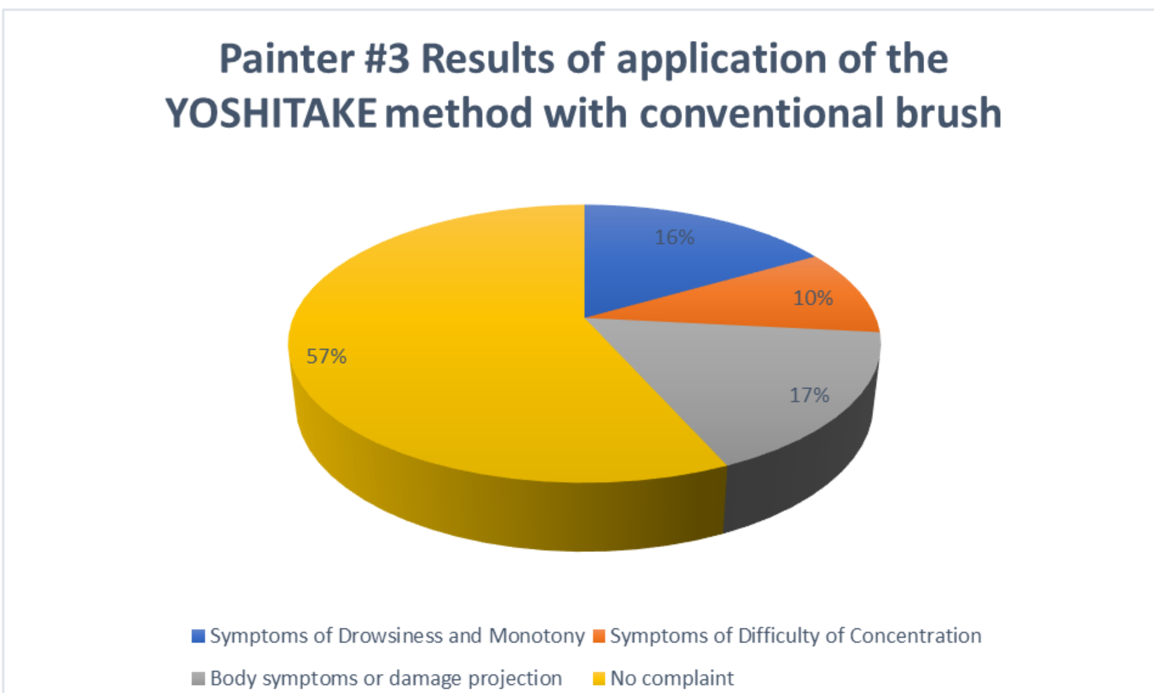



Graphic 3 YOSHITAKE method results in painter #2

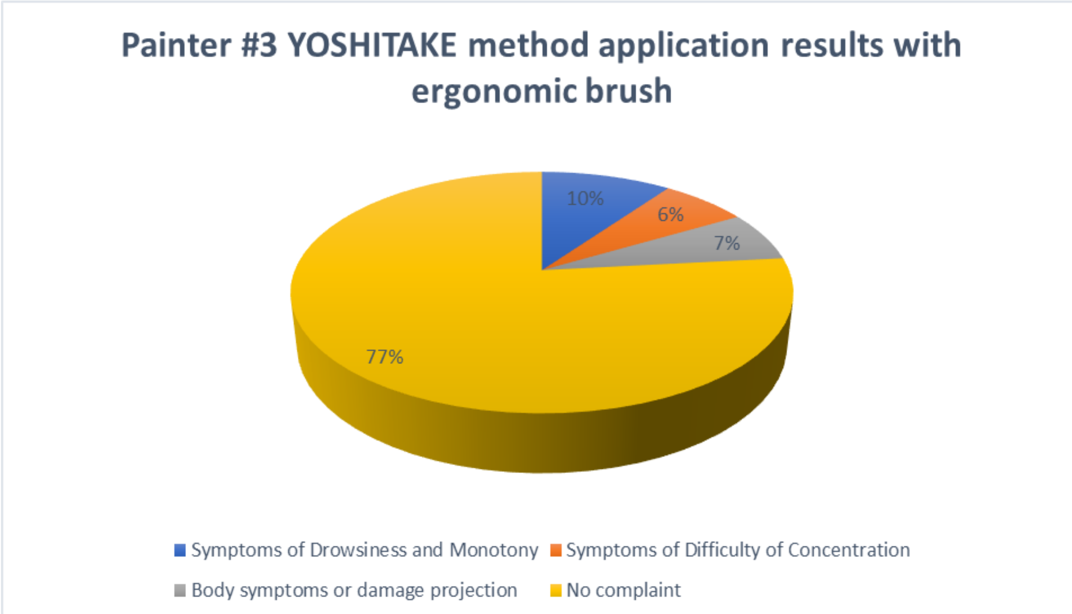



Graphic 4 YOSHITAKE method results in painter #2

Again, for the application with ergonomic brush the symptoms decrease considerably, however, the demands are classified physical and mental type for the use of conventional brush.




Graphic 5 YOSHITAKE method results in painter #3




Graphic 6 YOSHITAKE method results in painter #3

For all three applications, considerable symptoms were shown in the use of a conventional brush, therefore, it was necessary to carry out a study of postures using a method, in this case, the RULA method.

Table 7 **Action levels in the RULA method**

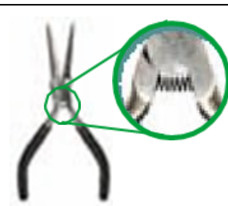
| Rula Score | Risk Level | Action Level |
|---|---|---|
| 1 o 2 | 1 | Posture is acceptable, and changes are not required |
| 3 o 4 | 2 | In-depth research is required, it is possible to make changes. |
| 5 o 6 | 3 | It is required to redesign the task; it is necessary to carry out research activities. |
| 7 | 4 | Immediate changes are required |

According to the results that were thrown in the study, the action degree of the conventional brush is higher for the activity, in comparison with the ergonomic brush, however, very similar results are thrown, having a score of 5 with conventional brush and 4 with ergonomic brush, because the method is focused not only on the wrist - arm - back, it also takes into account the legs and trunk. With our redesign of the brush handle the risk of these diseases is reduced as we can see in the final tables of the rula method. In conclusion, the redesign of the brush could be considered one more success, evaluated with the RULA method.

The checklist provided by NIOSH is the following:

Consider Tool 1 as the ergonomic brush and Tool 2 as the conventional brush. The gray spaces does not applied for our tool, because it is not a double-handle tool.

Table 8 **NIOSH Guide**

| | **Checklist for Hand Tool Selection**<br>Select the tool that has the most "YES" answers. | **Examples** | Check if "YES"<br>Single- handle tools | | Double-handle tools | |
|---|---|---|---|---|---|---|
| | | | Tool 1 | Tool 2 | Tool 1 | Tool 2 |
| 1 | For single-handle tools used for power tasks:<br>Does the tool feel comfortable and have a handle diameter between 1 1/4 inches and 2 inches? (pg. 8) |  | ✓ | ✓ | | |
| 2 | For single-handle tools used for precision tasks: Is the handle diameter between 1/4 inch and 1/ 2 inch? (pg. 8) |  | | | | |
| 3 | For double-handle tools used for power tasks:<br>Is the grip span at least 2 inches when closed and no more than 3 1/2 inches when open? (pg. 8) |  | | | | |
| 4 | For double-handle tools used for precision tasks: Is the grip span no less than 1 inch when closed and no more than 3 inches when open? (pg. 9) |  | | | | |
| 5 | For double-handle tools:<br>Is the handle spring-loaded? (pg. 9) |  | | | | |

***COMPLETE BOTH SIDES***

| | **Checklist for Hand Tool Selection**<br>Select the tool that has the most "YES" answers | **Examples** | Check if "YES" for all tools<br>Tool 1 | <br>Tool 2 |
|---|---|---|---|---|
| 6 | Is the tool handle without sharp edges or finger grooves? (pg. 9) |  | ✓ | ✓ |
| 7 | Is the tool handle coated with soft material? (pg. 9) |  | | |
| 8 | Can the tool be used while keeping your wrist straight? (pg. 10) |  | ✓ | |
| 9 | Can the tool be used with your dominant hand or with either hand? (pg. 10) |  | ✓ | ✓ |
| 10 | For high-force tasks:<br>Is the handle longer than the widest part of your hand (usually 4 inches to 6 inches)? (pg. 11) |  | ✓ | |
| 11 | Does the tool handle have a non-slip surface? (pg. 11) |  | ✓ | ✓ |

As a result of the guide we managed to clarify that our tool does comply with most of the aspects necessary for a hand tool to be considered as ergonomic, having a score of 6/8 while the standard brush got 4/8.

The other considerations could be implemented in our prototype as a second edition so that the tool improves and is more ergonomic still taking care of the well-being of the workers.

# 4 CONCLUSION

The Yoshitake questionnaire together with the RULA method are a great tool to determine the degree of fatigue that exists when performing an activity and to identify in which part of the body it has more impact. Thanks to these tools we can conclude that the use of the conventional brush does cause enough fatigue to carry out complementary research and make changes in the activity.

Likewise, thanks to the checklist of ergonomic tools, the preference among painters of the ergonomic brush over the conventional brush is shown, because when evaluated by NIOSH as an ergonomic hand tool it guarantees the correct performance of the task, as well as the health of the worker.

Unfortunately, it is impossible to eliminate the painter's unsuitable positions in their entirety when performing the activity, because at some point during their task they tend to climb stairs, bend over, or lean for certain periods of time, but there is enough evidence to determine that the ergonomic brush redesign proposal presented in the research has the requirements to help reduce physical injuries in the job of a housepainter, specifically in the activity of painting cutouts and corners.

# 5 REFERENCES

Félix, M. (2014). Posturas de trabajo: Evaluación de riesgos. Por el Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT). Recuperado el día 20 de Febrero de 2020 del sitio web: http://www.insht.es/MusculoEsqueleticos/Contenidos/Formacion%20divulgacion/material%20didactico/Posturas%20trabajo.pdf

Jenny Rodríguez, Fernanda Maradéi & Javier Martínez. (2018). Improvement of a cutting flowers tool by using ergonomic design . 01 de Marzo 2020, de Revista UIS Ingenierías Sitio web: revistas.uis.edu.co/index.php/revistauisingenierias

John Howard & Len Welsh(2004). Easy Ergonomics: A Guide to Selecting Non-Powered Hand Tools. 02 de Marzo 2020, de the California Department of Industrial Relations and the National Institute for Occupational Safety and Health Sitio web: https://www.cdc.gov/niosh/docs/2004-164/pdfs/2004-164.pdf?id=10.26616/NIOSHPUB2004164

Johnson SL(1993). Diseño ergonómico de herramienta manual. Clínicas de mano. 02 de Marzo 2020, National Librery of Medicine, Sitio Web: https://pubmed.ncbi.nlm.nih.gov/8509467/

Pueyo, A. (2015). Trastornos musculo-esqueléticos y enfermedades en las profesiones. Recuperado el día 01 de Marzo de 2020, de Universidad Politécnica de Catalunya Sitio web: https://upcommons.upc.edu/bitstream/handle/2117/76361/memoria.pdf

Rodríguez, S. (2014). Evaluación de riesgos ergonómicos mediante el método RULA. Recuperado el día 02 de Marzo de 2020, de la Universidad de Valladolid sitio web: https://uvadoc.uva.es/bitstream/10324/7860/6/TFM-I-89.pdf

# ERGONOMIC ANALYSIS AND DESIGN PROPOSAL; APPLIED TO POSTURE, REPETITIVE MOVEMENTS IN DOUGHNUT FRYING AND WORK TOOL DESIGN

**Christopher Dórame[1], Alejandro Picos[1],**
**Leslie González[1], Acela Castillón[1], Rigoberto Zamora[1,2]**

[1]Departamento académico de Ingeniería Industrial
Instituto Tecnológico de Mexicali
Av. Instituto Tecnológico s/n, Plutarco Elías Calles
Mexicali, Baja California, C.P. 21376
christopher.dorame98@gmail.com

[2]Departamento de Ingeniería Mecánica
Universidad Autónoma de Baja California
Calle Normal s/n Blvd. Benito Juárez Col. Insurgentes Este
Mexicali, Baja California, C.P. 21100
mczamora02@yahoo.com.mx

**Resumen:** Este proyecto tiene como fin disminuir el riesgo de lesiones por repetividad y postura del operador en su área de trabajo que es el freído de donas (Panadería), mediante un análisis del puesto de trabajo, tomando en cuenta normas oficiales mexicanas y empleando métodos de evaluación ergonómicos (OCRA y WERA) en el área de trabajo, dimensionamiento del lugar y antropometría del trabajador y la mejora con un diseño de herramientas. El proceso de freído se lleva a cabo con dos palitas de cocina, el trabajador voltea cada una de las donas generando movimientos innecesarios y repetitivos, además de adoptar una postura inadecuada. El beneficio de este estudio y la mejora diseñada se logra mejorar la productividad en el proceso, mediante recomendaciones del rediseño de la herramienta utilizada para voltear las donas además con la aplicación de herramientas de mejora continua como el diagrama espagueti y la metodología de 5s, se realizó el rediseño del área de trabajo para eliminar movimientos repetitivos en el operador.

**Palabras clave:** Normas, WERA, OCRA, Freidora, mejora.

**Relevancia para la ergonomía:** Diseñar equipos o áreas de trabajos aplicando principios, métodos y normas ergonómicas de forma creativa e innovadora tomando en cuenta aspectos psicosociales.

**Abstract:** The purpose of this project is to reduce the risk of repetitive injuries and the operator's posture in his work area, which is frying donuts (Bakery), through an analysis of the job position, taking into account official Mexican standards and using evaluation methods. ergonomics (OCRA and WERA) in the work area, dimensioning of the place and anthropometry of the worker and improvement with a design of tools. The frying process is carried out with two kitchen sticks, the worker turns each one of the donuts generating unnecessary and repetitive movements, in addition to adopting an inappropriate posture. The benefit of this study and the improvement designed is to improve productivity in the process, through recommendations for the redesign of the tool used to turn the donuts in addition to the application of continuous improvement tools such as the spaghetti diagram and the 5s methodology. performed the redesign of the work area to eliminate repetitive movements in the operator.

**Keywords:** Standards, WERA, OCRA, Fryer, improvement.

**Relevance for ergonomics:** Design equipment or areas of work applying ergonomic principles, methods and standards in a creative and innovative way taking into account psychosocial aspects.

## 1. INTRODUCTION

This project was carried out in a bakery; We took the chocolate donut making process for analysis, specifically the donut frying station. We chose this workstation because the area of opportunity to improve this process is varied; mainly repetitive movements and the posture of the worker when carrying out the activity.

The risk of injuries due to repetition and posture in the operator was reduced through an analysis of the job, taking into account official Mexican standards, and evaluation methods in the work area.

A tool was designed in the work area to eliminate repetitive movements, as well as repetitive movements were eliminated with the implementation of the use of appropriate equipment. The aim is to implement the appropriate use of equipment that improves current operating practices to improve worker comfort.

The Mexican standards and the methods to evaluate ergonomic risks OCRA (Occupational Repetitive Action) and WERA (Work place Ergonomic Risks Assessment) were applied to evaluate ergonomically, thus obtaining the level of risk that is handled in the station for which it was dimensioned the work station where ergonomic measures were taken, later we will design a tool which reduces time and movements.

## 2. OBJETIVO

Reduce the risk of receptivity injuries and posture in the operator, through a workplace analysis, taking into account Mexican standards, methods, ergonomic risk assessments in the work area and tool design, to implement the use of appropriate equipment to improve current operating practices and thus improve worker comfort.

## 3. METHODOLOGY USED

For the development of this project began with an evaluation analysis of a current process, with the following standards:

1. Application of Mexican Official Standards for valid physical workstation conditions

   NOM 011 STPS 2018 (noise). In this official Mexican standard we perform a method with a sound measurement instrument, delimiting the work area in nodes and with this taking measurements to know the sound pressure level, with this we are guided in the official standard to obtain results and so both were obtained that the shots exceeded the permissible dB limit.

   NOM 015 STPS 2011 (temperature). In this official Mexican standard we perform temperature measurement with the appropriate instruments, delimiting the area into nodes and focusing on the area of the worker where he performed his operations most of the time

   NOM 025 STPS 2008 (lighting). In this official Mexican standard we perform the measurement of lighting by delimiting the area in nodes and taking the measurements where the worker is in process to know the permissible light levels, with this taking as reference that standard.

   NOM 035 STPS 2018 (psychosocial risk). In this official Mexican standard we conduct surveys of workers to see that both affected psychosocial risks in day-to-day work and taking precautionary measures conforms to the results.

2. Analysis of station sizing and operator anthropometry.

   Managing to take the ergonomic measurements to the worker, as well as fryer measures for new tool design.

3. Ergonomic analysis application WERA, OCRA.

   Ergonomic methods were performed and in OCRA method results are recommended position improvement, medical supervision and training.

4. Design of work tools.

   Measurements were taken of the fryer in which the repetitive movements were performed and the fryer tool was designed to avoid injuries.

5. Application of improvement tools.

   We use continuous improvement tools such as 5's and improve the work area room, to have everything within reach of work taking into account what was most needed for the production of the product.

# 4. RESULTS

## 4.1 Application of Mexican Standards.

Analyzing the official Mexican standards for the work area and obtained information to comply with those standards and their requirements

In NOM-015-STPS-2001, on the occasion of workers' exposure to extreme thermal conditions high or despondent in the Workplace, the patterns should: Perform the recognition of areas and personnel occupationally exposed to temperatures extremes: at the site being evaluated, the area of frying in which extreme temperatures are present is not delimited. Areas of risk should be delimited and reported by extreme temperatures. (STPS,2002).

In the case of this project the exposure can be 100%. The operator is inside the work area throughout the day. Figure 1 shows the temperature at which it is exposed in the work area.

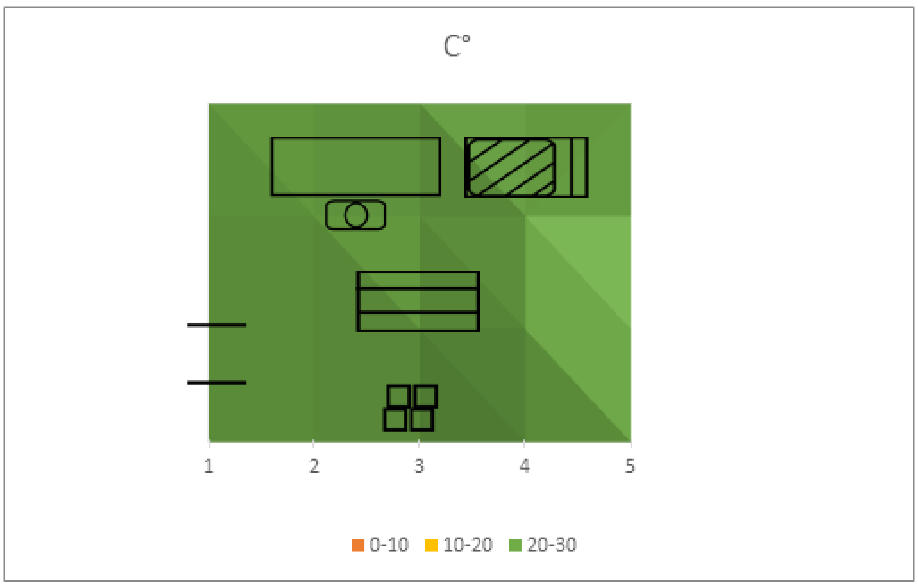



Figure 1. Temperature graph in the work area

In the case of this project exposure to moisture can be 100%. The operator can be inside the work area throughout the day. Figure 2 shows the humidity graph in the work area.

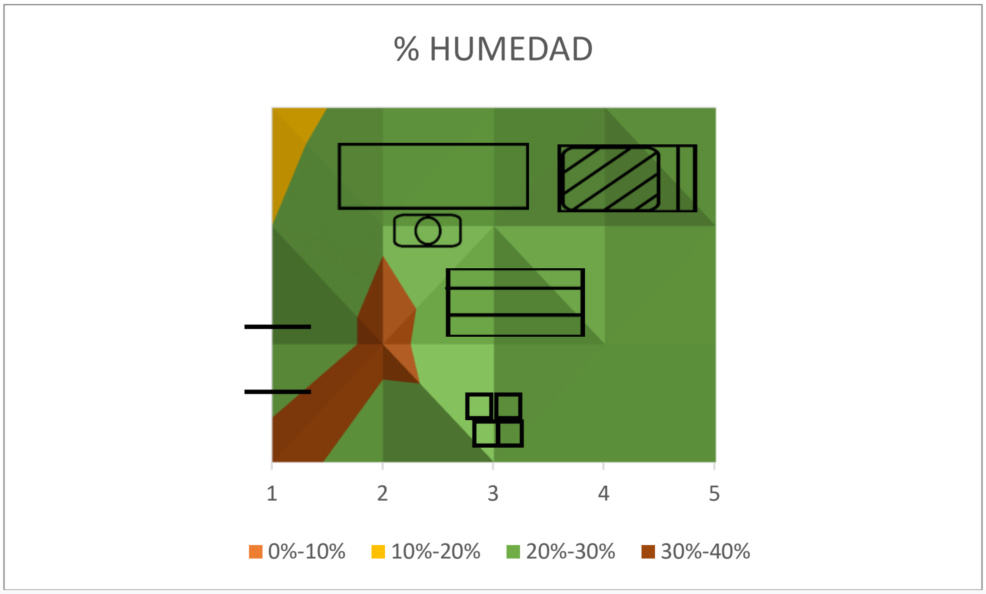



Figure 2. Graph of the percentage of humidity in the work area

Humidity inside the workstation averages 25%. With a variation between 10% and 15%.

Taking into account the results obtained in the studies carried out of temperature and humidity, we compare them with table1. We can determine as to the permissible maximum limits that the worker is at a higher temperature exposure than what is governed by the official Mexican standard.

Table 1. Maximum permissible limits of exposure to high thermal conditions.
Source: NOM 015-STPS-2001, p. 5.

| Temperatura máxima en C | | | | |
|---|---|---|---|---|
| **Régimen de trabajo** | **Ligero** | 30.0 | **Porcentaje de tiempo de exposición y de no exposición** | 100% de exposición |
| | | 30.6 | | 75 % de expoición; 25% de recuperación |
| | | 31.7 | | 50 de exposición; 50% de recuperación de cada hora |
| | | 32.2 | | 25% d exposición; 75% de recuperación en cada hora |
| | **Moderado** | 26.7 | | 100% de exposición |
| | | 27.8 | | 75 % de expoición; 25% de recuperación |
| | | 29.4 | | 50 de exposición; 50% de recuperación de cada hora |
| | | 31.1 | | 25% d exposición; 75% de recuperación en cada hora |
| | **Pesado** | 25.0 | | 100% de exposición |
| | | 25.9 | | 75 % de expoición; 25% de recuperación |
| | | 27.8 | | 50 de exposición; 50% de recuperación de cada hora |
| | | 30.0 | | 25% d exposición; 75% de recuperación en cada hora |

On the NOM-025-STPS-2008, lighting conditions in work centers. It states: "8.1. The purpose of the recognition is to identify those areas of the work center and the visual tasks associated with the workstations, as well as to identify those where there is poor lighting or excess lighting that causes glare" (STPS,2008).

The minimum levels of lighting that must affect the work plane, for each type of visual task or work area. Light levels in the work area do not reach 1 luxes, therefore that task does not meet the minimum luxes permissible for that standard.

Considering point 7 of the standard NOM-025-STPS-2008, lighting conditions in the workplaces. Figure 3 shows us the lighting decibels (lux) detected in the work area.

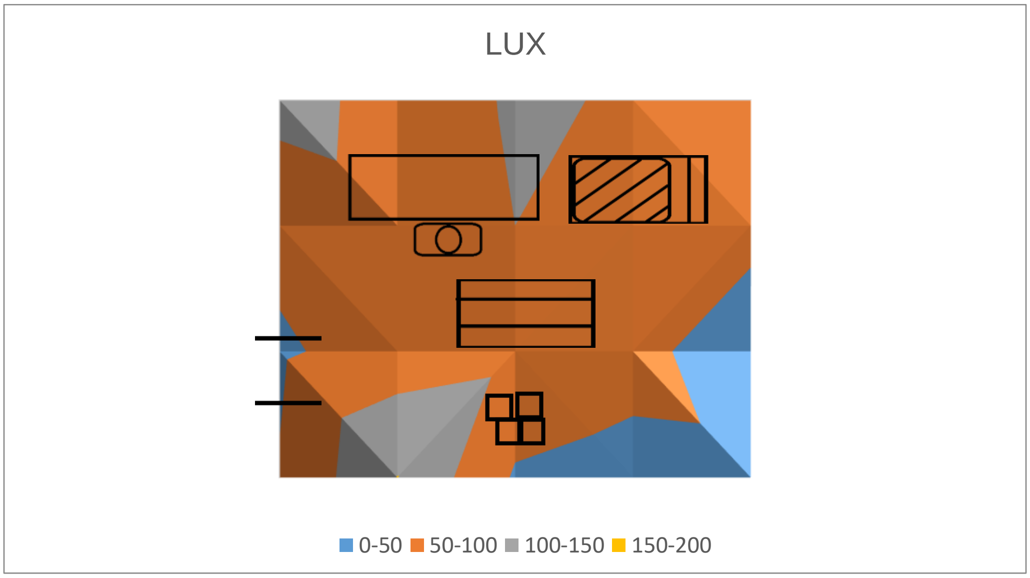



Figure 3. Illumination graph (lux) in the work area.

Light levels in the work area do not reach 300 luxes, therefore it is not complying with this standard. This requires corrective action.

In NOM -017-STPS-2008, about personal protective equipment- Selection of use and management in work centers. Indicates: "Provide personal protective equipment to protect occupationally exposed personnel" (STPS,2008).

Figure 4 shows the worker how he performs his activity and what personal protection elements he/she counts on.

Figure 4. Operator in the workspace.

The worker does not have the PPE and hygiene necessary for the performance of his work. Therefore, immediate corrective action is recommended for compliance with the standard. Needed:

- Cofia
- Gloves
- Covers
- White Mandil Mouths

In NOM-011-STPS-2001, safety and hygiene conditions in work centers where noise is generated. (STPS,2002). It sets the maximum permissible limits for exposure of workers to stable, unstable or impulsive noise during the work, in an 8-hour working day. Noise measurements were performed in the work area by delimiting it to nodes as shown in Figure 5.

The results obtained from the evaluation of compliance with NOM 011-STPS-2001, p. 109 of "Maximum permissible noise exposure limits". Obtaining as a result that for the 8-hour day the maximum permissible exposure limit is 90 dB, this shows that most of the shots exceed the permissible dB limit and immediate action is required.

Obtaining as a result that for the 8-hour day the maximum allowable exposure limit is 90 dB, this shows that most shots exceed the permissible dB limit and immediate action is required.

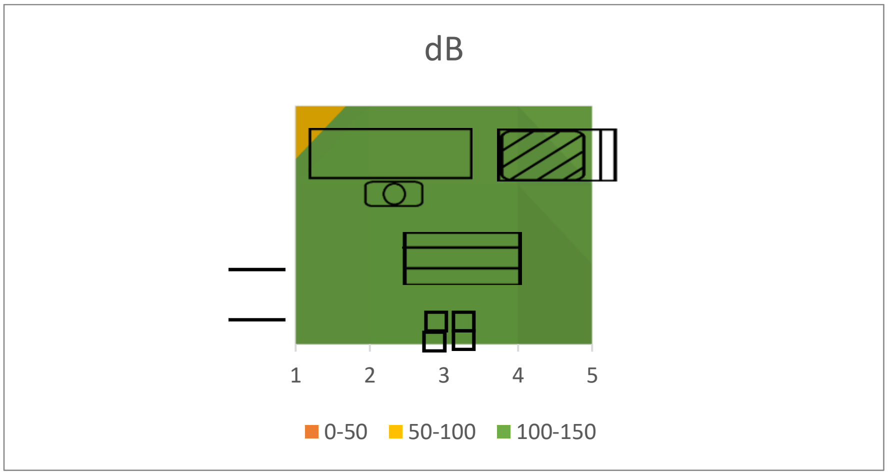



Figure 5. Noise level graph (dB) showing decibels in the work area.

Table 2. Maximum permissible noise exposure limits. Source: NOM 011-STPS, p. 109

| Límites máximos permitibles de exposición | | | | | | |
|---|---|---|---|---|---|---|
| **NER** | 90 dB | 93 dB | 96 dB | 99 dB | 102 dB | 105 dB |
| **TMPE** | 8 horas | 4 horas | 2 horas | 1 horas | 30 minutos | 15 minutos |

**4.2 Operator anthropometry, fryer station sizing**

For tool design we consider the following anthropometric measurements shown in Table 3.

Table 3. Worker's anthropometry.

| | | |
|---|---|---|
| Longitud de mano | 18.4 | Para el diseño del mango |
| Diametro empuñadora | 4.1 | Para el diametro del mango |
| Alcance brazo lateral | 95.2 | Verificar dimensión de la estacion de trabajo |
| Altura codo flexionado | 110.3 | Verificar dimensión de la estacion del trabajo |

The height of the workstation and is suitable according to the worker's anthropometry, according to this it was chosen to design only the tool that adapted to the fryer, as shows in figure 6.


Figure 6. Worker's measures.

The tool designed for the fryer as well as the specified handle dimensions for the best worker comfort, as show in the figure 7.

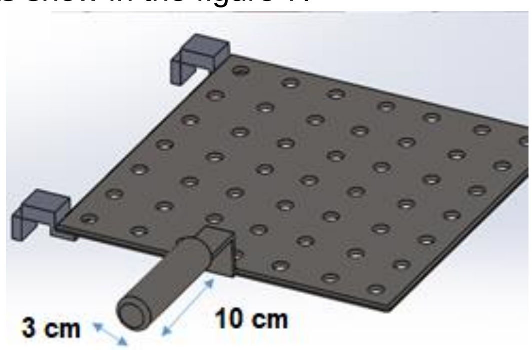



Figure 7. Tool dimensions

In anthropometry, the design was fulfilled so that the worker performs the operation properly.

### 4.3 Ergonomic analysis application

4.3.1 Ergonomic risk assessment methods.

Ergonomic evaluation with the WERA (Workplace Ergonomic Risks Assessment) method. Table 4 shows the evaluation that was performed using the WERA method, as well as the results obtained with each subscript.

Table 4. WERA Method (Workplace Ergonomic Risks Assessment). Source: self made

| Metodo WERA | |
|---|---|
| **Factor de riesgo** | **Puntuación** |
| **Hombro** | 4 |
| **Muñecas** | 2 |
| **Espalda** | 3 |
| **Cuello** | 5 |
| **Piernas** | 2 |
| **Fuerzas** | 2 |
| **Vibración** | 0 |
| **Stress por contacto** | 0 |
| **Duración de la tarea** | 3 |
| **TOTAL** | 21 |

Taking into account the result obtained from Table 4, it was compared with Table 5, to know at what level the process is.

Table 5. WERA method action level. Source: self made

| | | | |
|---|---|---|---|
| Job/Task | Proceso de freído de donas | | |
| Date | 16/02/2020 | | |
| Observer | Dorame Christopher | | |
| Risk Level | Final score | Action | Tick |
| Low | 18-27 | Task is acceptable | ■ |
| Med | 28-44 | Task is need to further investigate y required change | □ |
| High | 45-54 | Task is not accepted immediately change | □ |

Analysis of Results by WERA Method (Workplace Ergonomic Risks Assessment). Applying the proposed improvements. When applying the WERA (Workplace Ergonomic Risks Assessment) method. We got a 21-point finish score. Which is why it's acceptable. Therefore it poses no risk to the worker.

4.3.2 Analysis of Results by OCRA Method (Occupational Repetitive Action) applying the proposed improvements.

Ergonomic evaluation with the OCRA (Occupational Repetitive Action) method. Table 6 shows the acceptance rate of the OCRA method in which we will guide ourselves against our results.

Table 6. OCRA Method Assessment (Occupational Repetitive Action). Source: self made

| Índice CheckList OCRA | Nivel de Riesgo | Acción recomendada | Índice OCRA equivalente |
|---|---|---|---|
| ≤ 5 | Óptimo | No se requiere | ≤ 1.5 |
| 5.1 - 7.5 | Aceptable | No se requiere | 1.6 - 2.2 |
| 7.6 - 11 | Incierto | Se recomienda un nuevo análisis o mejora del puesto | 2.3 - 3.5 |
| 11.1 - 14 | Inaceptable Leve | Se recomienda mejora del puesto, supervisión médica y entrenamiento | 3.6 - 4.5 |
| 14.1 - 22.5 | Inaceptable Medio | Se recomienda mejora del puesto, supervisión médica y entrenamiento | 4.6 - 9 |
| > 22.5 | Inaceptable Alto | Se recomienda mejora del puesto, supervisión médica y entrenamiento | > 9 |

Final Formula (Real Data) ICKL (6 + 2.5 + 3 + 3.5 + 3) * .85 = 15.3 (1)

Comparing the results obtained from the ICKL value and the range established by the OCRA method, the result is between 14.1 - 22.5 which indicates that it is: Unacceptable Medium. So, it is recommended to improve the position, medical supervision, and training.

### 4.4 Work tool design

One of the factors that as a team we consider as a risk to the operator, is a repetitive operation; it is the action of flipping the doughnuts when frying them since the worker does this frequently and taking into account the results obtained from the OCRA method we choose to design a new work tool.

The risk of injuries and posture in the operator was reduced through an analysis of the workplace, considering Mexican standards, methods, evaluations in the work area, design of tools and materials used. To implement the use of appropriate equipment that improves current operating practices and thus improve worker comfort. Figure 8 shows the tool designed to be implemented in the workspace

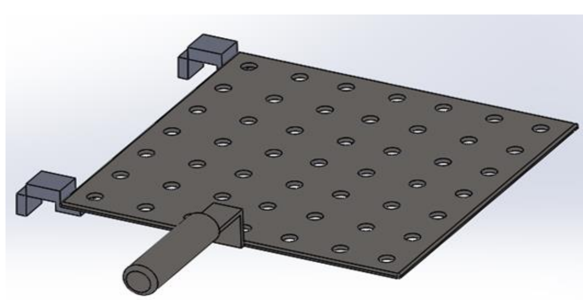


Figure 8. Tool designed to implement.

Figure 9 shows how the tool fits the fryer to be used properly.

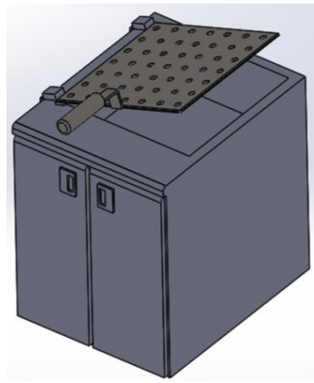


Figure 9. Tool installed on the workstation.

Under the dimensional conditions of the doughnut frying tool, the ergonomics in the design were met and in turn was achieved to improve productivity in the doughnut frying process by reducing the operating time by 52.4% and eliminating 37.2% of the WIP.

### 4.5 Application of improvement tools

A diagram was made to determine the activities of the donut fryer process in which considering that the operator has a working day of 8 hours; taking into account his 30 minutes of food and the times of non-operations where he performs other activities. In which it was determined that in route 1, with a time of 33.6 meters and route 2 with 50.4 meters, obtaining that in a total day of the route in 1 day (8 hours) it is 84 meters.

Based on the analysis of the spaghetti diagram and the application of the 5S improvement tool to the work area, an improvement was made to the layout in the distribution of the work station, as well as the place of each item was standardized since the location of these varied according to the day, shift or operator, as shown in figure 9. To thus reduce the operator's journey in their day by 31.03% of the worker's journey in a working day.

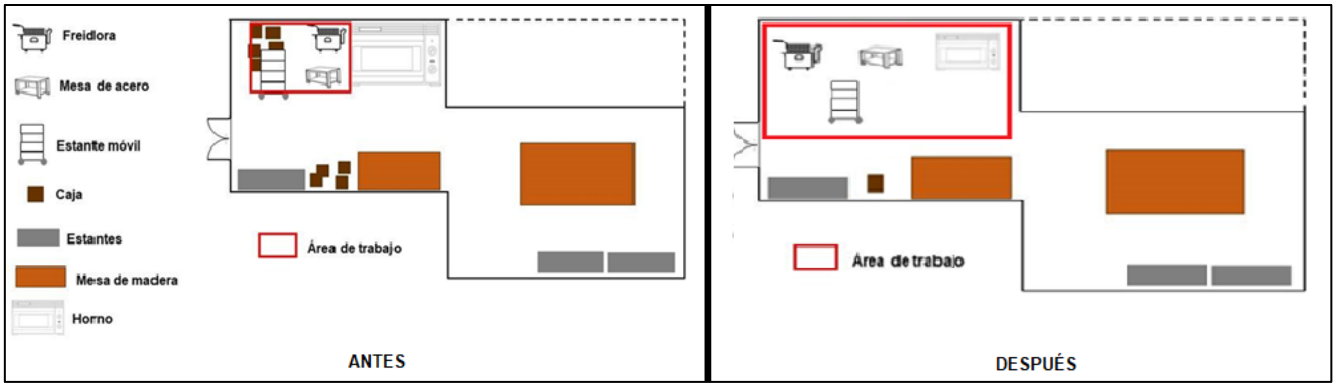



Figure 10. Current layout from the bakery.

## 5. CONCLUSIONS

Applying an analysis of the donut fryer area with respect to the standards: NOM 011 STPS 2018 (noise), NOM 015 STPS 2011 (temperature), NOM 025 STPS 2008 (lighting). NOM 035 STPS 2018 (psychosocial risk), in addition to the analysis of the sizing of stations and the anthropometry of operators and the Ergonomic analysis application WERA, OCRA, it was possible to make a proposal to redesign a work tool to improve the ergonomic conditions of operators In addition to the application of continuous improvement tools such as the spaghetti diagram and the 5s methodology, a redesign of the layout of the work area was carried out in order to reduce journeys and improve the working conditions of employees. In this study, the following advantages could also be observed:

• In the dimensional conditions of the donut fryer tool, it was possible to comply with the ergonomics in the design.

• In anthropometry it was possible to comply with the design for the worker who performs the operation.

• It was possible to improve productivity in the donut frying process, reducing operating time by 52.4% and eliminating 37.2% of WIP.

• Recommendations were given to improve the work area according to official Mexican standards, as some did not comply with the regulations.

• A working tool was designed to eliminate repetitive movements in the operator and thus take care of his health in future injuries.

• The operator's journey in their working day was reduced by 31.03% of the worker's journey in one working day.

• An improvement in the operator's route was obtained through an improvement in the layout.

• A tool was designed for the fryer that eliminates repetitive movements and forced postures of the activity, applying the rules of conditions in work centers, protective equipment and preventive health and safety services in the work area, In this way, the worker's health and well-being are guaranteed.

• Finally, the risk of repetitive and posture injury to the operator was reduced through an analysis of the workplace, taking into account Mexican standards, methods, evaluations in the workplace, design of tools and materials used. To implement the use of appropriate equipment that improves current operating practices and thus improve worker confort.

## 6. REFERENCES


Chanel, Alberto (2011). Método WERA. Formato y aplicación de método ergonómico WERA para la valoración postura, 1(1), 02-10. Recuperado de: https://es.scribd.com/document/412838172/Metodo-WERA

Ergonomic checkpoints: Practical and easy-to-implement solutions for improving safety, health and working conditions ISBN 92-2-109442-1, Ginebra, 1996

NORMA Oficial Mexicana NOM-011-STPS-2001, (2002). Condiciones de seguridad e higiene en los centros de trabajo donde se genere ruido. 02 febrero 2020, de Secretaría del trabajo y previsión social Sitio web: http://asinom.stps.gob.mx:8145/upload/noms/Nom-011.pdf

NORMA Oficial Mexicana NOM-015-STPS-2001, (2002). Condiciones térmicas elevadas o abatidas-Condiciones de seguridad e higiene. 02 febrero 2020, de Secretaría del trabajo y previsión social Sitio web: http://asinom.stps.gob.mx:8145/upload/noms/Nom-015.pdf

NORMA Oficial Mexicana NOM-017-STPS-2008, (2008). Equipo de protección personal-Selección, uso y manejo en los centros de trabajo. 02 febrero 2020, de Secretaría del trabajo y previsión social Sitio web: https://www.stps.gob.mx/bp/secciones/dgsst/normatividad/normas/Nom-017.pdf

NORMA Oficial Mexicana NOM-025-STPS-2008, (2008). Condiciones de iluminación en los centros de trabajo. 02 febrero 2020, de Secretaría del trabajo y previsión social Sitio web: http://asinom.stps.gob.mx:8145/upload/noms/Nom-025.pdf

Universidad politécnica, Valencia (2006). OCRA. OCRA Check list, 1(1), 1-1. Recuperado de: https://www.ergonautas.upv.es/metodos/ocra/ocra-ayuda.php

# HAND TOOL REDESIGN - ERGONOMIC BICYCLE HANDLE

**Indeliza Armenta Acosta, Jesús Iván Ruiz Ibarra, Jesús Mario Galaviz Armenta, Fidel Alejandro King Félix, Jesús Geovanny Cruz Cota.**

Department of Industrial Engineering
Tecnológico Nacional de México / I.T. de Los Mochis
Juan de Dios Batiz, Blvd. 20 noviembre
Los Mochis, Sinaloa 81259

*inde5@hotmail.com*, *jesus_ruizi@hotmail.com*, *jesusmariogalavis@gmail.com*, *fidel.15@live.com.mx*, *jesusgeovanny2498@gmail.com*

**Resumen:** El uso de la bicicleta se remonta a las épocas del Antiguo Egipto se fabricaron artefactos rudimentarios compuestos por dos ruedas unidas por una barra. También se conoció en China un artilugio muy similar, pero con ruedas hechas de bambú. Uno de los elementos que más cambios han sufrido durante todo este largo período de tiempo han sido los manillares de la bicicleta. El manillar se usa especialmente en bicicletas, motocicletas y ayuda a mantener un control firme de la bicicleta a la hora de ir manejando.

Siempre se ha hecho hincapié en las precauciones que se deben de tomar al momento de usar una bicicleta y especialmente el uso del manubrio por ser esta una herramienta de altas probabilidades para ocasionar una lesión en las manos por impacto, éste debe manejarse con sumo cuidado procurando que la herramienta no resbale por los manillares y el material del manubrio y así ocasione la lesión antes mencionada. Por este motivo se propone una mejora del diseño del manubrio añadiendole un agarre con cubierta de goma y en un angulo adecuado para su mejor y mas seguro desempeño.

**KEYWORDS:** Redesign-handlebars-bicycle- posture.

**RELEVANCE FOR ERGONOMICS:** Ergonomic handlebar handling must be designed to satisfy meeting people's needs to avoid injury.

**ABSTRACT:** The use of the bicycle dates back to the times of Ancient Egypt, rudimentary artifacts composed of two wheels connected by a bar was manufactured. A very similar contraption was also known in China, but with wheels made of bamboo. One of the elements that have undergone the most changes throughout this long period of time have been the handlebars of the bicycle. The handlebar is especially used on bicycles, motorcycles and helps maintain firm control of the bicycle when riding.

Emphasis has always been placed on the precautions that must be taken when using a bicycle and especially the use of the handlebars, as this is a highly likely tool to cause an injury to the hands due to impact; it must be handled with great care, ensuring that the tool does not slip by the handlebars and the material of the handlebar and thus cause the aforementioned injury. For this reason, an

improvement in the redesign of the handlebars is proposed by adding a grip with a rubber cover and at a suitable angle for its best and safest performance.

## 1. INTRODUCTION

According to a publication article made in Murcia, Spain by MC. María del Carmen Calvo López in her research work on the occasion of her thesis called "Analysis of Risk Factors for Injury in Federated Road Cycling in the Region of Murcia", 2009 mentions that:" Cycling is a healthy transport, it is continuous and its inappropriate use (how the driver holds and holds the handlebar) can lead to diseases such as ulnar nerve neuropathy, which occurs when the person is pedaling for hours uninterrupted and manifested through pain, tingling, numbness, and weakness of the hand through the ulnar nerve, mainly ring of scope and minimal fingers; and carpal tunnel syndrome which is produced by manual pressure on the handlebars of bicycles, which leads to compression of the tunnel where the flexor tendons of the wrist and the median nerve are located, being the compression of the median nerve can cause pain, muscle atrophy and tingling in the radial part of the hand among other pathologies".

Based on this information, this article reveals a proposal for a prototype for the improvement of the bicycle handlebar due to the fact that by conducting surveys and tests with cyclists it was concluded that a modification to the conventional bicycle is necessary to improve postures and prevent accidents.

## JUSTIFICATION

The main reason for doing this work is to delve into the study of bicycle handlebars. Bicycles are an urban transport vehicle that has experienced exponential growth, in terms of use, in most European cities in recent years. This growth in bicycle use has also been accompanied by a large growth in accidents involving bicycles.

Indicating from an ergonomic point of view, bicycle handlebars must meet a series of basic requirements to be effective such as: effectively perform the function that is intended for it, provide dimensions for the user, that is appropriate to the strength and resistance of the user and Minimize user fatigue.

Therefore, a proposal is created for a prototype of the ergonomic handlebar with adaptation of handlebars, in addition to adding a type of rubber, which will help the user to avoid any type of accident or risk to which they are exposed when getting on their bike and go for a walk.

**1.2. OVERALL OBJECTIVE:** Improve and innovate the grip of the urban bicycle handlebar by analyzing ergonomic risks and musculoskeletal injuries in order to avoid or minimize damage to the hands, wrists and elbows

.

### 1.2.1. SPECIFIC OBJECTIVES

- Identify the parts of the body where damage occurs due to the grip of the urban bicycle.

- Determine the appropriate standard of measurements for the redesign of the handlebar.
- Describe the diseases that can be generated.
- Explain the benefits generated by the use of the ergonomic handlebar redesign of the urban bicycle.

**1.3. DELIMITATION:** The redesign / use of this tool is aimed at people with an age range that ranges from 10 to 65 years because in Mexico the use of the bicycle on a daily basis is the most common since it can be used both for sports, as a means of transport or for fun.

## 2. METHODOLOGY

A type of exploratory research was carried out to find the causes and consequences of damage to the hands when using the conventional bicycle, as well as the characteristics of the study that was developed, the inductive method was used since a redesign is proposed ergonomic bicycle handlebar, where people were shown the new ergonomic handlebar prototype.

For the manufacture of an ergonomic bicycle handlebar, the physical capacities and limits of the parts of the body that interact directly with its grip must be taken into account.

The bicycle handlebar, apart from being in charge of directing the trajectory of the bicycle, is responsible for supporting part of the cyclist's weight.

**2.1. PROCESS DESCRIPTION:** A practice with the ergonomic handlebar was carried out for 30 people, this practice consists in that the person had to use the ergonomic handlebar once a day for at least a week, in order that the person who experiments with the new handlebar can us provide your expectations through a survey that will be conducted upon completion of said practice.

The parts of the body involved are the upper extremities such as the arms, wrists, elbows and fingers of the hands, measurements must be taken of these to know at what height and at what exact or approximate width the handlebar should be so that in this way it causes the least possible damage to the aforementioned limbs. "For this you can consult the Manual of Anthropometric Measurements (LINO CARMENATE MILIÁN, 2014)".

### 2.1.1. Injury from improper grip on the handlebars

The following shows the way in which the grip is made using the anti-ergonomic handlebar of the city bike:

In “figure 1” the elbows are involved, which in anatomy, the elbow joint is the one that joins the arm with the forearm, connecting the distal part of the humerus bone with the proximal ends of the ulna and radius bones.

**Fig. 1 front view**

Although the pain manifests in the internal area of the joint, it is normal for it to increase when you bend the wrists or bend the forearm.

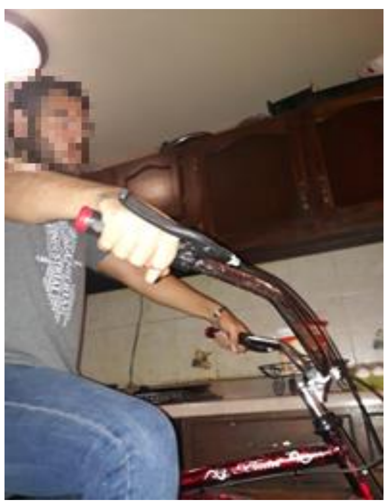


**Fig. 2 Side view**

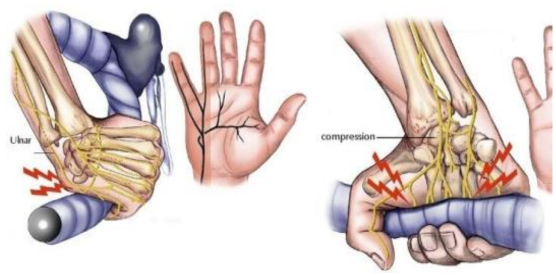



**Fig. 3 Hand position**

In “figure 2” everything that has to do with the grip is involved, such as the hands, wrists and elbows. In the hand we distinguish three zones with 27 bones in total.

As previously mentioned, the parts of the body involved are the upper extremities such as the arms, wrists, elbows and fingers of the hands, measurements must be taken of these to know at what height and at what exact or approximate width the handlebars should be so that in this way cause the least possible damage to the aforementioned extremities. Similarly, overuse and repeated movements can affect the hand and wrist.

People who practice cycling (cyclists and triathletes) frequently have injuries of the upper limb that are very different from those of other sports where injuries such as epicondylitis, rotator cuff tendinopathy or others predominate. A practice with the ergonomic handlebar was carried out for 30 people, this practice consists in that the person had to use the ergonomic handlebar once a day for at least a week, in order that the person who experiments with the new handlebar can us provide your expectations through a survey that will be conducted upon completion of said practice. Below are the graphs of the survey applied to the 30 people who accepted the practice:

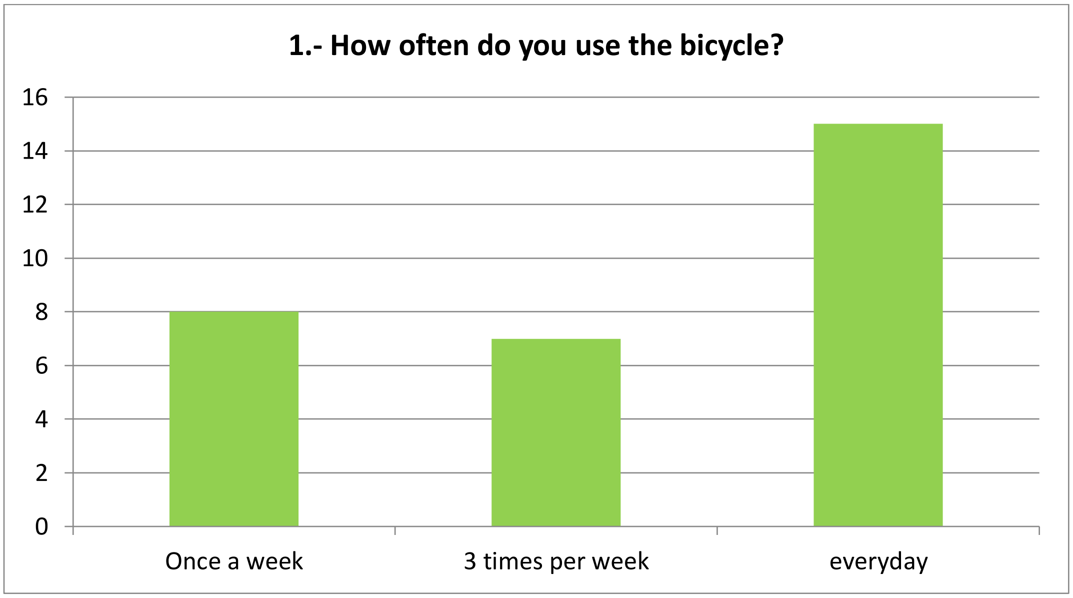



**Fig. 4 Results obtained in question 1**

As shown in the results of question 1, there is a large majority of people who use the bicycle as a means of transport, either to go to school or to use it as a means of training.

As the results of question 2 are shown, most of the voters if they want a bicycle to be comfortable and they are willing to make a change for everything is for the comfort of using this mobile device.

Figure 6 shows us that of the 30 people surveyed, 84% mention that they felt that the ergonomic handlebar helped them improve posture.

Figure 7 shows that 76% of our participants may decide to buy an ergonomic handlebar; it is thought that they have to invest a little in their health.

Observing figure 8, it was noticed that 64% of the people surveyed believed that they did not feel any discomfort while 30% were indifferent.

In figure 9 it can be seen that 77% of the people surveyed have no idea what kind of problems can cause bad posture when using a conventional bicycle.

In figure 10 it can be seen that 100% of the people surveyed have no idea if there is something that helps them improve their health when using a bicycle.

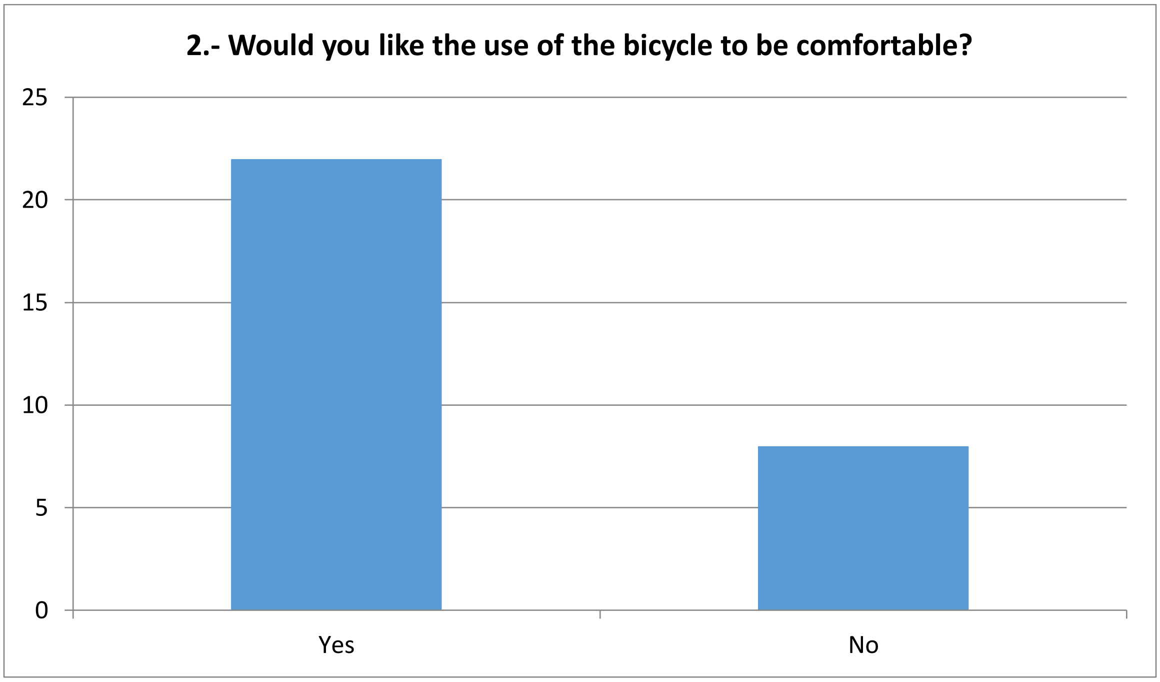



**Fig. 5 Results obtained in question 2**

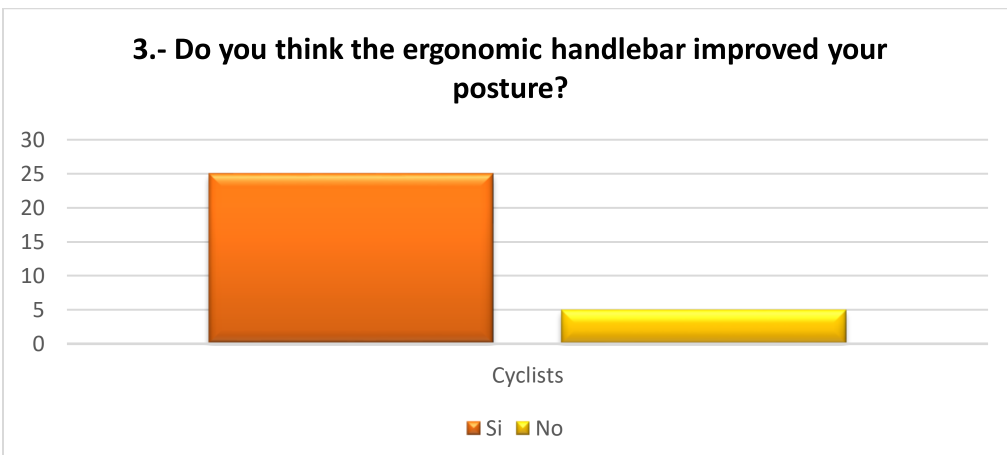



**Fig. 6 Results obtained in question 3**


**Fig. 7 Results obtained in question 4**

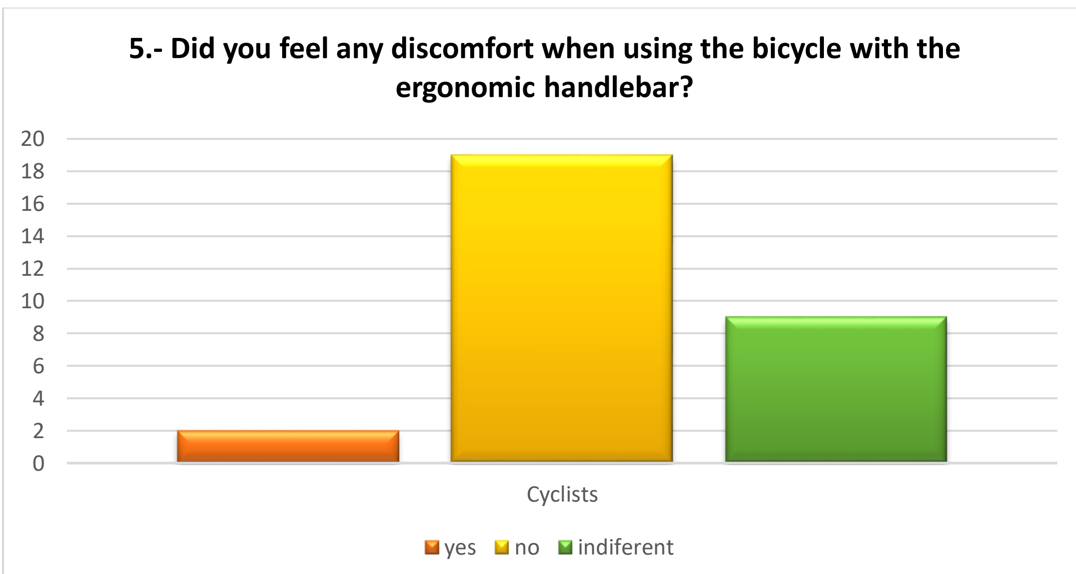



**Fig. 8 Results obtained in question 5**

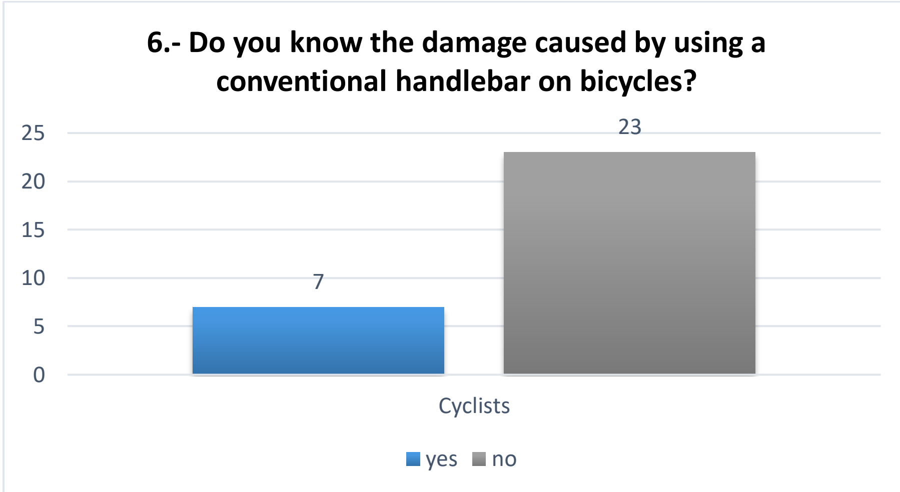



**Fig. 9 Results obtained in question 6**

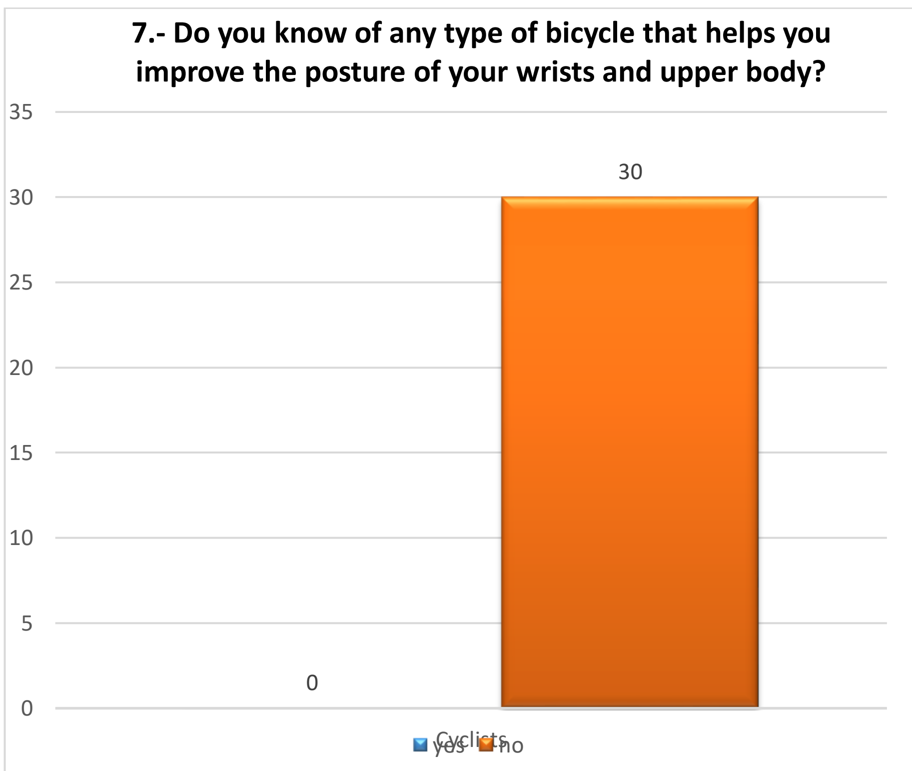



**Figure 10 Results obtained in question 7**

Derived from the information collected through the survey, it is proposed to continue using the ergonomic handlebar for the same benefit, therefore, according to the results of the survey, the need to propose the design of the handlebar to avoid future injuries is inferred.

## 3. RESULTS

30 samples of the measurements of the extremities (length of the arms, length of the forearm, width of the palm of the hand and the diameter of the grip) were taken from different subjects in order to record the results in a table to facilitate handling. From the information, take the average of the measurements of the population and thus standardize the suitable measurements for the redesign of the ergonomic handlebar so that it meets the previously established objectives as satisfactorily as possible.

Figure 11 shows the graph of the data collected from the different measurements in 30 people based on a 95th percentile, which showed us that the average is 72 cm in arm length. This gives us an idea of how to continue making our ergonomic handlebars.

Figure 12 show the graph of the data collected by the 30 people based on a 95th percentile, where it showed us that the average is 26 cm long of the forearm.

As we can see in figure 13, there is an average of 8.5 cm from the palm of the hand, which helps us adjust the measurements in which the ergonomic handlebar support should be given since this will open space to maneuver and adjust the measurements of the tubes of the ergonomic handlebar manufacture

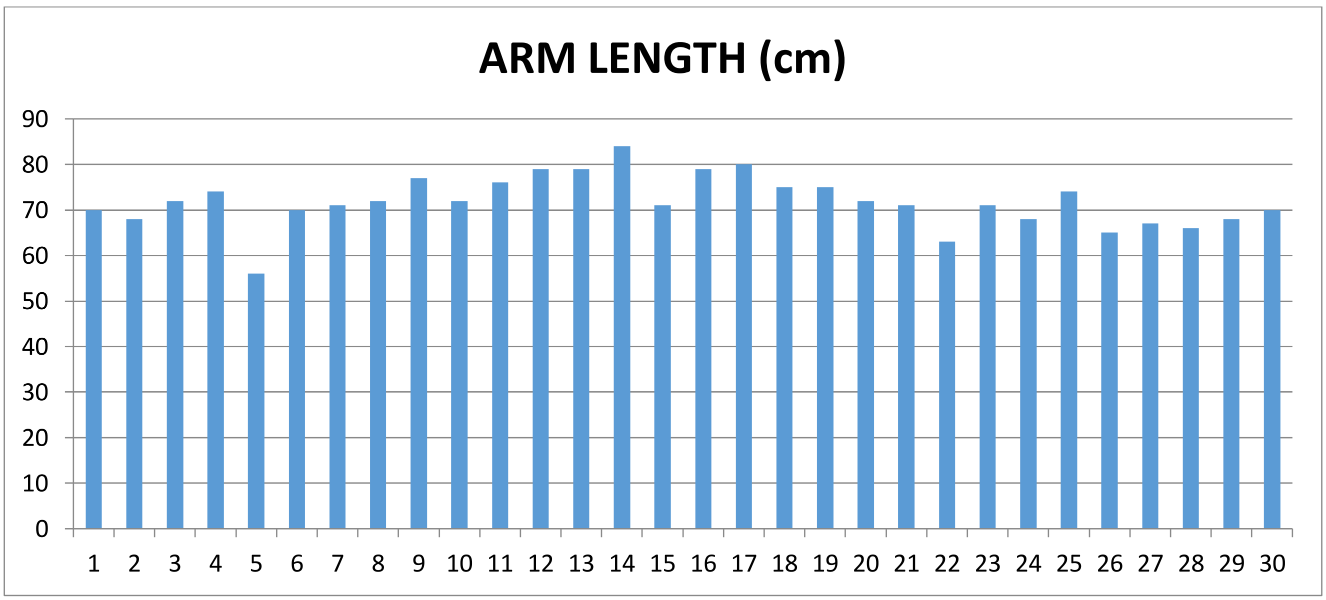



**Fig. 11 Arm length measurements in cm**

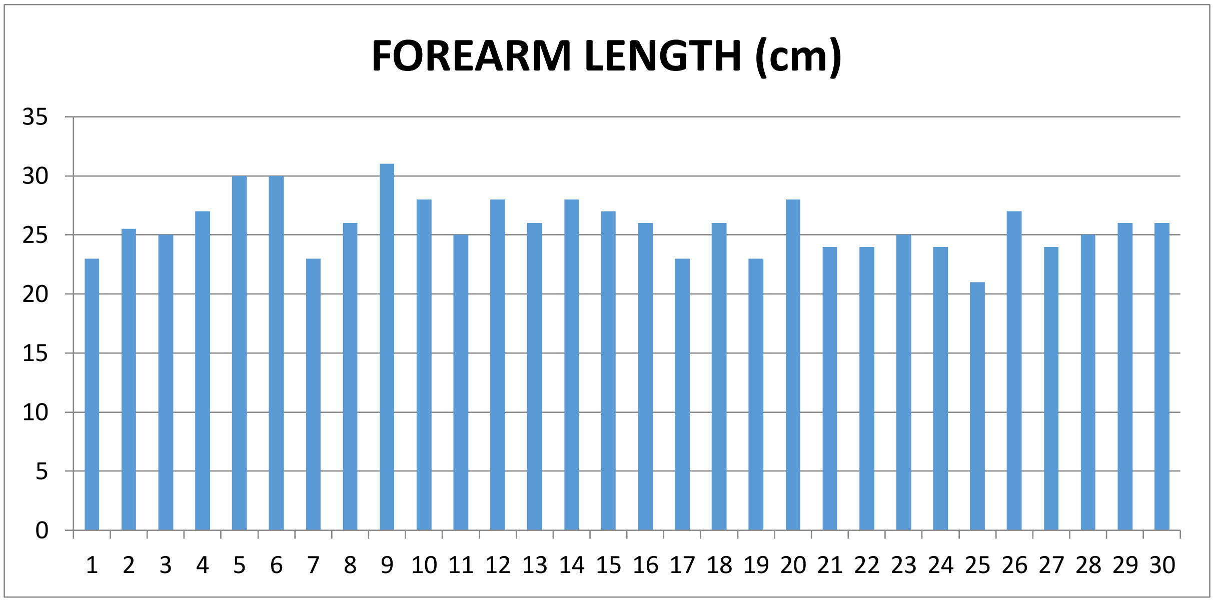



**Fig. 12 Forearm length measurements in cm**

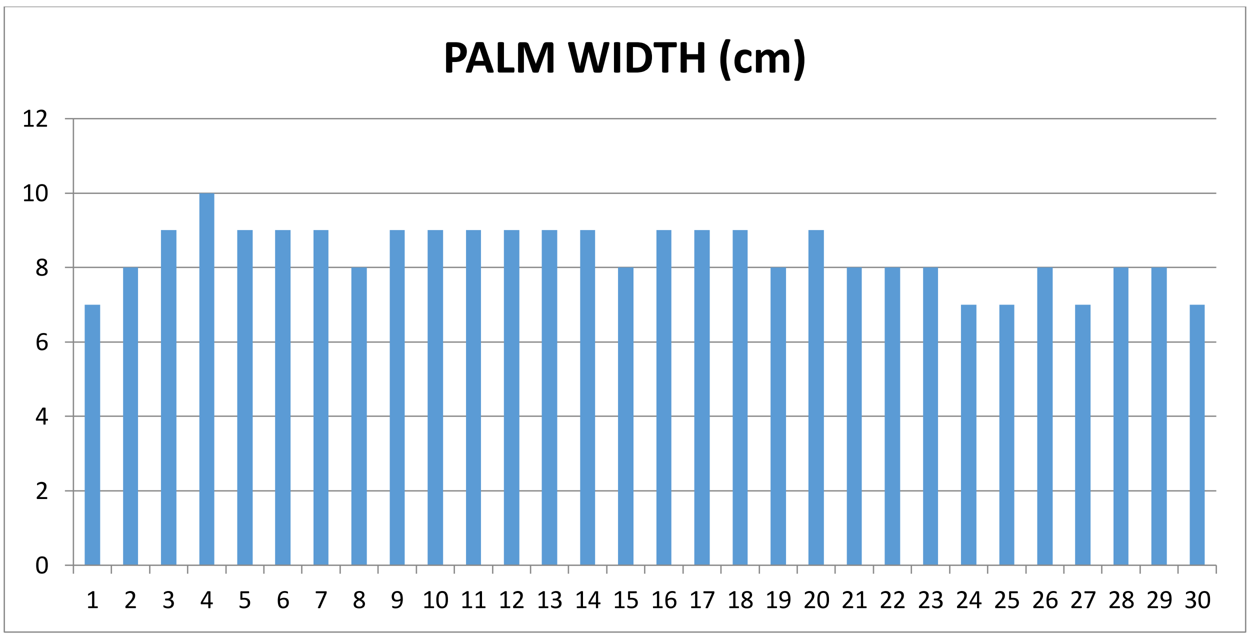



**Fig. 13 Width of the palm of the hand in cm**

.

Figure 14 shows the graph of the data collected from the different diameters in 30 people based on a 5th percentile, where it showed us that the diameter of 5 cm is the most suitable for the grip of the improved chisel prototype.

With the data collected from the distinctive people we proceed to manufacture the ergonomic handlebar with the data obtained and proceed to general use.

The ergonomic handlebar will be manufactured with aluminum tubes and special welding for them, in addition to having rubber grips to have precisely a better grip and greater flexibility.

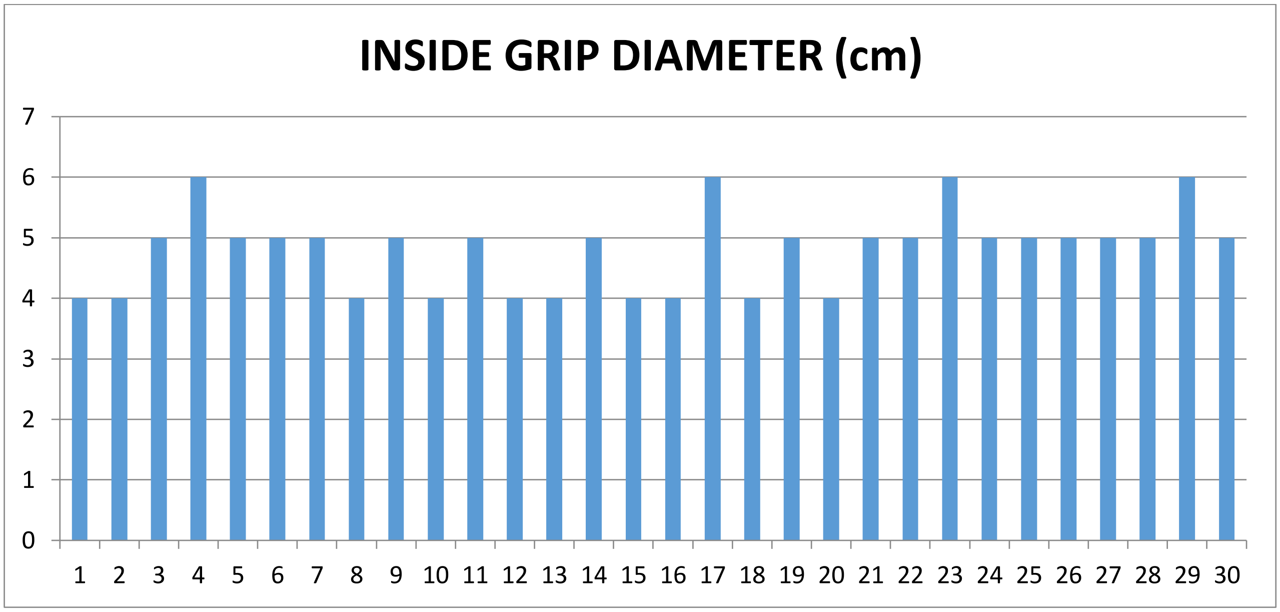



**Fig. 14 Grip diameter in cm**

As figure 15 shows the diameter of the tube that will be used according to the anthropometric measurements of the length of the fingers of the hands, the handles of the handlebars must be covered with a layer of rubber so that the fingers of the hand hold them completely, with a firm grip to avoid damage from the vibrations that these can cause when traveling on uneven roads.

**Fig. 15 Ergonomic handle**

As well as the length of the same tube will be according to the standard measurement of the length of the arms. The tube will be fixed and bent with the precise angle to prevent the wrist or elbow from being in bad posture to avoid problems and damage to them that can be caused in the short, medium or long term.

Finally, the ergonomic handlebar is fixed to the bicycle and the necessary tests and adjustments are carried out to verify that it works and meets the specific objectives.

Figures 16 and 17 show the correct way to use the handlebar, holding it in such a way that the wrist is almost 90º according to the arm. Users gave their own comment saying that they feel more comfortable using this type of handlebar, as they mention that the conventional handlebar has its flaws when knowing the risks involved in using the conventional handlebar.


**Fig. 16 Front view**

**Fig. 17 Side view**

## 4. CONCLUSIONS

Every day the use of urban bicycles is increasing massively mainly by economic and / or ecological issues, according to this pattern we can infer that it will become more and more recurrent to use the urban bike as a means of transport, so it is important to seek innovations to it, which motivates us permanently to seek the comfort of the user as well as their safety and integrity. Mexico is a country in which the bicycle is one of the most used means of transport by users, because there are cities in which there is a special lane for these vehicles, as well as programs so that one day a week only bicycles are used to lower the pollution levels of the city as mentioned above. The use of an ergonomic handlebar would too much help the user of the bicycle to use it on a daily basis, because this tool seeks to eliminate inappropriate postures in addition to preventing any type of accident that may occur and above all seeks the comfort of the users to feel comfortable and stop using the vehicle that largely pollutes a lot , as long as we can encourage the use of the bicycle as a good means of transport, it would be something that would eventually be very grateful to the care of the environment. Globally we obtained data from countries such as: China, Japan, Belgium, Switzerland, netherlands, Denmark, Germany, Sweden, Norway and Finland that among the millions of people with which they have 30% of them, use the bicycle as a means of transport to move from one place to another.

## 5. REFERENCES

Franco SA, P. L. (2014). Accidentes de trabajo en muñecas y manos en el estado de Jalisco, México en los años 2010, 2011 y 2012. *Revista Cubana de salud y Trabajo*, 9.

Galvez, J. J. (18 de Abril de 2018). *www.ciclismourbano.org/*. Recuperado el 30 de Enero de 2020, de https://www.ciclismourbano.org/: https://www.ciclismourbano.org/articles/posicion-correcta-sobre-una-bicicleta-urbana.html

Korff T, F. G. (2011). Effect of “Pose” cycling on efficiency and pedaling mechanics. *Eur J Appl Physio*, 111-119.

LINO CARMENATE MILIÁN, F. A. (2014). *Manual de medidas antropometricas "saltra".* Costa Rica: Saltra.

Luciana Almeida, M. V. (2019). POSTURAL COMPARISON BETWEEN A CONVENTIONAL BICYCLE HANDLEBAR AND AN ELLIPTICAL HANDLEBAR. *Sociedad de Brasileira*, 3-7.

Luis, D. V. (2019). Manillar de materiales compuestos. 1-14.

Mariño, A. C. (2018). Programa de seguridad y salud ocupacional para prevenir accidentes laborales en indutrias el cisce-2015. *Consciencia*, 179.

Pino, J. T. (1993). *Herramientas manuales: Condiciones generales de seguridad.* México: Atalanta.

Tonello1, M. G. (2019). *Maria Georgina Marques Tonello1.* España.

Vaz, F. D. (2008). Aspectos relacionados con la fatiga durante el ciclismo: un enfoque biomecánico. *Revista Brasileña de Medicina del Deporte*, 155-163.

Velazquez, A. (30 de Noviembre de 2013). *terra.org*. Recuperado el 04 de Febrero de 2020, de terra.org: http://www.terra.org/categorias/articulos/la-bicicleta-urbana-componentes-y-mantenimiento

Villalobos, J. (2015). Propuesta de un programa de prevención de accidentes por riesgos mecánicos durante las tareas de edificacion de la contructora navarro y avilés. *inventio*, 196.

# ERGONOMIC ANALYSIS AND REDESIGN OF PROTECTIVE COVER IN PNEUMATIC PRESSES"

**José Eduardo Segura Sánchez, José Alonso Urías Celaya, Anel Torres López**

Department of Industrial Engineering
Institute Technological of Tijuana
Technological Causeway S/N, C.P, 22379
Tel. 6 078400, 6 078414
Tijuana Baja California.

jose.segura19@tectijuana.edu.mx, alonso.urias@tectijuana.edu.mx
anel.torres@tectijuana.edu.mx

**Resumen:** El presente proyecto fue realizado debido a la necesidad de buscar una solución al problema de seguridad que se venía presentando en las estaciones de prensado de filtro y que representaba un gran riesgo para los operadores de las prensas.

Durante el primer semestre de 2019 se presentaron 9 accidentes relacionados con machucón de mano y dedos donde el caso más severo origino 11 días de incapacidad al operador involucrado, la problemática de machucones en los brazos, manos y dedos se presenta en las estaciones de prensado, los accidentes suceden debido a que el sistema que mantiene la puerta de la guarda tendía a colapsar, esto debido al diseño poco confiable, así como a la falta de mantenimiento y reparaciones poco profesionales. Se hizo un análisis de las operaciones, se elaboró un diagrama bimanual de operaciones y se hizo un estudio de tiempos, arrojando un ciclo de 14 segundos para elaborar una pieza en la estación de prensado, se realizó una evaluación ergonómica de las estaciones de prensado utilizando el método RULA el cual arrojo una calificación de 6 puntos en una escala de 7 lo cual indicaba que la operación estaba dentro de riesgo moderado indicando que era necesario ampliar el estudio y modificar pronto. Una vez comprendido que era necesario modificar la estación se concluyó que una manera de mejorar las condiciones y atacar la problemática que acontecía era trabajar en automatizar el funcionamiento de la guarda de protección de la prensa, con esto se atacaría directamente a la alta repetitividad de movimientos durante la jornada de operación así como también el integrar elementos neumáticos brindaría robustez a la guarda en comparación con el sistema actual que tiende a colapsar y provocar accidentes. La etapa de rediseño comenzó con un listado de los componentes necesarios para el nuevo concepto, se trabajó en una nueva estructura y en cómo se integrarían los componentes dentro de la misma ubicándolos en lugares estratégicos para mantener las dimensiones y todo al alcance del operador.

Con la nueva guarda de protección terminada se comenzó con el proceso de pruebas funcionales, primeramente la prensa fue probada en el taller de ingeniería donde se fabricó, ya aprobada en ingeniería se procedió a llevar la nueva herramienta a producción en donde se llevó a cabo una nueva evaluación ergonómica dentro del contexto real de trabajo, además se hizo un nuevo estudio de tiempos y movimientos con el cual se comprobó que el nuevo diseño cumplió con los objetivos y además trajo consigo un beneficio al tiempo de ciclo de la estación, se redujo de 14 a 11 segundos y también se llevó la calificación ergonómica de RULA de 6 a 3 quedando la estación como de bajo riesgo ergonómico.

**Palabras clave**: Análisis, RULA, rediseño, prensas, semi – automatización.

**Relevancia para la ergonomía:** Se determina que la operación fue de alto riesgo con una puntuación de 6 en la escala RULA por la herramienta designada, así como las posturas derivadas de su manejo.

Desarrolla una herramienta que previene la ocurrencia de accidentes que además integra componentes robustos y ergonómicos en beneficio del operador.

La evaluación de la picadura con el nuevo diseño arroja un puntaje de tres en la escala RULA, lo que resulta en una estación de bajo riesgo.

Se desarrolla un estudio de tiempos y movimientos en la estación que sirve como herramienta para atacar los movimientos con alta repetición que no agregan valor al producto.

El tiempo de operación se reduce de 14 segundos por pieza a 11 segundos.

Se mejoran las posturas de los trabajadores.

La prevención de accidentes conduce a disminuciones en los aumentos de las primas de seguros.

Se estima que la tasa de accidentes derivados por machucón en mano y dedos pasará de nueve a cero por año (no se han producido accidentes relacionados con la nueva cobertura en el trimestre diciembre-febrero) al erradicar los accidentes relacionados con la prensa, las herramientas pasarán del primer al segundo lugar de las principales causas de accidentes para la empresa.

Esta investigación es de gran relevancia darse a conocer ya que, derivado de una problemática bajo este contexto de trabajo en sistemas de producción a base de neumática, siempre se debe analizar la posibilidad de ajustarlos a las necesidades de los operadores (adecuación postural y cognitiva) con la finalidad de incrementar no solo su productividad, si no también su seguridad.

**Abstract:** This project was carried out due to the need to find a solution to the safety problem that had been presented in the filter pressing stations and that represented a great risk for the operators of the presses.

During the first semester of 2019, there were 9 accidents related to hand and finger bruising, where the most severe case caused 11 days of incapacity for the operator involved, the problem of bruises on the arms, hands and fingers occurs in the pressing stations, Accidents happen because the guard door maintenance system tended to collapse due to unreliable design as well as lack of unprofessional maintenance and repairs. An analysis of the operations was made, a bimanual diagram of operations was elaborated and a study of times was made, throwing a cycle of 14 seconds to elaborate a piece in the pressing station, an ergonomic evaluation of the pressing stations was carried out using the RULA method which yielded a score of 6 points on a scale of 7 which indicated that the operation was within moderate risk, indicating that it was necessary to expand the study and modify it soon. Once it was understood that it was necessary to modify the station, it was concluded that one way to improve conditions and attack the problem that occurred was to work on automating the operation of the protection guard of the press, with this, the high repetitiveness of movements would be directly attacked During the day of operation, as well as integrating pneumatic elements, it would provide robustness to the guard compared to the current system that tends to collapse and cause accidents.

The redesign stage began with a list of the necessary components for the new concept, we worked on a new structure and how the components would be integrated within it, placing them in strategic places to keep the dimensions and everything within reach of the operator.

With the new protective guard completed, the functional testing process began, firstly the press was tested in the engineering workshop where it was manufactured, once it was approved in engineering, the new tool was taken to production where a new ergonomic evaluation within the real work context, in addition a new study of times and movements was made with which it was verified that the new design met the objectives and also brought a benefit to the cycle time of the station, it was reduced by 14 to 11 seconds and also took the RULA ergonomic rating from 6 to 3, leaving the station as low ergonomic risk.

**Keywords**: Analysis, RULA, redesign, presses, semi-automation.

**Contribution to ergonomics:** It is determined that the operation was high risk with a score of 6 on the RULA scale due to the designate tool, as well as the postures derived from its handling.

It develops a tool that prevents the occurrence of accidents that also integrates robust and ergonomic components for the benefit of the operator.

The evaluation of the sting with the new design yields a score of three on the RULA scale, which results in a low-risk station.

A study of times and movements is developed in the station the serves as a tool to attack the movements with high repetition that do not add value to the product.

Operation time is reduced from 14 seconds per part to 11 seconds.

Worker postures are improved.

Accident prevention leads to decreases in insurance premium increases.

It is estimated that the rate of accidents derived by Machaon in hand and fingers will go from nine to zero per year. (no accidents related to the new cover have occurred in the Dec-Feb quarter)

When eradicating press-related accidents, the tools will go from first to 2rd place of the main causes of accidents for the company.

This research is of great relevance to be known since, derived from a problem under this context of work in pneumatic-based production systems, the possibility of adjusting them to the needs of the operators must always be analyzed (postural and cognitive adequacy) In order to increase not only your productivity, but also your safety.

## 1. INTRODUCTION

Occupational Health is a multidisciplinary activity aimed at promoting and protecting workers' health through the prevention and control of diseases, accidents, the elimination of factors and conditions that endanger health and safety at work. In addition, it seeks to generate and promote safe and healthy work, as well as good environments and work organizations by enhancing the physical, mental and social well-being of workers to support the maintenance of their work capacity. While seeking to enable workers to lead socially and economically productive lives by effectively contributing to sustainable development, occupational health enables their human and professional enrichment at work.

The term ergonomics comes from the Greek words ergon (work) and nomos (law or norm); the first reference to ergonomics is collected in the book of the Polish Wojciech Jastrzebowki (1857) entitled Compendium of Ergonomics or the Science of Work based on truths taken from nature, which according to Pacaud's translation (1974) reads: "To begin a scientific study of the work and develop a conception of the science of work as a discipline, we should not make it subject at all to other scientific disciplines,... so that this work science, which we understand in the not unilateral sense of physical work, of work, but of total work, simultaneously resorting to our physical, aesthetic, rational and moral faculties...". However, the modern use of the term is due to Murrell and has been officially adopted during the creation, in July 1949, of the first ergonomic society, the Ergonomics Research Society, founded by British engineers, physiologists and psychologists in order to "adapt the work to man".

The analysis of the needs and possibilities of man, by engineers, physiologists, psychologists, etc... It could not be based solely on "I put myself in place": a series of techniques had to be generated that would allow this "put in place" to be operated.

Technical competence and technological advancement, indispensable for the design of new machines, tools or equipment, was not sufficient and necessary to ensure the proper functioning of these machines. "Other" knowledge was needed, or perhaps another way of raising the problem that would allow, as far as possible, to anticipate the behavior of people in the P-M relationship situation, in order to reduce their risk of error, and to increase the degree of human reliability: modern ergonomics were born. (Pedro R. Mondelo, 1999)

This project seeks to improve the occupational health of the worker by concentrating on occupational ergonomics, which will impact the reduction of accidents and occupational diseases. The above will help prevent audits by IMSS that influence the classification of the main activity of the company and this will lead to increases in the work risk insurance premium.

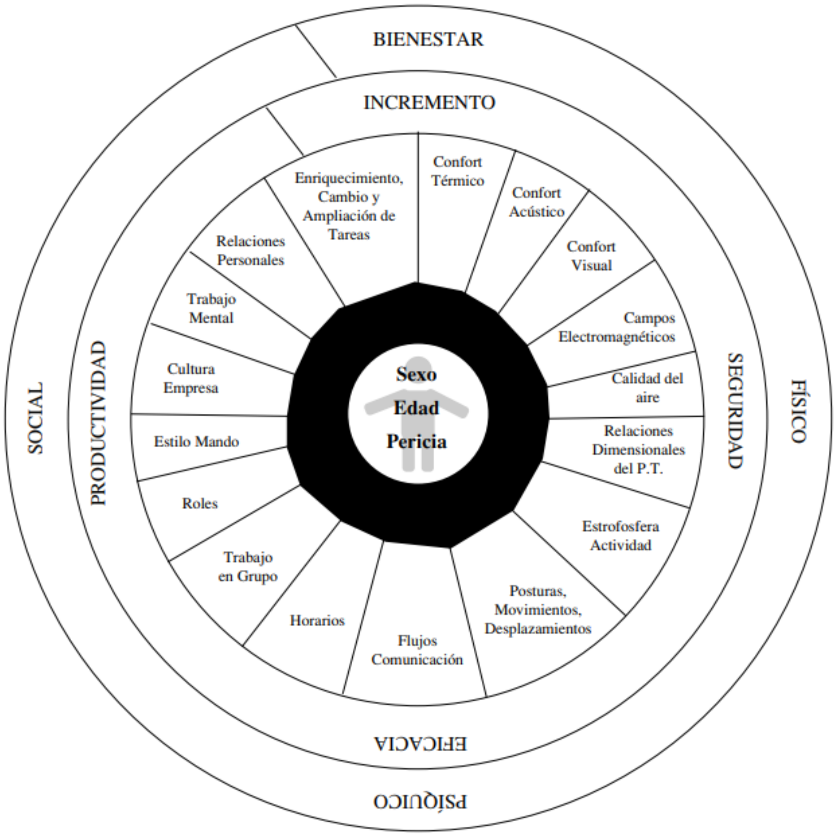
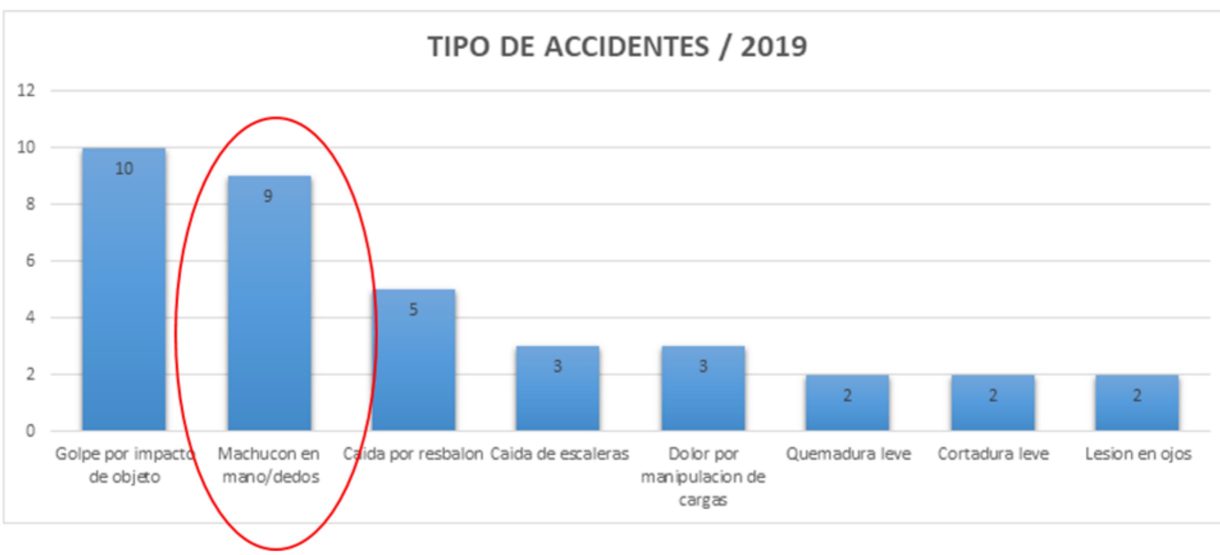



Figure 1. Minimum variables to consider in the design of an activity position for different users.
Source.(Pedro R. Mondelo, 1999)




***¡Error! Marcador no definido.***. Types of accidents 2019
Source. Biotix, 2019.

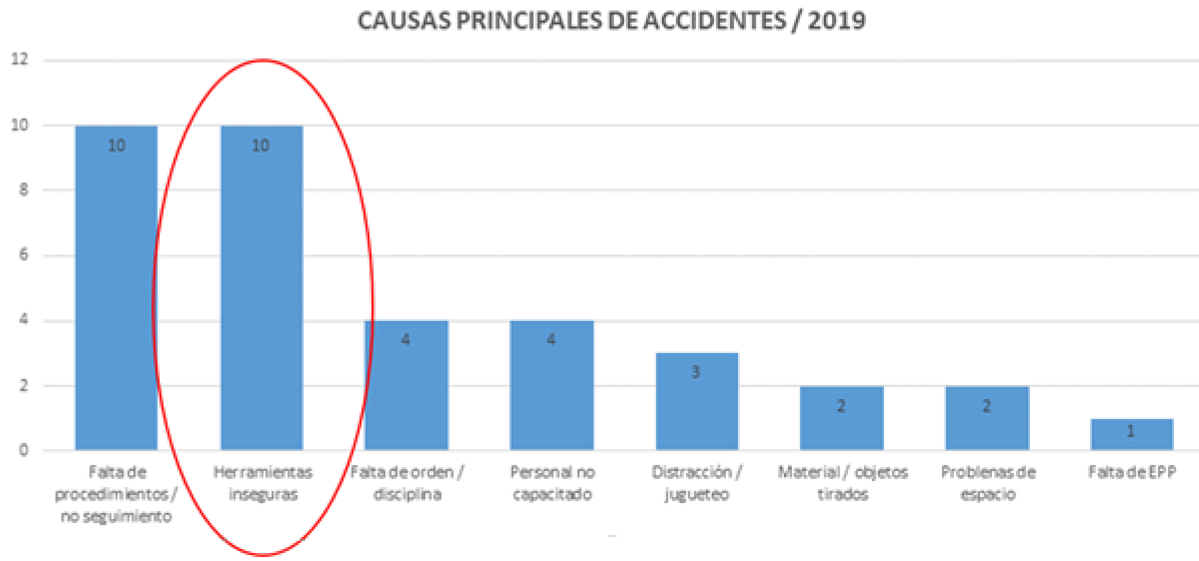



Figure 3 . Leading Causes of Accidents 2019
Source. Biotix, 2019.

It describes the generalities of the project, i.e. the contextual framework, objectives, problems to be solved, as well as the justification and delimitations of the problem.

The RULA ergonomic analysis method is developed as a support tool to diagnose the process areas subject to review, as well as some of the 12 principles of occupational ergonomics and some basics of electronics and pneumatics.
The results obtained after the improvement are presented.

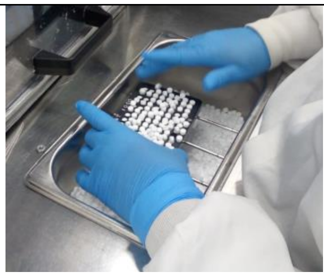
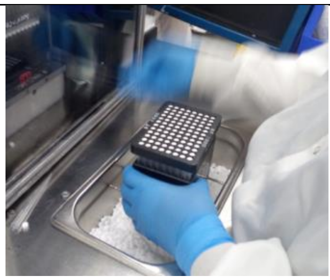
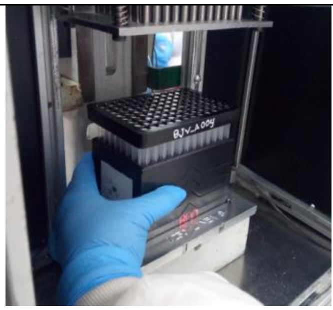
**Overall goal:** Design and manufacture air press protection cover by implementing RULA and principles of occupational ergonomics.

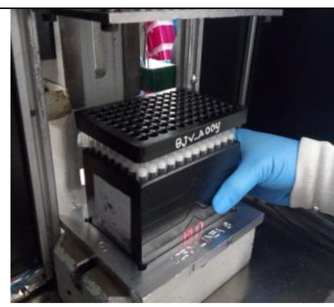
**Specific goals:** Evaluate the operation using RULA and determine the level of risk

- Develop an analysis at the pressing workstation
- Create a press protection cover based on operational and postural safe pneumatics.
- Decrease the accident rate by hand crush and fingers from nine to zero per year.
- Prevent penalties and increases in the insurance premium.

## 2. METHODOLOGY

The first step in initiating the entrepreneurship of improvements in the press protection cover was to perform an analysis of the pressing method; the current method established in the current working instruction was revised.

| Operation | Method | Photo | Risks |
|---|---|---|---|
| #1 | Fill low board with filters |  | Missing Filter |
| #2 | Taking a rack with pipettes |  | Missing Pipette |
| #3 | Place low board with pipette rack filters |  | Pipette missing filter |
| #4 | Insert pipette rack and filters into the press nest |  | |

| | | | |
|---|---|---|---|
| #5 | Lower press door |  | |
| #6 | Waiting for pressing cycle |  | |
| #7 | Remove rack with filter already pressed |  | |

Once each of the activities described in the pressing method was well identified, a study of activities and movements was carried out based on the annual bim diagram format, this diagram will help identify the activities that add value to the product, locate repetitive tasks and identify inefficient movements.

The cycle time are the pressing station will yield a total of 14 seconds, which according to the standard is 70 racks/hr. Do a clearance of 1 second per rack.
Analyzing the current situation of press covers with respect to the type of recurrent accidents it is observed that they occur due to the unreliable design, as well as the lack of maintenance and unprofessional repairs that were carried out during your period in service.

The pneumatic press is activated when the door is slide down, the door includes a sensor which sends a signal when the door is down and activates the press, this system does not provide full protection since the door is lowered quickly and immediately opens, so the press continues with the cycle, which leaves the operator in total vulnerability and is exposed to the crushing of its limbs.

The current system (magnets) keeps the door in a resting position, which has been the main cause of minor accidents at pressing stations. The current guard has an emergency stop button, which has been placed do on top of it and was strategically placed to reduce the risk of disruption.

**Diagrama Bimanual**

| | |
|---|---|
| Diagrama Num. Hoja Num. de | **Resumen** |
| Dibujo y Pieza: | DIAGRAMA BIMANUAL DE OPERACION DE PRENSADO DE FILTRO EN PIPETA 1000 XTIP |
| Operación: PRENSADO | |
| Lugar: 4-B | |
| Metodo : Actual / Propuesto | |
| Operario (s) : Ficha Num. | |
| Compuesto por: Fecha: | |
| Aprobado por: Fecha: | |

| | Tiempo | Simbolo | | | | Simbolo | | | | Tiempo | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Descripcion Mano Izquierda** | **segundos** | ○ | ⇨ | D | ▽ | ○ | ⇨ | D | ▽ | **segundos** | **Descripcion Mano Derecha** |
| LLENA BAJADOR DE FILTROS | | X | | | | X | | | | | LLENA BAJADOR DE FILTROS |
| TOMA RACKA DEL CONVEYOR | 2 | | X | | | | | X | | 2 | SUJETA BAJADOR |
| SOSTIENE RACKA CON PIPETA | 2 | | | X | | X | | | | 2 | COLOCA BAJADOR EN LA RACKA |
| INSERTA RACKA EN EL NIDO DE PRENSA | 3 | | X | | | | X | | | 3 | INSERTA RACKA EN EL NIDO DE PRENSA |
| REPOSO | 2 | | | X | | X | | | | 2 | BAJA LA PUERTA DE LA PRENSA |
| REPOSO | 2 | | | X | | X | | | | 2 | ABRE LA PRENSA |
| SACA LA RACKA DEL NIDO DE LA PRENSA | 1.5 | | X | | | | X | | | 1.5 | SACA LA RACKA DEL NIDO DE LA PRENSA |
| RETIRAR BAJADOR | 1 | X | | | | | | X | | 1 | SOSTIENE RACKA CON PIPETA Y FILTRO |
| SOSTIENE BAJADOR | 0.5 | | | X | | | X | | | 0.5 | PASA RACKA CON PIPETA Y FILTRO A SIGUIENTE |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| Total Movimientos | | 2 | 3 | 4 | | 4 | 3 | 2 | | | |
| Total tiempo | 14 | 11.85 | 6.5 | 6.5 | | 16.85 | 5 | 3 | | 14 | |

Figure 4. Two-manual diagram of pressing operation with manual activation press. Source. Own elaboration.

.

Figure 5. Pneumatic press with manual protective cover
Source. Own photography.

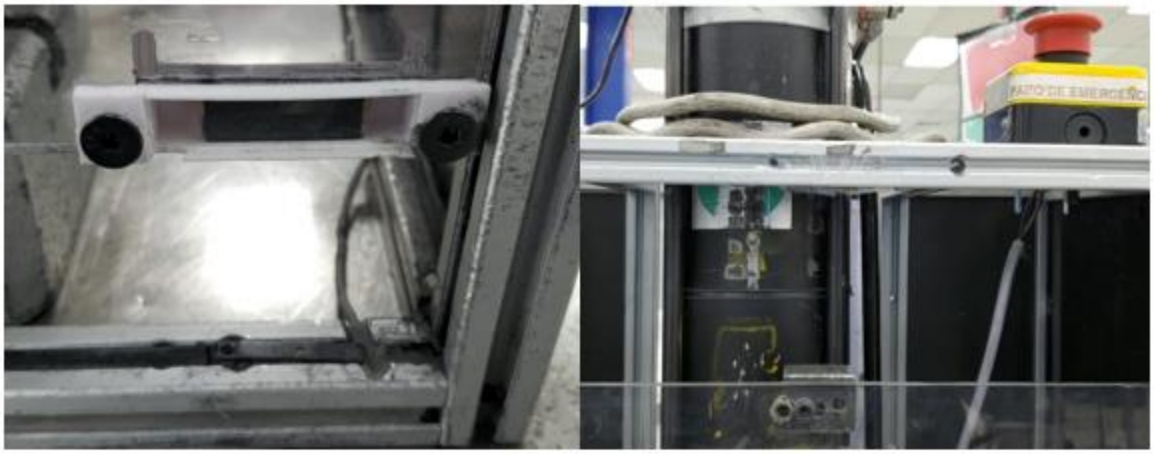


Figure 6. Left activation sensor and right emergency stop button
Source. Own photography.

Figure 7. Magnet in charge of holding the door.
Source. Own photography.

After physical review of the current situation of the protective casings, an ergonomic assessment was carried out using the Rapid Upper Limb Assessment (RULA) assessment method to analyses the current situation of the pressing station conditions.

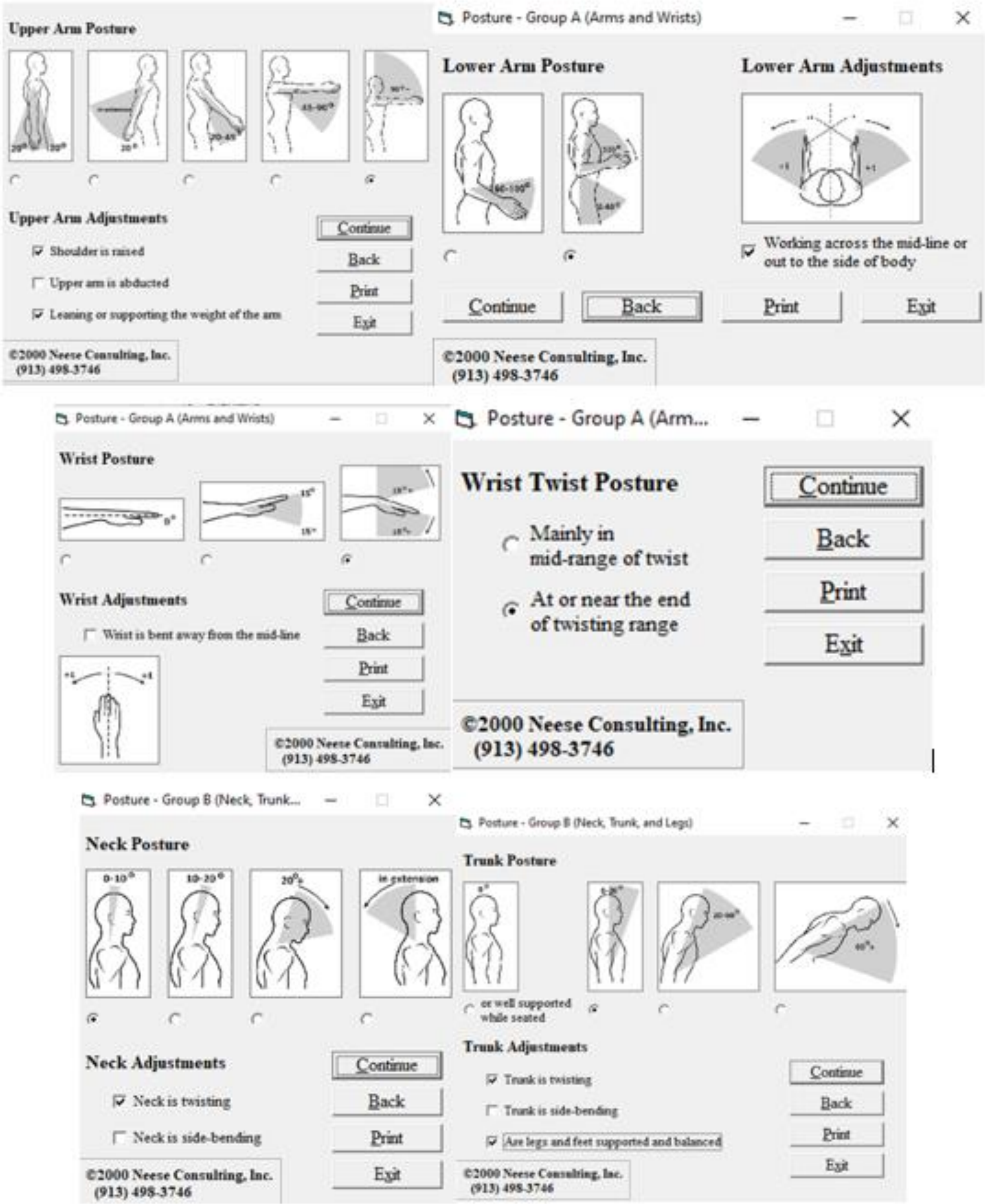



Figure 8. Qualification of pressing station postures with press by manual activation. Source. Own evaluation using software.

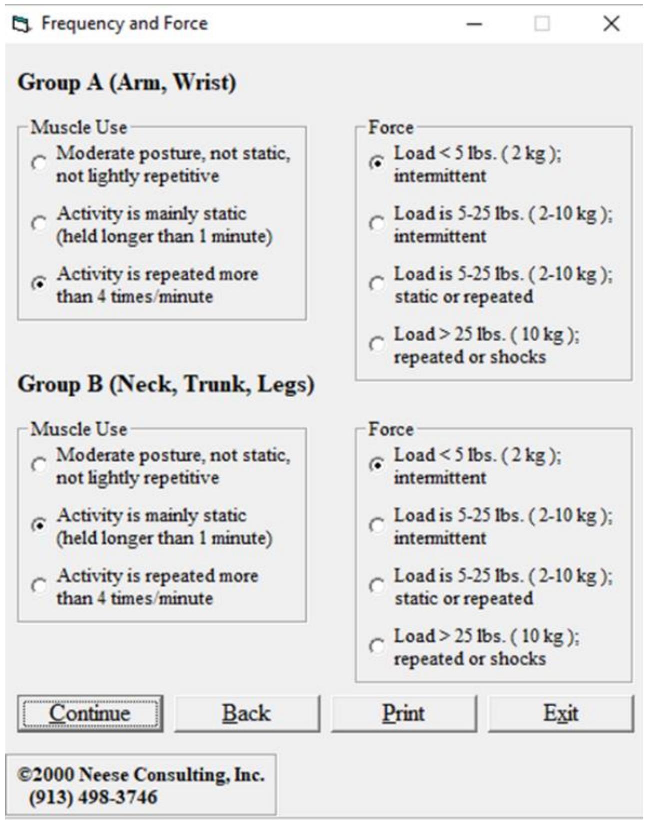



Figure 9. Frequency and strength rating of groups A and B.
Source. Own evaluation-using software.

Because of the RULA evaluation, which focuses on evaluating the two musculoskeletal groups at the upper end, a score of 6 points was obtained, indicating that it is a moderate risk season and that the season needs to be modified soon.

To open and close the cover you have to perform a repetitive movement of abduction of the arm and wrist, this movement represents a high risk of causing sufferings derived from the high repetitiveness of the operation since if the standard is 240 racks /hr. andthemovementmust be made twice to open and close the guard, thus deriving 480 repetitions per hour

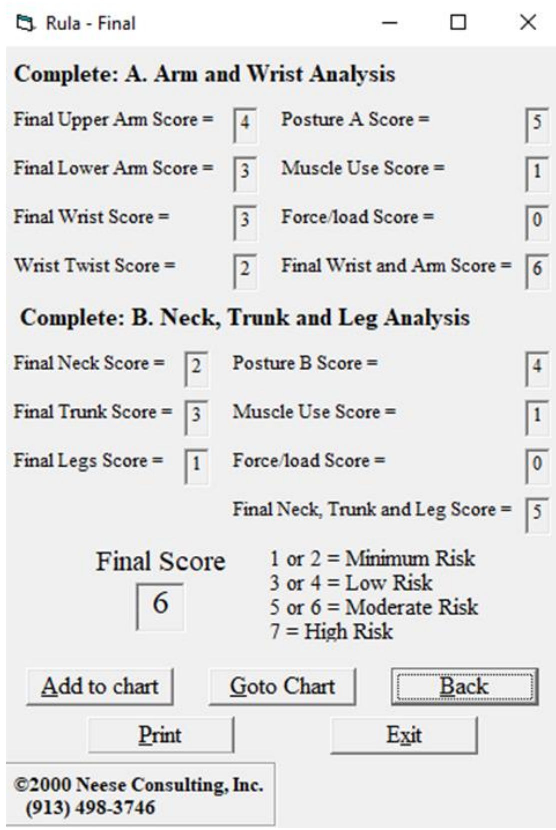



Figure 10. Result obtained from the evaluation.
Source. Own evaluation-using software.

## 3. RESULTS

An analysis of pneumatic press controls was performed concluding that automation was necessary to operate the deck to reduce repetitive movements of the operation and to add a bimanual control to avoid risk of accidents by crushing limbs.

Below is the new design of the protection cover and press resulting from the improvements implemented, to carry out the project it was necessary to integrate electro pneumatic systems as well as ergonomics, completely replaced the method of activation of the press with a semi-automated system activated by a bimanual control which halves the movements necessary to activate/deactivate the press during the operating day as well as offers an inviolable protection barrier Operator.

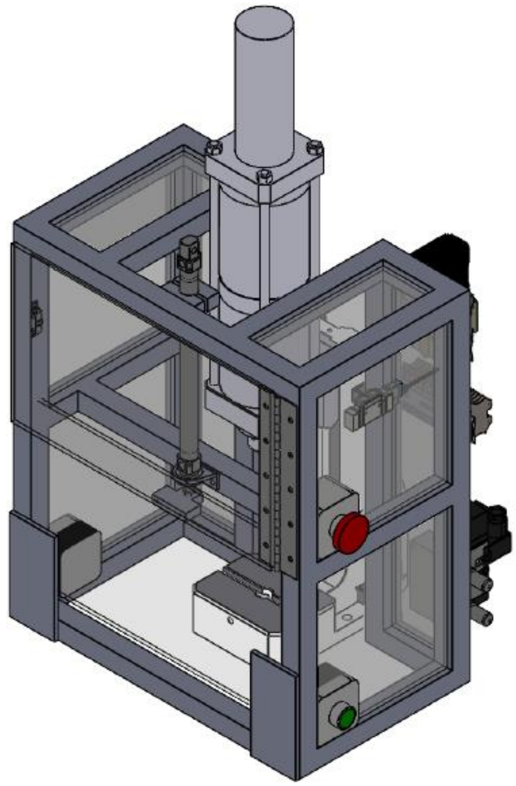


Figure 11. New design of protective cover and press Source. Own elaboration using Solid works.

Some elements were rescued which integrated the previous design such as the logical parts, PLC and the power source.

Work wasted on the 12 principles of occupational ergonomics applying them to the new design, highlighting the following principles:

(1) Keep everything within reach

(4) Find the right position for each job

(5) Reduce excessive repetitions

(9) Provision of spaces and accesses

The following image shows the final prototype of the protective cover integrated into the pneumatic press, a set ready for use in the pressing station.

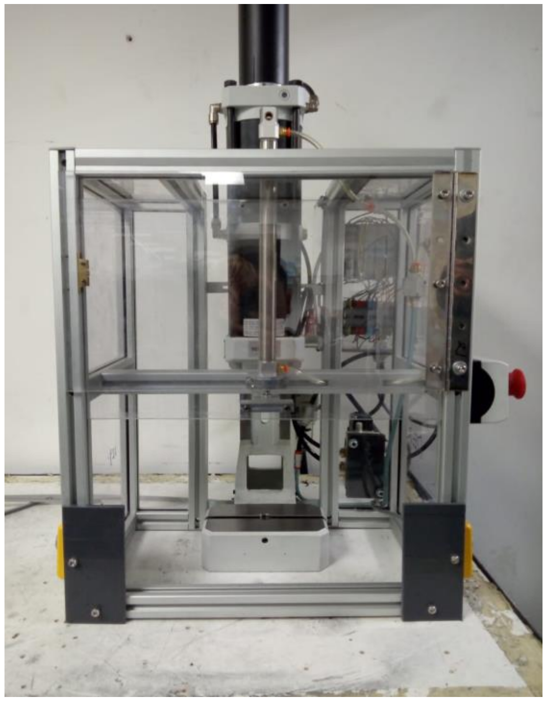


Figure 12. Final prototype new protection cover and press (A)


Figure 12. Final prototype new protection cover and press (B)

**Diagrama Bimanual**

Diagrama Num. | Hoja Num. de

**Resumen**

Dibujo y Pieza:

DIAGRAMA BIMANUAL DE OPERACION DE PRENSADO DE FILTRO EN PIPETA 1000 XTIP

Operación: PRENSADO

Lugar: 4-B

Metodo : Actual / Propuesto

Operario (s) : Ficha Num.

Compuesto por: Fecha:

Aprobado por: Fecha:

| Descripcion Mano Izquierda | Tiempo segundos | Simbolo ○ | ⇨ | D | ▽ | Simbolo ○ | ⇨ | D | ▽ | Tiempo segundos | Descripcion Mano Derecha |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LLENA BAJADOR DE FILTROS | | X | | | | X | | | | | LLENA BAJADOR DE FILTROS |
| TOMA RACKA DEL CONVEYOR | 2 | | X | | | | | X | | 2 | SUJETA BAJADOR |
| SOSTIENE RACKA CON PIPETA | 2 | | | X | | X | | | | 2 | COLOCA BAJADOR EN LA RACKA |
| INSERTA RACKA EN EL NIDO DE PRENSA | 3 | | X | | | | X | | | 3 | INSERTA RACKA EN EL NIDO DE PRENSA |
| PULSA BOTON ENCENDIDO | 1 | X | | | | X | | | | 1 | PULSA BOTON ENCENDIDO |
| SACA LA RACKA DEL NIDO DE LA PRENSA | 1.5 | | X | | | | X | | | 1.5 | SACA LA RACKA DEL NIDO DE LA PRENSA |
| RETIRAR BAJADOR | 1 | | X | | | | | X | | 1 | SOSTIENE RACKA CON PIPETA Y FILTRO |
| SOSTIENE BAJADOR | 0.5 | | | X | | | X | | | 0.5 | PASA RACKA CON PIPETA Y FILTRO A SIGUIENTE |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| Total Movimientos | | | | | | | | | | | |
| Total tiempo | 11 | 2 | 4 | 2 | | 3 | 3 | 2 | | 11 | |
| | | 11.85 | 6.5 | 6.5 | | 16.85 | 5 | 3 | | | |

**¡Error! Marcador no definido.**Two-year diagram of pressing operation with new cover with bimanual activation. Source. Own elaboration.

The improvements applied in the redesign of the cover for the press mainly impacted the skeletal group "A" encompassing arms and wrists, the arms went from having an abducted posture with high rate of repetitive movements to a posture adapted with a 50% reduction in repetitive movements.

Figure 14. New protective cover in pressing station.
Source. Own photography.

The protective cover was redesigned, two-manual drive activation was integrated, and the controls were placed within a quick range. The above replaced the manual movement to open/close the cover.
Once the new semi-automated protection cover with bimanual control was put into use, an analysis was carried out using the RULA ergonomic evaluation method to

evaluate the postures resulting from changes in the press activation and handling method.

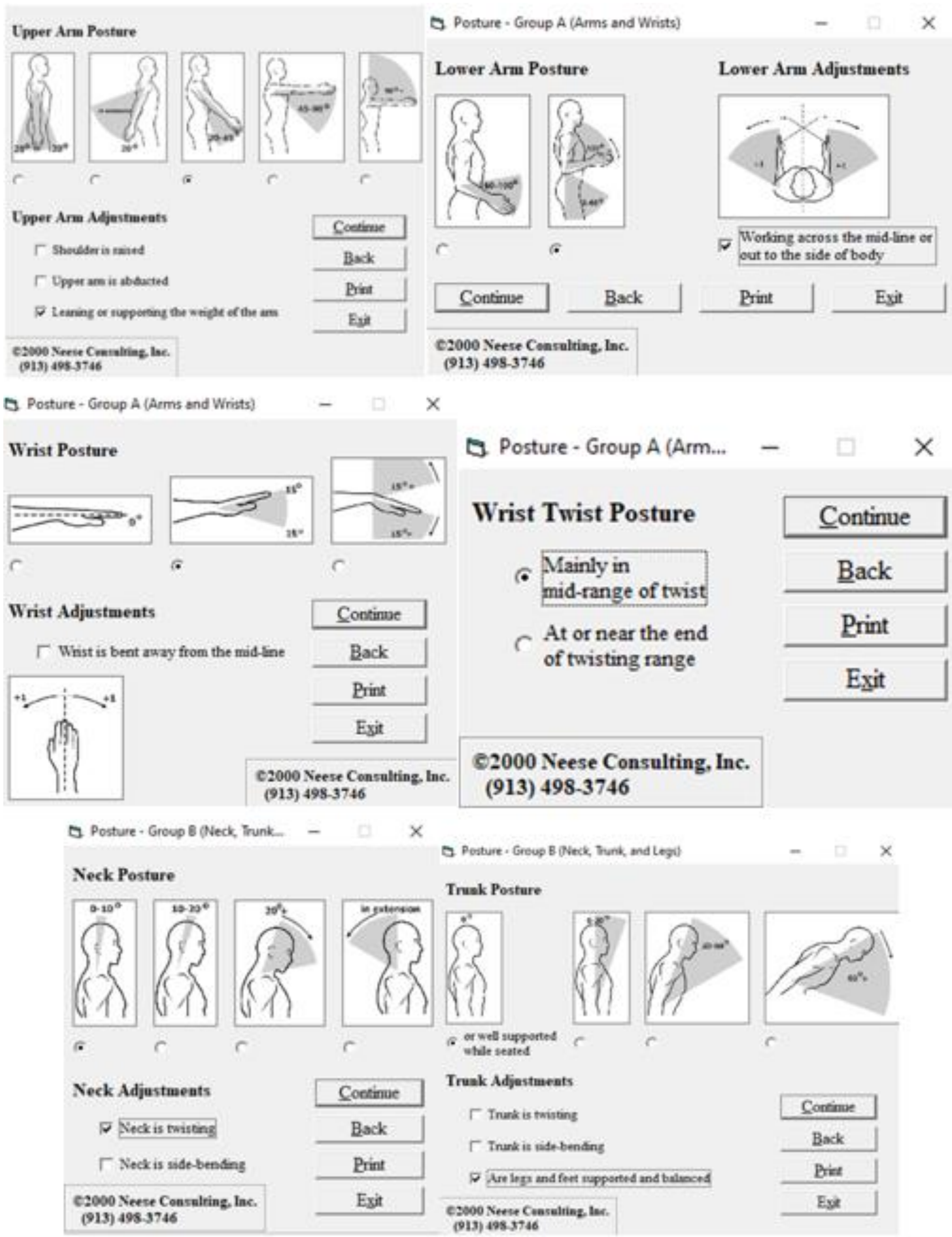



Figure 15. Qualification of postures in pressing station with new semi-automated protection cover with bimanual control.
Source. Own evaluation-using software.

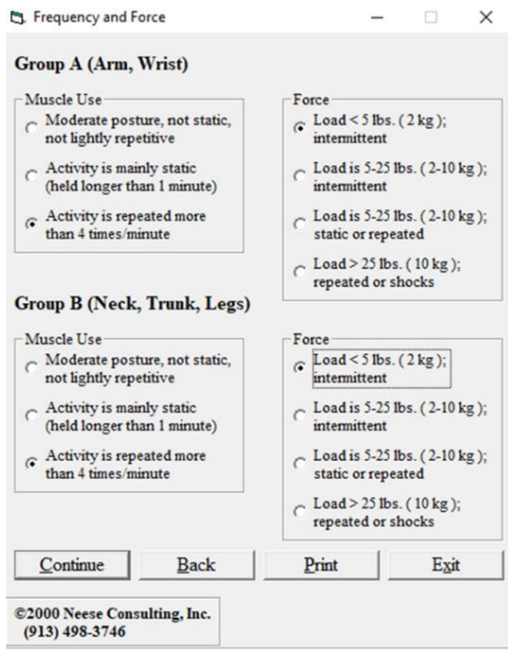



Figure 16. Frequency and strength rating of groups A and B.
Source. Own evaluation-using software.

The station with the new protective cover obtained a score of three after evaluation using the RULA method. The result of the evaluation is favorable compared to the first evaluation as it was achieved to bring the station to low risk only with the redesign of the press safety process.

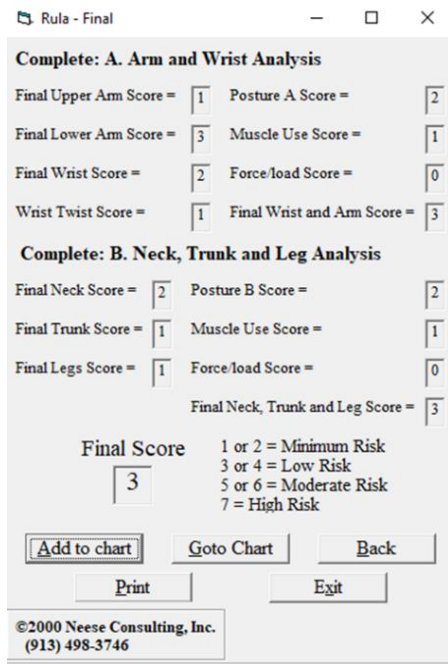



Figure 17. Result obtained from the evaluation.
Source. Own evaluation-using software.

The bimanual control ensures that there will be no risk of crushing because the operator will have both man occupied and also schedules a timer which does not allow the buttons to be released until the door is closed.

After re-mapping, the activities with the new guard it is determined that in addition to bringing a benefactor in the health of the operator helps to reduce the cycle time of the station, reducing the filter pressing operation by about 3 seconds.

## 4. CONCLUSIONS

It should be noted that adequate monitoring and improvement to all the equipment that is counted will obtain great benefits for the occupational health of the operators, reduce the risk of future conditions and improve the quality of life of the operator. This project does not seem to generate a significant economic impact, however, if you delve into what are the fees that companies pay to insurance providers, the project impacts in such a way that by preventing the occurrence of accidents that came toument their recurrence, it prevents the main activity from becoming classified more severely and this generates an increase in the insurance premium of occupational risks.

It is also true that if you delve into the functioning of the press toad protective cover that only provides a physical protection barrier to the operator, this barrier could be removed if a culture of responsibility in safety and hygiene were transmitted to the personal, although they are currently far from achieving a goal of that magnitude,, in the future work could be done on pass on those values to staff in order to bring benefits into their workplace and quality of life.

## 5. REFERENCES


Basham, Ringe and Correa. (March 22, 2018). *BASHAM*. Obtained FROM IMSS: INCREASE OF THE PREMIUM OF WORK RISK INSURANCE:https://www.basham.com.mx/imss-aumento-de-la-prima-del-seguro-de-riesgos-de-trabajo/

Bernal Hernandez, Israel Valente, Alberto Issac Ibarra Garcia, Thalia Fernanda Sobrino Mendez. (2017). *Implementation of a process management software for a business focused on nominating development.* Mexico: National Polytechnic Institute.

Biotix, Inc. (2017). *Biotix.* Retrieved from Biotix: http://biotix.com/

Diego Mas, Jose Antonio, (2015). Obtained from Ergonauts: https://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

Frank Ebel, Siegfried Idler, Georg Prede, Dieter Scholz. (2010). *Neumatica Electroneumatica Fundamentals.* Denkendorf, Germany: Festo Didactic.

Garcia, E. (November 10, 2016). *The Deming Cycle: Process Management and Improvement*. Retrieved from ALTRAN TEAM: https://equipo.altran.es/el-ciclo-de-deming-la-gestion-y-mejora-de-procesos/

Mexican Social Security Institute. (December 20, 2001). *Gob.mx.* Retrieved from CLEM-22: http://www.imss.gob.mx/sites/all/statics/pdf/formatos/CLEM-22.pdf

Mondelo, E. G. Pedro R. (1999). *Ergonomics 1 Basics.* Barcelona: Mutua Universal.

SOCIAL, S.D. (2014). *Federal REGULATIONS on Safety and Health at Work.* Mexico: Official Journal.

Solidarity, D.D. (2012). *Principles of Ergonomia.* San Jose, Costa Rica: NATIONAL INSTITUTE OF SOLIDARY INSURANCE

# ERGONOMIC DESIGN OF A TOILET TO PROVIDE A BETTER POSTURE

**Itzel Pineda Salinas[1], Vanessa Rosas Trujillo[1], Angélica María Clemente Perez[1], Blanca Isis Morales[2]**

[1]Departamento de Ingeniería Industrial
[2]Departamento de Económico Administrativo
Tecnológico Nacional de México/Instituto Tecnológico de Nogales
Av. Instituto Tecnológico no. 911
Colonia Granja
Nogales, Sonora 84065

Corresponding author's e-mail: itzelpinesali@outlook.com, nessa_trujillo@hotmail.com, aclemente28@gmail.com, blancaisis22@gmail.com

**Resumen** Este proyecto tiene como objetivo presentar un diseño ergonómico del inodoro convencional para reducir los riegos de salud que se presentan por la mala postura que se adopta al momento de usar el inodoro actual. Se tomará como principio la postura en cuclillas, ya que varias investigaciones de las que se comentaran en el desarrollo del proyecto fundamentan que es la mejor posición para evacuar completamente y en menor tiempo que la posición de 90 grados.

El diseño del inodoro ergonómico tendrá un descansa pies el cual podrá ser ajustable para que los usuarios puedan colocarlo en el lugar donde sus piernas adopten la posición en cuclillas, así los músculos del abdomen no se presionaran y evitara también algún accidente para aquellos usuarios que se suben al inodoro para adoptar dicha posición. Para este diseño se tomaron medidas antropométricas de la longitud de asiento al piso y de la rodilla al piso (ambas sentadas) para determinar los percentiles 5 y 95 y en base a estos resultados tomar las decisiones pertinentes en el diseño longitudinal que se pretende realizar. Otro método que se utilizó para recabar datos fue realizar 100 encuestas a personas de edades entré 30 y 70 años del Instituto Tecnológico de Nogales. Los resultados de las encuestas arrojaron que el 10% de los encuestados sufren alguna enfermedad intestinal y el 62 % dijo que sí creían que la postura adoptada en el inodoro convencional les afectaba.

**Palabras clave**: Enfermedades gastrointestinales, Postura incorrecta, inodoro convencional.

**Relevancia para la ergonomía**: El diseño de un inodoro enfocado a mejorar la postura al momento de ir al baño es relevante ya que permitirá la evacuación completa de los usuarios reduciendo con ello enfermedades intestinales.

**Abstract:** The objective of this Project is to introduce an ergonomic design of the common toilet, so this way we can reduce the health risks related to incorrect

postures that we adopt at the time we use the toilet. We will take as a principle the squatting posture since several research, that have been reviewed for this project development, state that this is the best posture to correctly evacuate in the shortest time possible, compared to the 90-degree position.
The toilet has a design that includes a device that allows the users to rest their feet, which can be adjusted so each person can put it in a position where they have their legs adopt the squat position, this way the abdomen muscles will not be under pressure, also, it will help to prevent accident when the users climb in the toilet. For this design we took anthropometric measurements from the toilet seat length to the floor, and from the knee to the floor (both seated) in order to determine the 5 and 95 percentiles; then based on the results, we were able to take the percentile decisions in the longitudinal design that we wanted to achieve.

Another method that we used to get data was to perform 100 polls to people between 30 & 70 years old from the Nogales Technological Institute. The poll's results shown that 10% of the people suffer of some kind of intestinal disease, and 62% of them did believe that the posture was affecting them.

**Key words**: Gastrointestinal diseases, incorrect posture, conventional toilet.

**Ergonomic relevance**: The design of a toilet focused to improve the posture when going to evacuate is relevant insomuch will let the complete evacuation from the users reducing with it the intestines diseases.

## 1. INTRODUCTION

Since John Harrington in 1589 (Davies, 2018), designed the first sanitary device that prevented humans from throwing their waste on the street, the toilet has received countless innovations; some have reduced water consumption, others, aesthetics within home and some more have contributed to the protection of the environment; However, none of these innovations have considered the health benefits of a correct ergonomic shape of the classic toilet.

In its original design, Harrington sought to provide a solution not to throw human waste on city streets and this objective was fully achieved; Ignorance of gastrointestinal function and the benefits of proper ergonomic posture were unknown and much less taken into account. "What the inventor was looking for was to be more comfortable during his moments of greatest inspiration," according to (author, year).

### 1.1 Evolution and innovation of the toilet.

1775, Water Closet valve. Alexandre Cummings, patented the toilet with a cistern. (Valery, 2004).

1778, Siphon valve and system. Joseph Bramah, it is still currently used. In 1848, it was pushed to be installed in all built houses. By 1890 it had already spread throughout Europe.

1884, U-pipe. Thomas Crapper, created a water plug to prevent the return of gases and odors produced by waste. This model of toilet has come to be regarded as a great achievement and sign of ´´civilization´´ in the West.

1900 toilets make the leap from the old to the new continent, installing the first units in America.

In recent times, Smart toilets appear, they are capable of performing the most diverse tasks, from automatically lifting the covers, practicing clinical analysis, talking to the user, massaging. (Prignanio, 2007)

1992, musical toilet. Roger Weisskopf, presented at the XXVI Geneva Inventors Fair an artifact that propagated a melody for twenty seconds to ´´receive´´ whoever was going to use it.

2002, toilet equipped with electrodes. Engineers from Matsushita, Japan. The engineers presented a model that emitted discharges on the user´s buttocks, allowing a digital measurement of fat in the body. In addition to this, it had a program to heat or cool the device before someone gets to use it.

2004, The Giant Toto Company, one of the most important sanitary ware factories in Japan, launches the Neorest luxury toilet in the United States. This appliance did not have a water tank and could be electronically programmed by a remote control, other features it had was that it has its own deodorants, a hot air dryer and options to regulate the temperature and pressure of the water. But one of his most appreciated qualities was to digitally massage buttocks!

In the same year, in Holland, Munster Leonard invented a toilet equipped with sensors that detected the visitor´s behavior and, if necessary, made comments about it.

Belgian Tony Cavarely, by his part, designed a mechanism that recycles water from the shower to use it for the toilet. The device, which was named Tank-Cava, filters the soap used during the bath so that the water reaches the toilet tank as clean as possible.

The argentine Mario Toia also made his contribution: in 2004 he invented a disposable pot that is made by molding the cellulose pulp. Each of them requires only 120 grams of newsprint and phone books. Its resistance and permeability could be improved with the addition of a starch, paraffin and pine resin, also adding a metal mesh to which the mixture adheres. This idea could be realized with the support of the Pulp and Paper Research Center and the National Institute of Industrial Technology. It supports the load of a person whose weigh is a hundred kilograms, resists liquids at forty degrees between six and eight hours. The United States patent office has already recognized his invention (Seeger, 2004)

### 1.2 Health disorders from the original design of the toilet.

Although the invention of the toilet was a great idea that came to banish urinals that used to be hidden under the bed by a water evacuation system, it also brought with it health problems that occur in today´s toilets, since the posture of 90 degrees that the body acquires when using them, causes the rectum not to loosen completely, but requires extra efforts to evacuate. For many, this forced posture is the cause of many serious ailments. Western countries have much higher rates of pelvic and colon diseases according to the report in the Israeli Journal of Medical Sciences.

*"The frequency of bowel disease (hemorrhoids, appendicitis, polyps, ulcerative colitis, irritated colon syndrome, diverticulosis, and colon cancer) is similar in white South Africans and in the population of prosperous western countries. Among black rural South Africans with traditional lifestyles, such as diseases are very rare and almost unknown´´ (Walker, AR, Segal I, 1979).*

### 1.2.1 Diseases of the digestive system

#### 1.2.1.1. Crohn disease

According to the National Institute of Diabetes and Digestive and Kidney Diseases (2016), Crohn´s disease is a chronic disease that causes inflammation and irritation in the digestive tract. Crohn´s disease most often affects the small intestine and beginning of the large intestine. However, the disease can affect any part of the digestive tract, from the mouth to the anus.

Crohn´s disease is a type of inflammatory bowel disease (IBD) that includes ulcerative colitis and irritable bowel syndrome; It affects half a million people in the United States (Kappelman, Moore, Allen, Cook, 2013). This inflammatory disease is confined in countries of the western world, according to a study published in the specialized journal The Lancet (1997), which reported an increasing incidence of inflammatory bowel disease developed countries, nut notes the apparent absence of this disease in developing countries.

#### 1.2.1.2 Colon cancer

The colon is a tube, between 1.6 and 1.8 meters long, as shown in Figure 1. (Targen, 1966), which stores waste from the small intestine and moves it to the rectum through rhythmic muscle contractions. In the process, water is continuously extracted to avoid dehydration. If the flow is interrupted for some reason, continuous water withdrawal causes to waste to dry out and stick to the walls of the colon. (NATURESPLATFORM.COM)

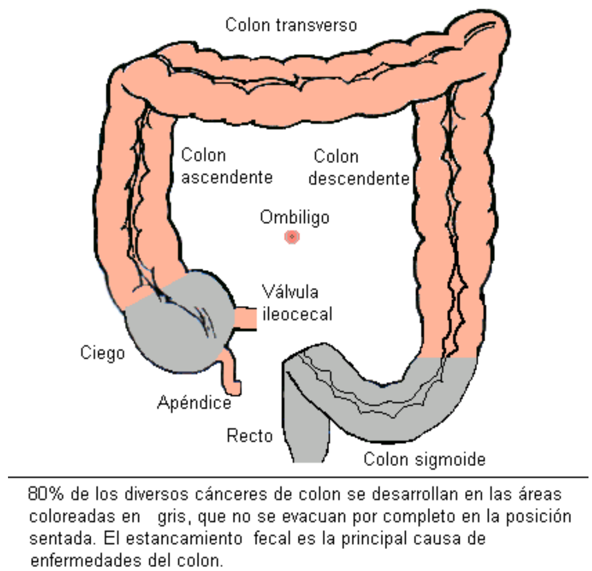



**FIGURE 1. Colon.**
**Reference: (Isbit, 2001)**

In 2001 it was determined that the toilet seat obstructs the flow because it ignores four basic requirements: see FIGURE 1

1. The sigmoid colon (the usual site of colon cancer) requires the support of the left thigh
   raises the sigmoid and opens the fold where it meets the rectum.
2. The cecum (the second most common colon cancer site) needs to be squeezed by the
   right thigh, which pushes the waste up and into the ascending colon.
3. The rectum (the third most common site for colon cancer) requires relaxation of
   constipation of the puborectalis muscle designed to prevent incontinence.
4. The entire colon requires compression, with the ileocecal valve closed securely to
   generate the necessary pressure for expulsion (Isbit, 2001).

For safety, nature deliberately created obstacles to evacuation, which can only be removed by squatting. In any other position, the colon returns to ´´continence mode´´ and this is the reason why the conventional sitting posture deprives the colon of the support of the puborectalis muscle causing an incomplete elimination that together with the constant extraction of water makes the waste stick to the wall of the colon. The passage becomes smaller and the cells begin to suffocate; prolonged exposure to toxins often triggers malignant mutations.

In 1998 in the Epidemiology Journal (Jacob, 1998), he suggests that colon cancer is related to constipation since ´´people who feel constipated were often four times more likely to develop colon cancer than those who did not complain constipation´´

the study also found that frequent use of commercial laxatives was associated with a ´´substantial increased risk of colon cancer´´.

### 1.2.1.3 Constipation

According to the article published in 2006 by the REED (Spanish Journal of Digestive Diseases), (Rey, 2006), chronic constipation is due to a malfunction of the large intestine, rectum or anus. This first is that the large intestine does not contract properly and does not generate the necessary movements to advance to stool to the rectum. The second problem that may exist is that the rectum does not have sensitivity and therefore when the stool arrives it does not detect it and does not generate the feeling of wanting to evacuate, accumulating stool in the rectum. The last problem may be a failure to perform the defecation maneuver. This can occur because the anus contracts rather than relaxes, thereby preventing the passage of stool, or because sufficient contraction of the abdominal muscles is not exerted to generate the force necessary to evacuate the stool.

### 1.2.1.4 Diverticulosis

Diverticulosis is a type of hernia caused by years of pressing. The outer layer of the colon ruptures and allows the inner lining to form bumps or pockets. This hernia can lead to complications such as infection, puncture or tear, blockage, or bleeding. These complications always require treatment (surgery) to prevent them from progressing and causing serious illness. (Sikirov, 1988)

### 1.2.1.5 Hiatal hernia and gastric reflux

Hiatal hernia is the protrusion of an organ, usually the stomach, through the esophageal hiatus from its site in the abdomen to the mediastinum and to the chest (Figure 2). There are three main types: Type I or sliding hernia (axial displacement of the gastric esophagus junction to the thorax), Type II (gastric esophagus junction in normal position with gastric slipping and occasionally spleen, colon or greater omentum, towards the thorax to one side esophagus) and type III the combination of both. Types II and III are known as paraesophageal hernias, usually larger, can be associated.


**Figure 2. Hiatal Hernia**
**Image taken from Victoria Eugenia Cruz Roja Seville Hospital.**
**(Torres, 2016)**

The doctor specialized in the digestive system, Yolanda Torres, from the Victoria Eugenia hospital, in Seville Spain, explains that the hiatus hernia occurs when the esophageal hiatus weakens and enlarges, allowing part of the stomach to enter or herniate through from the hiatus into the thoracic space. This bad position of the stomach favors acid reflux from the stomach to the esophagus, causing various symptoms such as: burning, gastroesophageal reflux, difficulty swallowing, chest pain, bad breath, among others. (Torres, 2016)

## 1.3. Design proposal.

The aforementioned diseases are some of many that occur in the digestive tract, the causes can be various, however, in this section, according to several studies, one of the causes is due to the posture that the body acquires and the time it takes the user to evacuate, as well, there are studies that determine that the best position to completely dispose of stool is squatting.

The study conducted by Dr. Saeed Rad published in 2002, (Saeed, 2002) comparing the effectiveness of sitting versus squatting for evacuation, concluded that using squat toilets, all people reported “complete” evacuation relaxation Puborectails occurred easily, and straightening of the rectum and anal canal became clear with no bends in the terminal rectum, in addition, the angle opened at an average of the 132 degrees. Instead, in the sitting position, a significant fold was created in the terminal rectum, this fold was 92 degrees, forcing him to exert pressure and all patients reported that the evacuation felt “incomplete”. Dr. Rad concluded that the use of the squat toilet ´´is the most comfortable and efficient method for a bowel movement than the conventional toilet. (Saeed, 2002).

Another interesting investigation was carried out by F.A. Hornibrook (1933), in this study doctors recognized the connection between seat toilets and constipation. The statement he came up with was the following:

"The design of western touilets disobeys the laws of nature by encouraging the person to press without the natural support given to the abdominal walls by the thighs when in the squatting position. This pose weakens the muscles and the ileocecal valve swells. This valve is vital for proper intestinal plumbing, and its dysfunction is the cause of many diseases such as the aforementioned of modern civilization." (Hornibrook, 1933).

Jacobs E.J. White E, 1990 demonstrated that squatting prevents constipation in four ways:

1. Gravity does most of the work. The weight of the torso presses against the thighs and
naturally compresses the colon.
2. The ileocecal valve, between the colon and the small intestine, is adequately sealed,
allowing the colon to be fully pressurized.
3. Squatting relaxes the puborectails muscle that normally closes the rectum to maintain
continence.
4. Squatting raises the sigmoid colon (see figure 1), to undo the ¨fold¨ at the entrance to
the rectum. (Jacobs E J, White E, 1998).

In other words, the author establishes that the colon is made up of an inlet valve (ileocecal valve, figure 1) and an outlet valve (the puborectalis muscle). Squatting simultaneously closes the inlet valve to keep the small intestine clean and opens the outlet valve to allow free passage of waste. Sitting posture defeats the purpose of both valves; makes removal difficult and incomplete soils the small intestine.

Anist Seth, gastroenterologist, led a study conducted by Stanford University in 2016, which aimed to determine the correct way to defecate. The test consisted of three types of positions, namely: Position 1, high and straight; Position 2, tilt at a 60-degree angle and Position 3, squat at a 35-degree tilt. Being able to obtain as a result that defecating in position 3 that is, squatting it takes less than a minute to complete the action, due to the ease that this position implies for the body.

## 2. OBJECTIVE

Reduce the health risks of poor posture by ergonomically redesigning the toilet.

## 3. METHODOLOGY

As the toilet is a piece of furniture that is used by people of all ages, with different characteristics (children, adults, older adults and with different capacities) it is necessary to take in count the dimensions and biomechanics of people.

To collect data, it was necessary to design and apply a survey to 100 people between ages of 30-70 within the Instituto Tecnológico de Nogales, this sample was inferred since there are the ages according to the aforementioned studies where the most intestinal problems occur. In addition, from the taken anthropometric measurements that indicate the percentiles and based on them make the pertinent decisions in the longitudinal design that is intended to be carried out.

These measurements were: distance from the seat to the floor (Figure 3): in this measurement the percentile that was taken is the 5 percentile, since based on this result it will be the maximum height that will be given to the toilet.

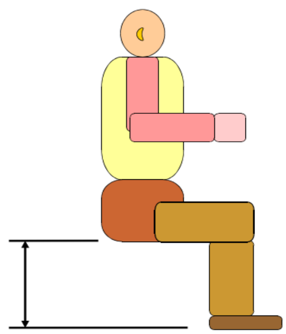


**Figure 3. Distance from the seat to the floor.**

To determine the design of the footrest, the anthropometric measurement of the knee to the ground will be taken as shown in Figure 4, for this measurement the results of the 95 and 5 percentile will be needed since this is intended to be adjustable.

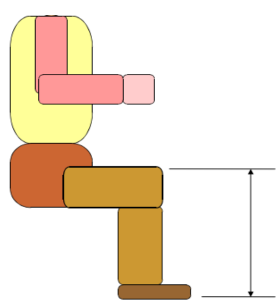


**Figure 4. Distance from the knee to the floor.**

To realize the design, it was also necessary to take in count the biomechanics of the people, mainly the most vulnerable, such as adults, older adults and people with different abilities. That is why, with the anthropometric measurements, a survey was taken consisting of 7 questions with which it is intended to know the time it takes to evacuate and if they have suffered from any disease in their digestive system, since there are risk factors in people´s health and with the incorrect posture make, this make the body overwork forcing to put more pressure on the digestive system and causing various health problems that were previously discussed.

Other questions that were applied were in order to know if people have knowledge about the squat position and if they have already done this position before when evacuating; this will provide us information to define how much users know about the correct positions and if they are willing to change their habits.

## 4. RESULTS

The anthropometric measurements that were taken in this study resulted in the following percentiles, according to Figures 3 and 4 respectively.

| | |
|---|---|
| 95= 58 | 5= 42.5 |
| 95= 45.3 | 5= 35.4 |

The results of the surveys showed that 10% of surveyed people suffer from some intestinal disease, as shown in Figure 5. In addition, another questions showed that 19% of users suffer from constipation and 33% sometimes they do.

Another question that was asked was that if they had heard of the squatting position and 72% answered ¨yes¨. The fifth question that was asked was if they believed that the adopted position in the conventional toilet affected them and 62% answered ¨yes¨ and 38% did not.


**Figure 5.**

The sixth question was to determine if the surveyed people used a bench to elevate their legs when evacuating, and 6% answered yes, 85% did not and 9% sometimes. By last, they were also asked if they believed that squatting would help them to have a quick and safe evacuation and 47% answered yes and 39% maybe. Figure 6

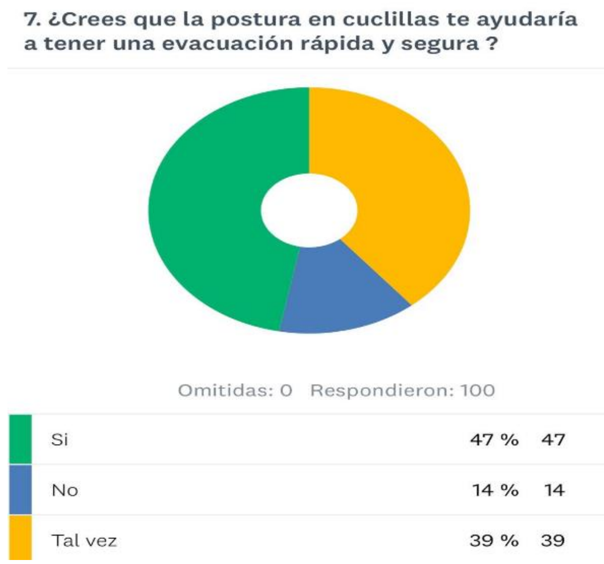



**Figure 6.**

Figure 7 shows the proposed design of the ergonomic toilet. One of the advantages that it has unlike the conventional toilet and some designs that have already been made to figure out the squatting position, is that it has a footrest that also is adjustable to user´s height after evacuating, it can be stored inside the base so that it cannot disturb or occupy a space like a bench or a ladder would.


**Figura 7. Toilet Comfort Ergonomic Design.**

## 5. DISCUSSION AND CONCLUSIONS

Based on the answers given in the survey, it was concluded that the most people are aware of squatting, this is a great advantage for this project since it could have a favorable acceptance in society. Other answers that although with low percentages, it was shown that some people are already beginning to implement awareness campaigns to use this type of toilet, since it does not exist in Mexico, and that they are used in the first instance in health sector, and strategies will be established to lower the information to the general population.

This design is intended to incorporate the squatting position to conventional toilets without sacrificing user´s comfort, offering an ergonomic product to avoid possible intestinal diseases, reducing the time it takes for a person suffering from constipation or difficulty defecating, and helping to people who already suffer from a disease that were mentioned above.

## 5. REFERENCES

Davies, M. (2018). (The Hidden World of Toilets: Volume. Huntington, California: Techer Created Materials.

Hornibrook, F.A., The Culture of the Abdomen, (Garden City, N.Y.: Doubleday, Doran & Co., Inc., 1933), pp. 75-78

Jacobs E J, White E., Constipation, laxative use, and colon cancer among middle-aged adults. Epidemiology, 1998 Jul, 9 (4): 385-91.

Kappelman MD, Moore KR, Allen JK, Cook SF. Recent trends in the prevalence of Crohn’s disease and ulcerative colitis in a commercially insured U.S. population. *Digestive Diseases and Sciences.* 2013; 58:519–525.

Isbit, J. (2001). Beneficios para la salud de la posición natural en cuclillas. 04 de Febrero 2020, de Nature Platform Sitio web: http://www.naturesplatform.com/health_benefits_sp.html#colon_diagram

Montgomery Scott M, Pounder Roy E, Wakefield Andrew J, Infant mortality and the incidence of inflammatory bowel disease, The Lancet Volume 349, Number 9050 DATUM: 1997-02-15.

Prignanio, J.A. (2007). El inodoro y sus conexiones: la indiscreta historia del lugar de necesidad. Buenos Aires, Argentina: Biblos.

Rey, E. (2006). Estreñimiento. Revista Española de Enfermedades Digestivas, 98(4), 308. Recuperado en 17 de marzo de 2020, de http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1130-01082006000400010&lng=es&tlng=es

Seeger, M. (2004). Página 12: Una muestra de inventos en busca de mejorar la vida en la ciudad. 2020, de La unidiversidad Sitio web:http://www.unidiversidad.com.ar/pagina-12-una-muestra-de-inventos-en-busca-de-mejorar-la-vida-en-la ciudad?utm_campaign=Prensa&utm_term=56

Saeed,Rad. (2002) "Impact of Ethnic Habits on Defecographic Measurements", Archives of Iranian Medicine, Vol 5, No. 2, April 2002, p.115-117.

Sikirov BA, Etiology and pathogenesis of diverticulosis coli: a new approach, Medical Hypotheses, 1988 May;26(1):17-20.

Tagart REB. The Anal Canal and Rectum: Their Varying Relationship and Its Effect on Anal Continence, Diseases of the Colon and Rectum 1966:

Tagart REB. The Anal Canal and Rectum: Their Varying Relationship and Its Effect on Anal Continence, Diseases of the Colon and Rectum 1966: 9, 449-452.

Torres, Dr. Y. (2016). ¿Es normal tener “ardores” de estómago? Hernia de hiato. 10 de Feb. 2020, de Hospital Victoria Eugenia Cruz Roja. Sitio web: https://hospitalveugenia.com/comunicacion/consejos-de-salud/hernia-de-hiato-sintomas-tratamiento-ardor-de-estomago-digestivo-sevilla/

Valery, Y. (2004). El inodoro: de lujo a lo inimaginable. 2020, de BBC Mundo Sitio web: ews.bbc.co.uk/hi/spanish/specials/newsid_3497000/3497555.stm

Walker AR, Segal I., Epidemiology of noninfective intestinal diseases in various ethnic groups in South Africa. Israel Journal of Medical Science, 1979 Apr;15(4):309-13. (En línea en PubMed.).

# ERGONOMIC ANALYSIS AND PROPOSAL OF WINDING EQUIPMENT IN THE CABLE CUTTING OPERATION, IN A COMPANY PROVIDING ELECTRICAL MATERIAL

**Janely Julieth González Sánchez[1], Ricardo Iván Ching Rosales[1], José Jesús Pérez Cancio[1], Baudelio Rivera Ramos[1], Rigoberto Zamora Alarcón[2]**

[1]Departamento de Ingeniería Industrial
Instituto Tecnológico Nacional de México, Campus Mexicali
Av, Instituto Tecnológico S/N Plutarco Elías calles 21376
Mexicali, Baja California

janeulieth@hotmail.com, Ricardoivanr@gmail.com, jesuscancio98@gmail.com, baude.109@live.com.mx

[2]Departamento de Ingeniería Industrial/Ingeniería Mecánica
Instituto Tecnológico Nacional de México, Campus Mexicali
/Universidad Autónoma de Baja California
Av, Instituto Tecnológico S/N Plutarco Elías calles 21376
Blvd. Benito Juárez S/N CP 21280 Mexicali, B.C.
zamora@uabc.edu.mx

**Resumen:** El presente proyecto es una propuesta desarrollada para una empresa proveedora de material eléctrico con el fin de reducir repetividad y cargas manuales que exceden lo establecido en la NOM 036 STPS 2018 a los empleados que laboran directamente con la devanadora de cable. Para lo anterior se desarrollaron estudios de la problemática general y de las condiciones en las que se encontraba el área de trabajo que pueden mejorar distintos aspectos para el trabajo. Se desarrollaron análisis ergonómicos de las posturas de los empleados durante la realización de las actividades con Suzanne Rodgers y Rula, mediciones antropométricas, encuestas referentes a la NOM 035 STPS 2018 para validar que no se sufra de algún riesgo psicosocial en el trabajo.

La devanadora de cable propuesta se validó conforme a los estándares establecidos para su diseño y finalmente proponer la selección de una maquina con diseño ergonómico que permite la disminución de repetitividad.

La estandarización de cargas permisibles y el uso de montacarga propuesta se validó conforme lo establecido a la NOM 036 STPS 2018 y finalmente dar plática a los trabajadores sobre el levantamiento correcto de los carretes de cable.

**Palabras clave:** Suzanne Rodgers, Rula, NOM-035-STPS-2018 y NOM-036-1-STPS-2018.

**Aportación a la Ergonomía:** La aplicación de las normas mexicanas, las validaciones ergonómicas, el dimensionamiento de estaciones y operadores, así

como las herramientas de mejora continua, permiten validar y mejorar las estaciones para confort de los operadores al verlo como un sistema de mejoramiento para la ergonomía.

**Abstract:** This project is a proposal developed for a company supplying electrical material in order to reduce repetrivity and manual loads that exceed that established in NOM 036 STPS 2018 to employees working directly with the winding Cable. For the above, studies of the general problem and the conditions in which the work area was located were developed that can improve different aspects for the work. Ergonomic analyses of employee postures were developed during activities with Suzanne Rodgers and Rula, anthropometric measurements, surveys concerning NOM 035 STPS 2018 to validate that they do not suffer from some psychosocial risk at work.

The proposed cable winder was validated according to the standards established for its design and finally propose the selection of a machine with ergonomic design that allows the reduction of repetitiveness.

The standardization of permissible loads and the use of proposed forklift was validated in accordance with the NOM 036 STPS 2018 and finally to give workers talks about the correct lifting of the cable reels.

**Keywords** : Suzanne Rodgers, Rula, NOM-035-STPS-2018 and NOM-036-1-STPS-2018.

**Contribution to Ergonomics**: The application of Mexican standards, ergonomic validations, the sizing of stations and operators, as well as the tools of continuous improvement, allow to validate and improve the stations for the comfort of operators see it as an improvement system for ergonomics.

## 1. INTRODUCTION

It was developed in an electrical equipment supplier company that has 4 operators working directly with the cable winder for the delivery of the final product to the industrial sector. To make a pre-diagnosis, each operator operating the activity was required to enter the area of operations where the activity is carried out, conducting Nordic kuorinka questionnaire based on NOM-036-1-STPS-2018 to each operator that handles the cable winder to determine the symptoms initial to a work illness.

In the Nordic kuorinka questionnaire conducted on 4 employees who are constantly active with the cable winder, it was observed that 3 out of 4 employees have discomfort or had any muscle health problems from the activity of lifting reels of Cable. Operators who perform cable cutting activity directly make repetitive movements by having wrist and shoulder pains. For the poor design of the manual cable winder. On average they do 3,806 laps per day. And for the lifting of cable reels they had pain in the back high and low. The heaviest reel they get to lift from the floor is 77,319kg.

## 2. OBJECTIVES

Disminuir los movimientos repetitivos y cargas manuales a través de la aplicación, análisis y evaluación ergonómica para la mejora en las condiciones de trabajo dadas en las normas oficiales mexicanas v de la secretaria de trabajo y prevención social.

## 3. METHODOLOGY

Application of Mexican standards to validate physical workstation conditions NOM 001 STPS 2008 (Working conditions), NOM 006 STPS 2014 (Material storage), NOM 011 STPS 2018 (Noise), NOM 025 STPS 2008 (Lighting), NOM 026 STPS 2008 ( Signaling) as well as the one that allows the operator to assess the conditions at workstation NOM 017 STPS 2017 (Personal Protection Equipment), NOM 035 STPS 2018 (Psychosocial Factors), NOM 036 STPS 2018 (Load Management). Analysis of station sizing and operator anthropometry. Ergonomic workstation analysis and evaluation, NOM 036 STPS 2018 methodology, Suzanne Rodgers, Rula. Use of continuous improvement methodologies and ILO (International Labour Organization), to identify areas of ergonomic opportunity.

## 4. RESULTS

### 4.1 Application of Mexican standards.

Below, we will describe the findings found in the work area that are mandatory to each of the Mexican standards of the Secretary of Labor and Social Prevention (STPS). NOM-001-STPS-2008 (working conditions). Regarding the soil in the work area, in which he mentions that should be kept in optimal conditions for the activities to be carried out avoiding unsafe conditions within it, it was detected that the floor of the work area of the company is not in conditions appropriate for the worker and the activities he must perform. (STPS, 2008) In applying the Mexican standard to validate physical conditions of the NOM 001 STPS 2008 workstation, we realized that the floor was in poor condition leading to work accidents so a budget was made to pave the floor improving its conditions. NOM-006-STPS-2014 (Material storage). According to the requirements of the standard, the shelves anchored to the floor were not found, there is no limit on the maximum stomp of material as specified by the standard. (STPS, 2014) In applying the Mexican standard to validate the NOM 006 STPS 2014, the shelves for placing the reels were not in conformity with the standard, so the observation and recommendation was made to anchor all the shelves to the floor and place them maximum stomp.

For NOM 035 STPS 2018, surveys were carried out on staff working directly on the activity assessed to determine whether there are psychosocial factors in the work area by reference and following the reference guidelines established by the standard. (STPS 2018) In applying the standard, staff showed full participation when answering surveys, the information provided tells us that there are no psychosocial factors in the area of work that impede full and rewarding development in the work area, so there is no needed to take control measures. For NOM 11 STPS 2001 decibel levels must be below or within the acceptable terms of the standard to obtain total exposure during the working day and have no hearing impact on occupationally exposed personnel. (STPS 2001)

The results obtained in the evaluation of noise in the workstation are below that established in NOM 11 STPS 2001 so no modifications or regulations have to be made to occupationally exposed personnel. As you can see in Figure 1, the graphical illustration in which nodes were made throughout the workspace is shown to get the results of how decibels behave in the workspace.

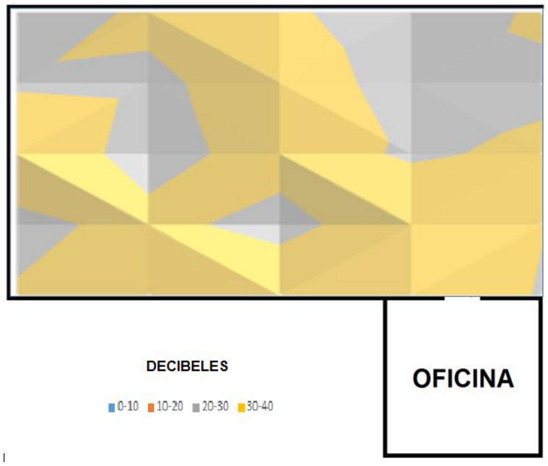



Figure 1. Graphic plane of noise

NOM-017-STPS-2017 (Personal Protective Equipment). According to Table 1, a verification of the activities carried out in the work area was carried out that personal protective equipment is adequate and required to safely carry out the activities. (STPS, 2017).

Table 1. Values obtained under NOM 017 STPS

| Equipo de Proteccion Personal | |
|---|---|
| Botas con casquillo | Serequiere |
| Guantes Anti Corte | Se requiere |
| Lentes de seguridad | No se requiere |
| Casco | No se requiere |
| Tapones Auditivos | No se requiere |

The NOM 025 STPS 2008 corresponding to Lighting was found below the necessary lumens at 200 lux and complying with the reflection part as set out in the standard. (STPS 2008).

Figure 2a shows the lumens graph plane and Figure 2b shows the reflection graph, therefore nodes were made throughout the workspace to get the results of how lumens and reflection behave in the work area. The results shown in Table 2 correspond to operator data for cable lofting activities and in the manual cable reel loads.

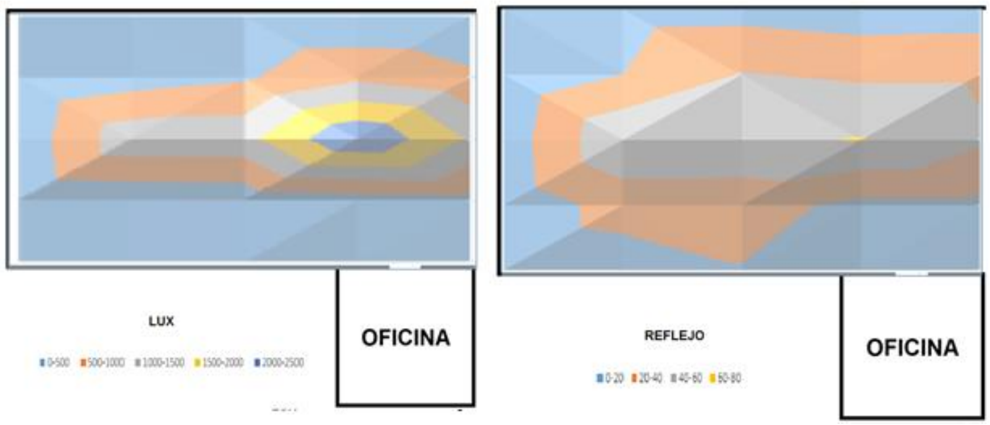



Figure 2. a. It is the graph of the lighting values and b. values of the reflection in area

## 4.2 Analysis of station sizing and operator anthropometry.

Table 3 shows the anthropometric measurements taken on the 4 operators working directly with cable winding, it was feasible to identify all the critical dimensions to start a proposal to select an ergonomic winder.

In the analysis of the sizing of stations according to operator anthropometry does not meet the dimensions of comfort of operation on the work table it was necessary to apply recommendations.

## 4.3 Analysis of ergonomic methods

Workstation analysis and ergonomic evaluation the cable reel load lifting activity was evaluated using the NOM 036 1 STPS 2018 methodology, Rapid UpperLimbAssessment- (RULA) and The National Institute for Occupational Safety and Health- (NIOSH). For the activity of cable winding was evaluated with the Occupational Repetitive Action Method- (OCRA) and Suzanne Rodgers (Sue Rodgers) as these methodologies estimate the fatigue of the muscles of the body when performing a specific task. Three important factors are studied: stress level, duration of activity and frequency of activity. It was analyzed when cutting the cable on the manual winder.

Table 2. Results of the survey of operational staff.

| Descripción de la evaluación | Resultados | Observaciones |
|---|---|---|
| Numero de personas en el puesto | 4 | Hombres |
| Edad | 22-37 | 22, 23, 30, 37 |
| Antigüedad | 1-3 años | 1(2), 2, 3 |
| Evaluación del ambiente | | |
| 1. Iluminación | Regular | |
| 2. Ruido | Aceptable | |
| 3. Temperatura | Muy buena | |
| 4. Condición física que influye en el trabajo | Mala | Piso con grietas |
| Evaluación del estado de la estación de trabajo | | |
| 5. Equipo y herramienta | Mala | Actividad Manual |
| 6. Altura de la maquina | Aceptable | |
| 7. Molestias atribuibles al trabajo condiciones | 50% | Requiere de esfuerzo físico, repetitividad |

Table 3. Anthropometric measurements of the 4 operators

| Medidas tomadas | Operador 1 | Operador 2 | Operador 3 | Operador 4 |
|---|---|---|---|---|
| 2. Estatura | 169 | 174 | 166 | 170 |
| 3. Altura al ojo | 157 | 165 | 153 | 159 |
| 4. Altura al hombro | 136 | 149 | 138 | 140 |
| 5. Altura al codo flexionado | 105 | 112 | 107 | 109 |
| 7. Altura a la rodilla | 48 | 52 | 46 | 48 |
| 8. Alcance brazo frontal | 58,6 | 62,2 | 57,3 | 58,4 |
| 9. Alcance brazo lateral | 58,8 | 62,5 | 57,5 | 58,8 |
| 10. Profundidad de tórax | 36,7 | 29 | 39,4 | 37,6 |
| 15. Anchura codo-codo | 37 | 39,3 | 34 | 36 |
| 16. Anchura de la mano | 8,3 | 8,7 | 8,2 | 8,6 |
| 17. Longitud de la mano | 17,1 | 19,3 | 16,3 | 17,6 |
| 18. Longitud de la palma de la mano | 12 | 13,3 | 11,8 | 12,6 |
| 19. Diámetro de empuñadura | 3.7 | 3,9 | 3,5 | 3,7 |
| 20. Longitud del pie | 27 | 29,5 | 26 | 27 |
| 21. Anchura del pie | 8.8 | 8,4 | 8,6 | 8,4 |
| 22. Anchura de talón | 4.3 | 4 | 4,2 | 4,1 |

Table 4 shows the results obtained from the ergonomic evaluation with the OCRA method in which it indicates that for the right hand we have a risk index of 15.93 that places this activity at an unacceptable risk medium and for the left hand of 7,475 that we placed at an acceptable risk. (OCRA)

Table 4. OCRA method for analyzing cable winding

| Método OCRA | Derecha | Izquierda |
|---|---|---|
| Tiempo de recuperación insuficiente | 4 | 4 |
| Frecuencia de movimientos | 1 | 0 |
| Aplicación de fuerza | 8 | 2 |
| Hombro | 1 | 1 |
| Codo | 8 | 2 |
| Muñeca | 8 | 2 |
| Mano-dedos | 8 | 2 |
| Estereotipo | 1,5 | 1,5 |
| Posturas forzadas | 9,5 | 3,5 |
| Factores de riesgo complementario | 2 | 2 |
| Factor Duración | 0,65 | 0,65 |
| Índice de riesgo | **15.93** | **7.475** |
| Valoración | 14,1-22,5<br>No aceptable<br>nivel medio | Riesgo aceptable |

Table 5 shows the results of the Suzanne Rodgers method in which cable winding was evaluated by obtaining a high-moderate risk index for upper limbs. With the proposed improvement it was reduced to a low risk index for all members of the body that evaluated this methodology. (Sue Rodgers)

Table 5. Suzanne Rodgers method for cable winding analysis

| Devanado de cable | | | | | | Devanado de cable semiautomatizado | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Esfuerzo | Duracion | Por minuto | Puntaje | Evaluación | | Esfuerzo | Duracion | Por minuto | Puntaje | Evaluación |
| Cuello | 2 | 2 | 3 | 8 | Alto | Cuello | 1 | 1 | 1 | 1 | Bajo |
| Hombro | 1 | 1 | 1 | 3 | Bajo | Hombro | 2 | 1 | 1 | 3 | Bajo |
| Espalda | 1 | 3 | 2 | 5 | Moderado | Espalda | 2 | 2 | 1 | 4 | Bajo |
| Brazo y Codo | 2 | 3 | 2 | 7 | Moderado | Brazo y Codo | 1 | 3 | 1 | 3 | Bajo |
| Muñeca, mano, dedo | 2 | 1 | 1 | 3 | Bajo | Muñeca, mano, dedo | 2 | 1 | 1 | 3 | Bajo |
| Piernas y Tobillos | 1 | 2 | 2 | 2 | Bajo | Piernas y Tobillos | 1 | 2 | 1 | 2 | Bajo |

The photographs in Figure 3 show the winding process, for greater understanding of the activity evaluated.

Figure 3. Photographs show the sequence of the winding process

The methodology of the NOM036-1 STPS 2018 and NIOSH was used for the activity of cable reel loads as these methodologies evaluate loads greater than 3 kilos, manual load lifting and RULA method for forced postures. Four important factors are studied: lifting technique, operator posture with the object already loaded, design of the object to be grasped and complications when loading the object.

Table 6 shows the risk factors referenced to NOM 036 STPS 2018 with a score of 19 by placing this activity at a significant score by placing this activity at a high-significant risk level requiring control measures as high as soon possible. (STPS 2018)

Table 6. NOM 036 STPS 2018 method for reel lifting analysis

| **Estimación del Nivel de Riesgo** | |
|---|---|
| **Factores de riesgo** | **Levantar** |
| Peso y ascenso de la carga/ frecuencia de transporte | **10** |
| Distancia horizontal entre las manos desde la parte inferior de la espalda | **6** |
| Región de levantamiento vertical | **1** |
| Torsión y flexión lateral del torso; Carga asimétrica sobre el torso (transporte) | **0** |
| Restricciones posturales (posturas incómodas, forzadas, o restringidas) | **1** |
| Acoplamiento mano-carga (elementos de sujeción) | **0** |
| Superficie de trabajo | **1** |
| Otros factores ambientales | **0** |
| **Puntuación** | **19** |

Table 7 shows the results obtained when applying the NIOSH method with a score of 14.41 placing this activity with a very important level of risk which implies that it requires significant over-effort when performing cable reel lifting. (NIOSH)

Table 7. NIOSH method for reel lifting analysis

| Datos de las mediciones | |
|---|---|
| Control significativo en destino | Si |
| Peso del objeto manipulado | 75 kg |
| Constante de peso, Límite de carga | 23 kg |
| Origen (Distancia horizontal origen) | 63 cm |
| Origen (Distancia Vertical origen) | 50 cm |

| | |
|---|---|
| Destino (Distancia horizontal destino) | 50 |
| Destino (Distancia Vertical destino) | 112 cm |
| Desplazamiento vertical de carga | 62 cm |
| Asimetría origen | 60° |
| Asimetría destino | 20 |
| Frecuencia | 0.02 Lev/min |
| Duración del trabajo | 1 - 2 |
| Calidad de agarre | Malo |
| Índice de riesgo | **14.41** |

Figure 4 shows the sequence when you load the reel to place it on the warehouse base. Table 8 shows the results obtained in the reel loading activity on the shelf using the RULA methodology. Initially we had level 4 acting (final score 7) which tells us that urgent changes in the activity are required. With the improvement implemented level 1 of action was obtained (final score 2), it tells us that the postures are acceptable and do not require ergonomic implementation. (RULA).



Table 8. RULA (Rapid UpperLimbAssessment) method for reel lifting analysis.

| Antes | Mejora | Después |
|---|---|---|
| Nivel 7 | | Nivel 2 |
|  | 71.42% |  |

## 5. CONCLUSIONS

It semi-automatize an electric winder with an electronic controller that increased productivity to 67% and improved the ergonomic condition in a range of 70 to 80%, so it no longer requires over-effort on the part of the operator. Allowable manual loads and forklift loads are standardized.

The improvement was found between the 70 and 75% Budget to repair floor in poor condition to avoid accidents in the future. The proposals were submitted to the company for evaluation and final decision. Finally, we achieved our goal of reducing repetitive movements and manual loads through the application, analysis and ergonomic evaluation to improve the working conditions given in the official Mexican standards and the secretary of work and social prevention.

## 6. REFERENCES

Secretaria del Trabajo y Previsión Social (STPS), (2008). NOM-001-STPS-2008, Edificios, locales, instalaciones y áreas en los centros de trabajo Condiciones de seguridad. Diario oficial de la federación, 24 de noviembre de 2008

Secretaria del Trabajo y Previsión Social (STPS), (2014) NOM-006-STPS-2014, Manejo y almacenamiento de materiales-Condiciones de seguridad y salud en el trabajo. Diario oficial de la federación

Secretaria del Trabajo y Previsión Social (STPS), (2008) NOM-017-STPS-2008, Equipo de protección personal-Selección, uso y manejo en los centros de trabajo. Diario oficial de la federación, 9 de diciembre de 2008

Secretaria del Trabajo y Previsión Social (STPS), (2008) NOM-025-STPS-2008, Condiciones de iluminación en los centros de trabajo. Diario oficial de la federación, 30 de diciembre de 2008

Secretaria del Trabajo y Previsión Social (STPS), (2008) NOM-026-STPS-2008, Colores y señales de seguridad e higiene, e identificación de riesgos por fluidos conducidos en tuberías. Diario oficial de la federación, 25 de noviembre de 2008

Secretaria del Trabajo y Previsión Social (STPS), (2018) NOM-035-STPS-2018, Factores de riesgo psicosocial en el trabajo-Identificación, análisis y prevención. Diario oficial de la federación

Secretaria del Trabajo y Previsión Social (STPS), (2018) NOM-036-1-STPS-2018, Factores de riesgo ergonómico en el Trabajo-Identificación, análisis, prevención y control. Parte 1: Manejo manual de cargas. Diario oficial de la federación

# FATIGUE AMONG UNDERGRADUATE STUDENTS

**Patricia Eugenia Sortillón González[1], Enrique Javier de la Vega Bustillos[2]**

[1]Universidad de Sonora
Rosales S/N, Colonia Centro, CP 83000
Hermosillo, Sonora, México
Corresponding author's e-mail: psortillon@gmail.com

[2]Tecnológico Nacional de México/Instituto Tecnológico de Hermosillo
Avenida Tecnológico S/N, Colonia El Sahuaro, CP 83000
Hermosillo, Sonora, México
author's e-mail: e_delavega_mx@yahoo.com

**Resumen**: En los últimos años, la fatiga ha recibido mucha atención debido a su impacto en el rendimiento y la eficiencia del trabajo. Si bien el cansancio está mayoritariamente relacionado con los trabajadores por turnos, algunos estudios revelan que tiene mucho impacto en el grado de atención de los estudiantes durante su actividad en el aula y podría influir en el proceso de aprendizaje y debilitar la formación profesional. En esta investigación se llevó a cabo un estudio de fatiga en estudiantes de ingeniería, para investigar la asociación entre la fatiga autoinformada experimentada durante tres lapsos diferentes de la mañana de un día de clase, durante los días de la semana y durante las semanas. La presencia de fatiga se evaluó con un instrumento de autoinforme multidimensional que incluye la información sociodemográfica de los individuos, la lista de verificación de síntomas de fatiga de Yoshitake y el mapa de trastornos musculoesqueléticos de Corlett-Bishop. Nuestros resultados muestran que existe una fuerte asociación entre el nivel de fatiga experimentado por los estudiantes dentro del transcurso de los lapsos en un día y dentro de las semanas, también se observó que el nivel de fatiga durante los días bajó al final de la semana. Nuestros resultados son consistentes con otros estudios que establecen fuertes vínculos entre la fatiga percibida y el horario de trabajo. Se necesitan más estudios para explorar la influencia de otros factores asociados con la fatiga en estudiantes de pregrado, que incluyen la privación del sueño y trabajos previos.

**Palabras clave**: Fatiga, estudiantes, semanas, días.

**Abstract:** In recent years fatigue has received much attention due its impact on work performance and efficiency. Although fatigue is mostly related to shift workers, some studies reveal that it has a lot of impact on the degree of attention of students during their activity in the classroom and could have an influence on the learning process and weaken professional education. In this investigation it was conducted a fatigue study in engineering undergraduate students, to investigate the association between self-reported fatigue experienced during three different lapses of the morning of on a class day, thru the days of the week and thru the weeks. The presence of fatigue was assessed with a multidimensional self-report instrument which includes the sociodemographic information of individuals, the Yoshitake's fatigue symptom checklist and the Corlett-Bishop's musculoskeletal disorder map. Our results show that there is a strong association between the level of fatigue experienced by students within the passage of the lapses in a day and within the weeks, it was also observed that fatigue level over the days went down at the end of the week. Our results are consistent with other studies that establish strong links between perceived fatigue and work schedule. Further studies are needed for exploring the influence of other factors associated with fatigue in undergraduate students, which include the sleep deprivation and previous work.

**Keywords:** Fatigue, students, weeks, days

## 1. INTRODUCTION

Fatigue has received much attention in recent years due to its impact on work performance and efficiency. Fatigue is a complex problem that doesn't respond to the degree of health. According to Moraes et alt (2010) it can be related to cognitive and emotional components, whose symptoms includes tiredness, drowsiness and inhability for concentrate, it also can be considered as a multidimensional phenomenon. Although fatigue is related to shift workers from different labour sectors, some studies reveals that it has a lot of impact on the degree of attention of students during their activity in the classroom. Åshberg (2001) considered that fatigue is related to the work performed and the demand of work done, specifically with physical or mental work. Under fatigue, people make incorrect judgments, do not follow procedures as written, and has a poor accomplishment of its tasks.

In spite of the small number of research relating to fatigue on undergraduate students, there is evidence that suggest that it could have an influence on the learning process and weaken professional education. Previous studies (Dorrian et al., 2003; Barger et al., 2018; Dawson and Fletcher, 2001) have shown that fatigue increases thru the hours of working, this could suggest that students may experience different levels of fatigue during the course of class hours. An extensively research has established a link between subjective feelings of fatigue and decrements in performance (Kaida et al., 2006). Other studies (Zhou et al., 2012) indicated that individuals exhibit performance decrements associated with fatigue. Akerstedt et al. (2002) found that fatigued individuals are less likely to generate compromised actions and overall performance.

It was conducted a fatigue study in engineering undergraduate students, to investigate the association between self-reported fatigue experienced during a work day and thru the week, which could let us understand how fatigue evolves thru hours of the day and between days in a week , and between the weeks. Fatigue was measured using the Fatigue Symptom Checklist (Yoshitake,1978) and it was applied the Corlett and Bishop Musculoskeletal Disorder Map to know the associate disorders linked to self-reported fatigue (Corlett et al.,1976).

# 2. METHODOLOGY

## 2.1 Study design and participants

A prospective and observational study was conducted within 5-week period in the Industrial Engineering Program (IEP) of the Universidad Estatal de Sonora (UES). Students of the latest courses from IEP, routinely started their classes from 7:00 a.m. to 3:00 p.m. in a five continuous day basis in a week. Current investigation involved 42 undergraduate engineering students, which attended the above schedule. Participants were excluded if they were pregnant or were currently undergoing medical treatment. Data were collected during the morning period. Approval of the study was obtained from the Ethics Committee at the UES. Participants received information of the study goals and after this, students who agreed to participate, signed a consent term. Participants were free to withdraw from the study at any time and were provided with their individual study results.

## 2.2 Procedure

Following informed consent, in order to gather information about short- and long-term fatigue symptoms, participants were provided with a composed fatigue Survey (CFS) to assess the presence of fatigue during the day and thru the days of the week. The CFS is a multidimensional self-report instrument comprising three parts.

The first part of the instrument is to gather sociodemographic information and it was applied only the first day of assessments, second part is the Yoshitake's fatigue symptom checklist (YFSC), developed in Japan to measure fatigue in three categories: General symptoms of fatigue, intellectual fatigue and physical fatigue; and the third part of the instrument is the Corlett-Bishop's musculoskeletal disorder map (CBDM). The composed survey was translated to Spanish. The reliability and validity of modification were tested. The CFS was applied from Monday to Friday during five continuous weeks in three lapses of time: 7:15 a.m., 11:15 a.m. and 2:15 p.m.

## 2.3 Data analysis

Data processing and analysis regarding to sociodemographic information of participants, YFSC and CBDM is briefly described below:

### 2.3.1 Sociodemographic information of participants

Average and standard deviation of students age was calculated, for both women and men. Percentages of students who have an employment relationship were also calculated.

### 2.3.2 Yoshitake's Fatigue Symptom Checklist

A Fatigue Index (FI) was calculated for the totality of gathered data, summarizing in each CFS the total amount of questions answered with yes and diving it for 30. Data of FI was split into three categories: week FI, day FI and lapse FI.

2.3.3 Corlett and Bishop's Musculoskeletal Disorder Map

Data from CBDM was split by gender and percentages of musculoskeletal disorders were calculated.

2.3.4 Statistical analysis

Data management and statistical analysis were carried out using the software suite IBM SPSS (v24, SPSS Inc., Chicago, USA). In order to summarise gathered data, mean and standard deviation of participants age were calculated for both genders. Mean and standard deviation of FI was calculated for weeks, days and lapses in the total period of analysis. After verifying normally distributed data of FI from YFSC, the influence of days, weeks and lapses on the overall FI mean was analyzed using an ANOVA test with a significance level of 0.05 and a Duncan's multiple range test was applied in the days, weeks and lapses. Percentages of disorders from CBDM was calculated.

## 3. RESULTS

### 3.1 Participants

This study included 42 undergraduate engineering students, from which three participants (7.1%) were excluded due to participation withdrawal (N = 1) or medical treatment (N = 2), resulting in a study sample of 39 participants, 18 women and 21 men (women age 22.53 ± 1.63 years, men 22.94 ± 2.75 years). Percentage of women who have an employment relationship was 33% and percentage of the men who also work was 76%. All participants answered the CFS for the totality of the days and weeks of study.

### 3.2 Yoshitake's Fatigue Symptom Checklist

The three categories of the YFSC showed good internal consistencies with Cronbach's alpha values of 0.91 (General symptoms of fatigue), 0.89 (Intellectual fatigue) and 0.92 (physical fatigue). The corresponding FI mean for weeks (Fig. 2) were 18.833 ± 7.447 ($week_1$), 17.778 ± 5.367 ($week_2$), 18.951 ± 7.225 ($week_3$), 19.002 ± 6.604 ($week_4$), and 19.364 ± 6.110 ($week_5$).

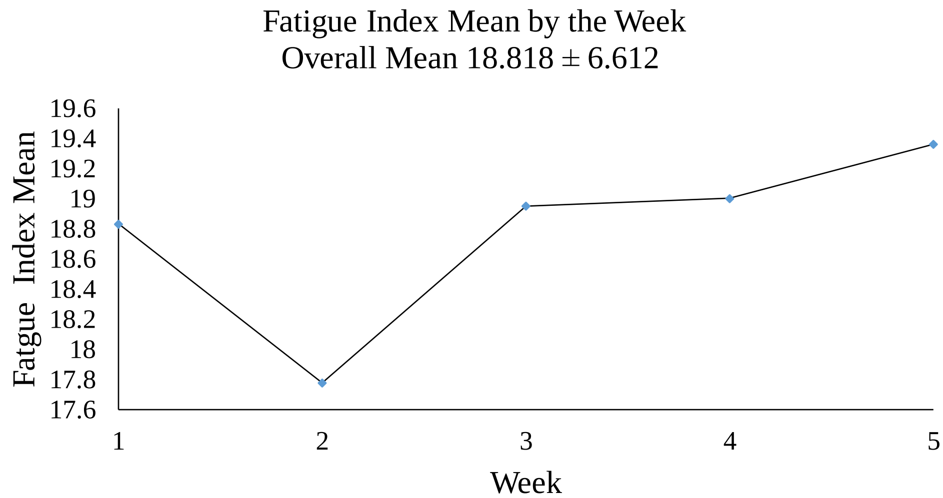



Fig. 2. Fatigue Index Mean of the five weeks

FI mean values for days (Fig. 3) were 18.833 ± 7.447 ($day_1$), 17.778 ± 5.367 ($day_2$), 18.951 ± 7.225 ($day_3$), 19.002 ± 6.604 ($day_4$), and 19.364 ± 6.110 ($day_5$).

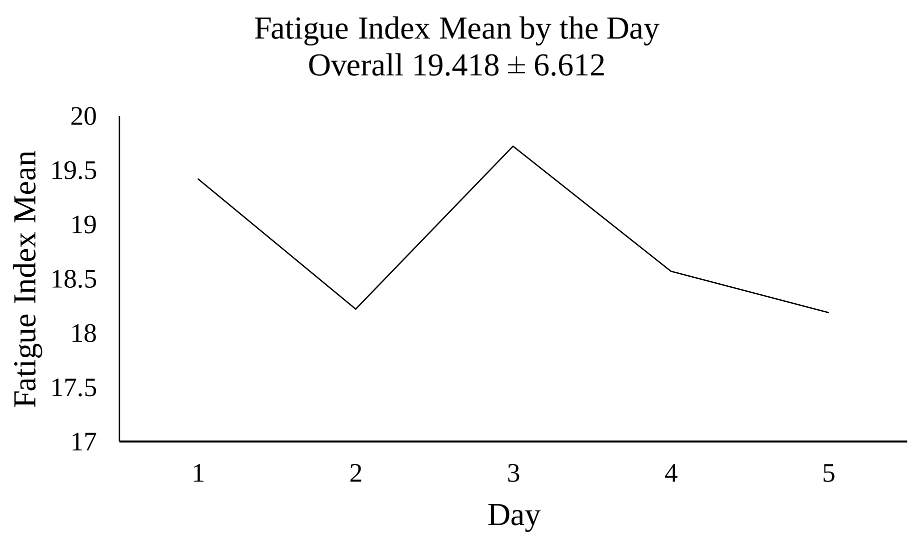



Fig. 3. Fatigue Index Mean of the five days

FI mean values for lapses were 18.833 ± 7.447 ($lapse_1$), 17.778 ± 5.367 ($lapse_2$), 18.951 ± 7.225 ($lapse_3$), the total FI mean and standard deviation FI mean for days is 19.418 ± 6.612 (Fig. 3).

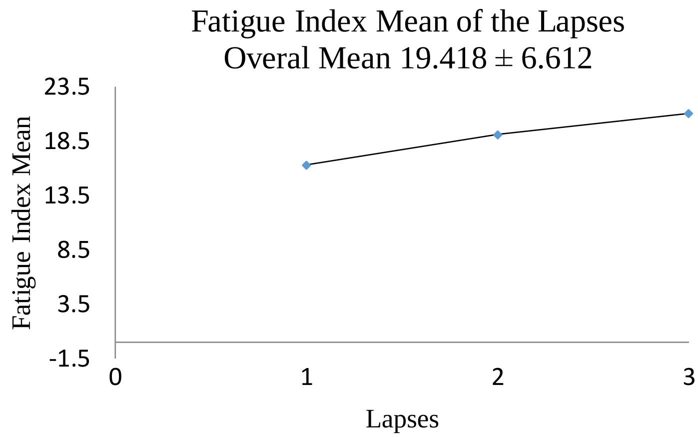



Fig. 3. Fatigue Index Mean of the Lapses

An ANOVA test with a = 0.05 was performed for independent variable Fatigue index mean and as independent variable the weeks (Table 1).

Table 1
ANOVA Test Mean of Fatigue Index, Effect: Weeks
**Mean of Fatigue Index, Effect: Weeks**

| **Source** | Square Sum | | Square Mean | fo | p-level |
|---|---|---|---|---|---|
| **Week** | 833.450 | 4 | 208.362 | 4.869 | 0.001 |
| **Week Error** | 124606.843 | 2912 | 42.791 | | |
| **Total** | 125440.293 | 2916 | | | |

For this test, $f_0 = 4.869 > f\ (0.05, 4{,}2912) = 2.374$, which tell us mean of fatigue is different between weeks. Duncan test was performed and FI mean is equal for weeks 1,2,3,4 and at least one is different.

An ANOVA test with a = 0.05 was performed for independent variable fatigue index mean and as independent variable the days (Table 2).

Table 2
ANOVA Test Mean of Fatigue Index, Effect: Days
**Mean of Fatigue Index, Effect: Days**

| **Source** | Square Sum | | Square Mean | Fo | p-level |
|---|---|---|---|---|---|
| **Days** | 1218.217 | 4 | 304.554 | 7.122 | 0.000 |

| | | | |
|---|---|---|---|
| **Week Error** | 124689.333 | 2916 | 42.760 |
| **Total** | 125907.551 | 2920 | |

For this test, $f_0 = 7.122 > f(0.05, 4{,}2916) = 2.3749$, which tell us mean of fatigue is different between the days. Duncan test was performed and FI mean is equal for days 1 and 3 and between days 2,4, and 5.
An ANOVA test with a = 0.05 was performed for independent variable Fatigue index mean and as independent variable the lapses (Table 3).

Table 3
ANOVA Test Mean of Fatigue Index, Effect: Lapses
**Mean of Fatigue Index, Effect: Days**

| **Source** | Square Sum | | Square Mean | fo | p-level |
|---|---|---|---|---|---|
| **Lapses** | 11034.895 | 2 | 5517.447 | 138.021 | 0.000 |
| **Week Error** | 116808.319 | 2922 | 39.975 | | |
| **Total** | 127843.214 | 2924 | | | |

For this test, $f_0 = 138.021 > f(0.05, 4{,}2922) = 2.9988$, which tell us that mean of fatigue is different between the lapses. Duncan test was performed and FI mean is different between all lapses.

### 3.3 Corlett and Bishop's Musculoskeletal Disorder Map

Most relevant musculoskeletal disorders were in the neck, shoulders and back, this could be associated with the fact that students have prolonged postures during the class sessions, such impairments in these upper members could be related to the physical fatigue, however, there is a fifteen minute rest, that could help to recover from physical fatigue.

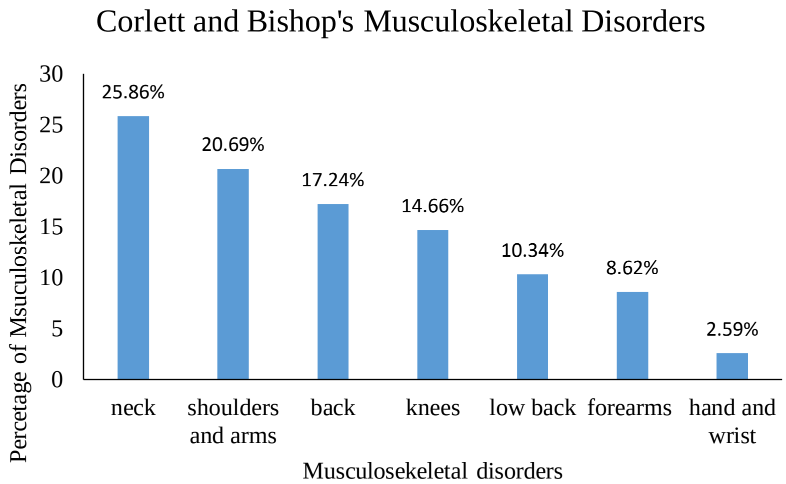



Fig. 4. Percentage of Musculoskeletal Disorders

## 4. DISCUSSION

Prior work has documented the evolution of fatigue among undergraduate students. Moreas et al. (2010) reports higher levels of fatigue on nurse students. Dorrian et al. (2011) reports fatigue in a subjective form in rail workers. However, these studies have either been long-term studies or have not focused on how fatigue evolves through weeks, days and lapses. In this study we evaluate the fatigue through a fatigue index, for five continuous weeks, and during three lapses of time during the day, and thru the days of a week. We found that there is a strong association between the level of fatigue experienced by workers within the passage of the weeks and also for the passage of the days in a day and within the weeks, it was observed that fatigue level over the days went down at the end of the week.

Our study has some limitations, linked to the time the students had to answer the survey, during the class time, due to the different tasks related to academic work and in some cases due that the schedule to apply the survey interfered with tests and sport assignments. In this context we faced difficulties in gathering at specific timestamps during the morning activity, as initially planned. Although collected data are not equally distributed throughout the weeks, there were very little data missing that was discarded in order to work with a balanced data. Fatigue has been measured by uni-dimensional scales (Åshberg, 2001) as they used in this study, in this context, this type of rating give no information of qualitative differences between individuals which could possibly limit the results. This investigation is an approach that may be useful to analyze academic schedules for undergraduate students as a strategy to productivity gain and rest breaks recommendations. Further studies are needed for explore the influence of other factors associated with fatigue feelings in undergraduate students, which include the sleep deprivation and previous work related activity, and probably a larger samples are necessary in order to evaluate the effect of individual characteristics such as age and labor experience.

## 5. CONCLUSION

With most research to date focused on fatigue among workers from different professional areas, which establish strong links between perceived fatigue and work schedule, specifically in long shifts, our results showed that fatigue among undergraduate students had a similar trend, a greater association was found between fatigue and the lapses of the day, mean of fatigue index is greater in the third lapse than the first one. The findings with regards to fatigue thru the days of the week, revealed, that at the end of the week fatigue index went down, this result has a possible association that the fact in the two last working days of the week, there was a reduced work schedule compared to those the previous day of the week.

## 6. REFERENCES


Åshberg, Elizabeth (2001); Dimensions of fatigue in different working population, Scandinavian Journal of PJournal of Psychology (41), 231-241.

Akerstedt, T., Wright, K.P. (2009) Sleep loss and fatigue in shift work and shift work disorder, Sleep Med Clin. 4(2). 257-271.

Åshberg, Elizabeth (2001), Dimensions of fatigue in different working population,

Akerstedt, T., Fredlund, P., Gillberg, M. and Jansson, B. Work load and work hours in relation to disturbed sleep and fatigue in a large representative sample. J. Psychosom. Res., 2002, 53: 585–588.

Barger, L.K., Runyon M.S., Renn, M.L., Moore, G.G., Weiss, P.M., Condle, J.P., Flickinger, K.L., Divecha, A.A., Coppler, P.J., Sequeira, D. J., Lang, E.S., Higgins, J.S., Patterson, P.D. (2018), Effect of fatigue training on safety, fatigue, and sleep in emergency medical services personnel and ther shift workers: a systematic review and metanalysis, 22 (Suppl. 1), 58-68.

Corlett, E.N., Bishop, R.P. (1976). A technique for measuring postural discomfort, Ergonomics, 9, 175-182.

Dawson, D, Fletcher, A. (2001) A cuantitative model of work related fatigue: background and definition, Ergonomics, 44(2), 144-163.

Dorrian, J. Lamond, N.,Holmes, A.L. (2003). The ability to self-monitor performance during a week of simulated night shift. Sleep 26 (7), 871-877.

Kaida, K., Takahashi, M., Akerstedt, T., Nakata, A., Otsuka, Y., Haratani, T. Fukasawa, K. (2006) Validation of the Karolinka sleepiness scale against performance and EEG variables. Clin. Neurophysiology 117 (2), 1574-1581.

Moraes, A., Delalibera, D., de Mattos, A (2010). Fatigue in undergraduate nurses students, Rev Esc Enferm USP 44(4), 1047-1053.

Yoshitake, H. (1978) Three Characteristic Patterns of Subjetive Fatigue Symptoms. Ergonomics, 21(3), 231-233.

# ANALYSIS OF RISKS CAUSED BY FATIGUE IN REPETITIVE WORK.

**Gerardo Meza Partida, Luis Angel Gámez Dávila, Enrique Javier De la Vega Bustillos, Francisco Octavio López Millán, Teresita de Jesús Velarde Talamante.**

División de Estudios de Posgrado e Investigación.
Tecnológico Nacional de México/Instituto Tecnológico de Hermosillo,
Ave. Tecnológico y Periférico Poniente S/N Colonia Sahuaro.
Hermosillo, Sonora, México. C.P. 83170
E mail: gerardo.mezap@hermosillo.tecnm.mx

**Resumen:** El servicio de centro de atención de llamadas telefónicas (Call Center) ha tenido un gran crecimiento debido al bajo costo de las llamadas para brindar servicio a los ciudadanos y gracias a su sistema e infraestructura. La industria del servicio al cliente, marketing y ventas son algunos de los ejemplos del uso que se le está dando a este recurso. Los trabajadores de estos centros es un grupo que tiene un impacto grande en caso de problemas musculares y en articulaciones debido a extensos periodos de tiempo sentados y haciendo trabajo repetitivo, esto sin mencionar problemas en la vista, oídos y garganta que se pueden generar en este tipo de labor. Para disminuir y prevenir este tipo de riesgos en la salud de los trabajadores, se debe analizar las causas de fatiga y dar un entrenamiento de los riesgos sobre las afectaciones que puede tener para la salud al personal que está expuesto a este tipo de trabajo, además del diseño de la estación en la que el empleado realiza su trabajo, esta debe ser mejorada en base a los principios ergonómicos.

**Palabras clave:** Trabajo repetitivo, análisis de fatiga, desórdenes musculo-esqueléticos.

**Abstract:** The telephone call center service (Call Center) has had a great growth due to the low cost of calls to provide service to citizens and thanks to its system and infrastructure. The customer service, marketing and sales industry are some of the examples of the use that is being given to this resource. The workers of these centers is a group that has a great impact in case of muscle and joint problems due to long periods of time sitting and doing repetitive work, this not to mention problems in the sight, ears and throat that can be generated in this type of work. In order to reduce and prevent this type of risk to the health of workers, the causes of fatigue must be analyzed and a training on the risks on the health effects that may have on the personnel who is exposed to this type of work should be given, in addition of the design of the station in which the employee performs his work, it must be improved based on ergonomic principles.

**Key words:** Repetitive work, analysis of fatigue, musculoskeletal disorders.

## 1. INTRODUCTION

Fatigue is an indicator that something must be taken care of in the working conditions that are carried out. The consequences of not doing so can affect our health, well-being and that of others; in productive capacity and efficiency; in social and economic costs. In the workplace it is also related to demotivation, increased absenteeism and job turnover (Yamin, et al 2020).

Fatigue in the upper extremities of the body in people who perform repetitive typing on a computer has been inevitable in this age of technology and in addition to the current situation of the health contingency due to COVID 19, which forces a large part of the working and school population to carry out their work from home. The body has been stretched every so often, mainly by hand to de-stress it during the working day and even with this, it has not been possible to eradicate at all the fatigue of the hands and wrist in the company. This is where the problem of conducting a study is found, because it is repetitive work and throughout the day, finding a position that when typing is minimal fatigue (Kar &Hedge, 2020).

Computer typing postures are important because typing is necessary during a workday. Ergonomics plays an indispensable role in this activity, which is why it is necessary to reduce or optimally eradicate fatigue mainly in the hands. It will be determined with the application of the Nordic questionnaire (Kourinka, et al 1987) in repetitive typing, which are the most common annoyances during the capture of the information of the surveys carried out by telephone. Musculoskeletal disorders (MSD) related to this type of repetitive work constitute one of the most common health problems and therefore relevant to be addressed by occupational health and safety. In the report "The prevention of occupational diseases" of the International Labor Organization (ILO) of 2019, it refers that MSD are the most frequent disorders in the European Union (ILO, 2020). Also, in 2019 these disorders represented 31% of the total cases of non-fatal work injuries and illnesses reported by the United States Department of Labor Statistics (U.S. Bureau of Labor Statistics, 2020).

## 2. OBJECTIVES

The general objective of this study is to analyze the anatomical area that presents fatigue when using a computer keyboard as a working tool with the support of the Nordic musculoskeletal questionnaire.

### 2.1 Limitations

The study will only represent people without previous muscular disorders, so the risks that the work entails for workers with previous illnesses or injuries cannot be defined. In addition, the results may not fully agree with previous studies due to the conditions of the volunteers when performing the test and this only covers the basic positions when using the keyboard

## 3. METHODOLOGY

The experiment will be carried out based on a study previously carried out by Kuorinka, et al (1987), who used the same procedure that is intended to be used in this research. In this study, two groups of volunteers will be used, one of 16 and the other of 19 test subjects who are dedicated to using the computer during their workday, healthy and without previous muscular disorders, the questionnaire will be applied individually once who have completed their working day on typing.

This survey consists of the worker answering according to the symptoms caused by repetitive work in his usual work day. The information obtained will be analyzed to determine the parts of the body that most cause discomfort and fatigue. Minitab 17 software will be used for statistical analysis. Previous studies showed that there was a high ergonomic risk in which they were exposed to suffering from MSD. To prevent this, there must be ergonomic training for workers, so that they know the risk factors in the office and work area. In addition, the behavior of the staff and the design of the work stations should be improved according to the ergonomic principles.

## 4. RESULTS

By applying the questionnaires, information is obtained on discomfort in the neck, shoulders, elbows, hand / wrist, upper back, lower back, hips, knees and feet. With the data obtained, it is possible to know which anatomical area produces more ailment and causes fatigue, with which the risks of contracting an MSD can be known. Table 1 shows the results of the application of the questionnaire.

Table 1. Application of questionnaires in call center 1 and call center 2

| | | Call center 1 (n=16) | | | Call center 2 (n=19) | | |
|---|---|---|---|---|---|---|---|
| | | Freq. | Pct | Pct acc | | Pct | Pct acc % |
| | | | % | % | Freq. | % | |
| Neck | No | 11 | 68.8 | 68.8 | 13 | 68.4 | 68.4 |
| | Yes | 5 | 31.3 | 100 | 6 | 31.6 | 100 |
| Shoulder | No | 6 | 37.5 | 37.5 | 7 | 36.84 | 36.84 |
| | Right | 2 | 12.5 | 50 | 2 | 10.53 | 47.37 |
| | Left | 2 | 12.5 | 62.5 | 4 | 21.05 | 68.42 |
| | Both | 6 | 37.5 | 100 | 6 | 31.58 | 100 |
| Elbow | No | 13 | 81.3 | 81.3 | 18 | 94.7 | 94.7 |
| | Right | 2 | 12.5 | 93.8 | 0 | 0 | 94.7 |
| | Left | 1 | 6.3 | 100 | 1 | 5.3 | 100 |
| | Both | 0 | 0 | 100 | 0 | 0 | 100 |
| Hand/Wrist | No | 13 | 81.3 | 81.3 | 14 | 73.7 | 73.7 |
| | Right | 3 | 18.8 | 100 | 4 | 21.1 | 94.7 |
| | Left | 0 | 0 | 100 | 1 | 5.3 | 100 |
| | Both | 0 | 0 | 100 | 0 | 0 | 100 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Upper Back | No | 12 | 75 | 75 | 12 | 63.2 | 63.2 |
| | Yes | 4 | 25 | 100 | 7 | 36.8 | 100 |
| Lower Back | No | 5 | 31.25 | 31.25 | 11 | 42.1 | 42.1 |
| | Yes | 11 | 68.75 | 100 | 8 | 57.9 | 100 |
| Hips | No | 16 | 100 | 100 | 19 | 100 | 100 |
| | Yes | 0 | 0 | 100 | 0 | 0 | 100 |
| Knee | No | 15 | 93.75 | 93.75 | 19 | 100 | 100 |
| | Yes | 1 | 6.25 | 100 | 0 | 0 | 100 |
| Feet | No | 14 | 87.5 | 87.5 | 19 | 100 | 100 |
| | Yes | 2 | 12.5 | 100 | 0 | 0 | 100 |

With the information obtained, it is known that the anatomical areas of the lumbar area and the shoulders are the sections that present the most ailments, which can be observed as a total percentage both in call center 1 and in call center 2, as shown in table 2:

Table 2. Percentage of cases by anatomical area

| **Anatomical area** | **Call Center 1** | **Call Center 2** |
|---|---|---|
| Neck | 31.3 | 31.6 |
| Shoulder | 62.5 | 63.15 |
| Elbow | 18.8 | 5.3 |
| Hand/Wrist | 18.8 | 26.4 |
| Upper Back | 25 | 36.8 |
| Lower Back | 68.75 | 57.9 |
| Hips | 0 | 0 |
| Knee | 6 | 0 |
| Feet | 12.5 | 0 |

It is observed that the highest percentage is 68.75, which occurs in the lower back pain relief area in the call center 1 sample, followed by the anatomical area of the shoulders, which is 63.15 in the call center 2 sample. Note that call center 1 shows a similar result in the anatomical area of the shoulders with 62.5 percent of cases, as shown in figure 1.

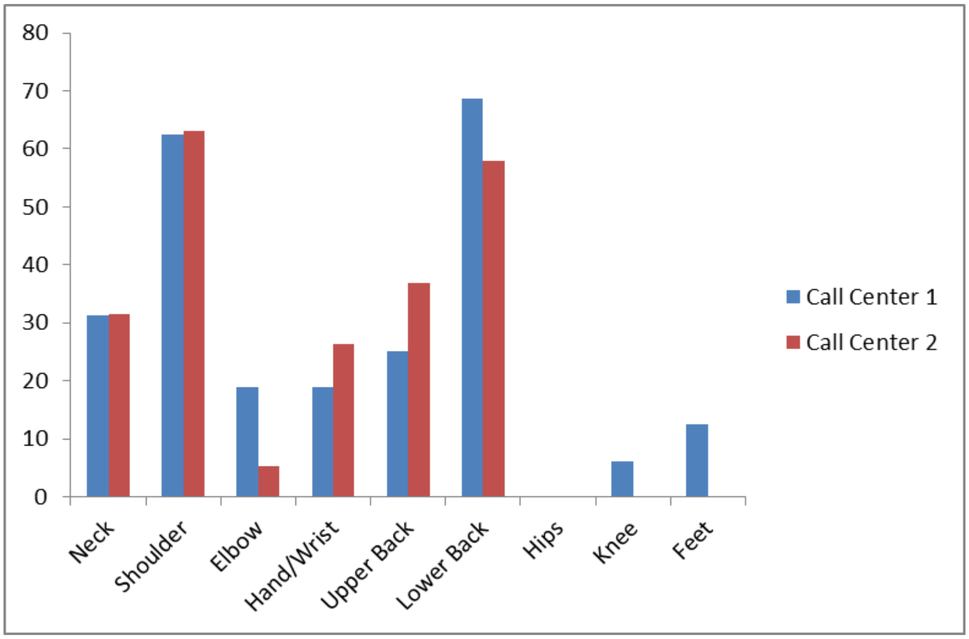



Figure 1. Cases presented in percentage by call center

Other anatomical areas affected are neck with 31.3% in call center 1 and 31.6% in call center 2; upper back with 25% in call center 1 and 36.8% in call center 2; hand / wrist with 18.8% in call center 1 and 26.4% in call center 2. To a lesser or no extent, the affected areas are elbow, hips, knees and feet.

## 5. CONCLUSIONS

Given the conditions caused by the confinement that is occurring, it has become a necessity to develop office work at home, similar to that of a call center. The considerations for this safe work at home are the same as in the office, specifically in the use of computer equipment. Sure, some adaptations will have to be made at home to adapt the workplace, so the recommendations are practically the same; maintain good work postures, schedule recovery periods, have adequate environmental conditions, however, the furniture at home may be different from that in the office, it is then necessary to try to adapt the work station as well as possible. For example, if the chair does not allow height or depth adjustments, it is possible to use cushions to maintain good posture, basically to adjust the height and to provide lumbar support, which is presented as one of the biggest complaints of the study.

These indications will help reduce the risk of contracting an MSD and to a great extent, prevent fatigue mainly in the anatomical areas of the lower back and shoulders. The work risk factors observed in the study are: work space, work surface, chair, monitor, keyboard, mouse, additional equipment, environmental conditions, work organization, workload, work intensity, periods of work, rest, work hours and personal factors.

# 6. REFERENCES

Kar, G. & Hedge, A. (2020). Effects of a sit-stand-walk intervention on musculoskeletal discomfort, productivity, and perceived physical and mental fatigue, for computer-based work. *International Journal of Industrial Ergonomics.* Vol 78, 102983

Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sorensen F, Anderson G. & Jorgensen, K. (1987). Standardised Nordic questionaries for the analysis of musculoskeletal symptoms. *Applied Ergonomics*. 18 (3):233-7.

International Labour Organization. www.ilo.org Consulted 02/03/2020

U.S. Bureau of Labor Statistics. www.bls.gov/iif/ Consulted 02/14/2020

Yamin, R.; Wahyu, A.; Ishak, H.; Salmah, U. & Paatittingi, F. (2020). Effect of BMI, workload, work fatigue, and complaints of musculoskeletal disorders on nurse performance in Sawerigading Hospital Palopo

# DETERMINATION OF FATIGUE IN A SEAMSTRESS IN LOS MOCHIS, SINALOA, MEXICO

**Indeliza Armenta Acosta, Ana María Almeida Soto, Silvia Iveth Félix Egurrola, Raudel López Palafox, Christian Alejandro Vizcarra Castro**

Department of Industrial Engineering
Tecnológico Nacional de México/Instituto Tecnológico de Los Mochis
Juan de Dios Batiz Blvd. and 20 Noviembre
Los Mochis, Sinaloa 81259

indel5@hotmail.com, anm.als@hotmail.com, ivethfe@gmail.com, raudellopez16@gmail.com[4], christian.vizcarra@hotmail.com.

**Resumen** La evaluación ergonómica, ya sea de fatiga/molestia o postural, de los pequeños empresarios como en este caso el taller de costura, resulta relevante pues normalmente dejamos de lado los riesgos que se presentan en los trabajos cotidianos o de menor impacto, sin tomar en cuenta que, al ser mayormente realizados de forma manual por su reducida producción en comparación con las grandes industrias, suelen presentarse lesiones y problemas concurrentes en los operarios.

Por esto, se realizará un estudio por medio del cuestionario Yoshitake a una costurera de Los Mochis Sinaloa, Mexico, que opera en un pequeño taller para descubrir si existen molestias o presenta fatiga al llevar a cabo su trabajo por 3 semanas. Se tomaran en cuenta los factores que intervienen: como el área o estación de trabajo, el ambiente (iluminación, ruido, espacio), entre otros.

Este cuestionario de síntomas subjetivos de fatiga Yoshitake evalúa tres áreas:

a) Síntomas generales de fatiga (somnolencia y monotonía)
b) Fatiga mental (dificultad en la concentración mental)
c) Fatiga física (proyección de deterioro físico).

**Palabras clave:** Yoshitake, Ergonomia, Fatiga, Costura.

**Relevancia para la ergonomía:** Es importante el estudio de las pequeñas o microempresas (taller de costura) en el ámbito ergonómico y ver por la salud y bienestar de los trabajadores.

**Summary** Ergonomic evaluation, whether fatigue / discomfort or postural in small entrepreneurs as in this case the sewing workshop, is relevant because usually we ignore the risks that arise in everyday or low impact work, regardless that, being mostly performed manually by the reduced production compared to large industries. Injuries and problem in the operators often occur.

Thus, a study will be conducted through the questionnaire Yoshitake to a seamstress of Los Mochis, Sinaloa, Mexico, who works in a small workshop to discover whether there are discomfort or fatigue presents in carrying out their work over 3 weeks. Different factors involved are taken into account: as the area or workstation, the environment (lighting, noise, and space), an others.

This questionnaire subjective symptoms of fatigue Yoshitake evaluates three areas:

a) General symptoms of fatigue (sleepiness and monotony)
b) Mental fatigue (difficulty in mental concentration)
c) Physical Fatigue (projection physical deterioration).

**Keywords:** Yoshitake, ergonomics, fatigue, Sewing.

**Relevance to ergonomics:** It is important the study of small or micro (sewing) in the ergonomic field and see for the health and welfare of workers.

## 1. INTRODUCTION

In many activities dedicated to the manufacture, is in addition to safety accidents other problems occur, perhaps more hidden but no less important, they have a lot to do with a correct approach of what the ergonomics of ( furniture, lighting, noise ...) and also with the organization of work (schedules, division of responsibilities, communication, workload, etc.).

It refers to health problems such as: muscle ailments, eye disorders, stress or physical and mental fatigue. Many people suffer these ailments, ignoring the relationship that may exist between their illness and poor job design and work organization. However, from the ergonomic field there is a clear association between such problems and activities that involve repetitive work, awkward postures, excessive pace of work, using hand tools, cargo handling, etc.

There are several methods to assess work fatigue. One of them, we will be using is Yoshitake questionnaire.

The ESSF (Scale of Subjective Symptoms of Fatigue) of Yoshitake is one instrument that has been used especially in Latin America, the references found are divided into two groups: those that only report their application and exploring the validity of the scale, the above can be seen in the following investigations:

(O & A., 1997), They conducted an exploratory study 42 display screens operators who worked continuously in the introduction or data capture, with the criterion that at least work 4 hours. a day in front of the screen, they had completed a minimum of 1 year and 6 months in the work and that their ages were between 20 and 40, the latter was done so that the condition will not result significantly influenced by age. The aim of this study was to determine the possible association of this work activity with pathological changes, the presence of fatigue and stress. By questioning the health status variables (visual disturbances, posture-related symptoms, impaired health and history gynecology) and psychological (chronic state of stress were obtained, subjective feeling of fatigue and activation level of the cerebral cortex as an indicator of fatigue), ergonomic (lighting, microclimate and job design), working time and seniority in office. In the study, it was also applied the ESSF, with the interest to know the subjective perception of fatigue in the investigation staff. This was applied after - 117 - culmination of the workday. Relationship between alterations frequently reported health (fatigue, eye and nervous disorders) and the existence of poor ergonomic conditions observed, all associated with stressful situations.

Villegas meanwhile, Martinez and Noriega (C. 2002) Also they conducted a study of fatigue and its synergistic effect on occupational morbidity, due to the importance of fatigue to explain phenomena of disease, as well as considered as a negative effect of work. The objective of this study was to analyze fatigue mediating between various variables work and certain psychic and psychosomatic disorders; to achieve this goal, it took a sample of 830 employees of a steel company, a survey to gather information on the process and characteristics of work and ESSF; for epidemiological and logistical statistical analysis methods were used to analyze the interaction between two or more working requirements in generating morbidity. The results show fatigue as a widespread problem for workers in the whole process with significant differences depending on the area and type of activity. In this research the high frequency fatigue resulting from the joint action of various elements of the work process and the role it can play as a mediator effect of other health disorders shown.

In a more recent review (Barrientos, 2004) They claim that the ESSF of Yoshitake has been used in Cuba, Mexico, Venezuela and Brazil, with workers from different areas, such as journalists, air traffic controllers, steelworkers and soft drink.

## 2. OBJECTIVES

### 2.1 GENERAL PURPOSE

- To determine the causes of fatigue and discomfort in a seamstress in Los Mochis, Sinaloa, Mexico.

### 2.2 SPECIFIC OBJECTIVES

- To implement the Yoshitake questionnaire to the seamstress.
- To identify the inconvenience presented by the seamstress.
- To identify symptoms of fatigue seamstress.

## 3. DELIMITATIONS

This study was conducted to job performance of a seamstress of Los Mochis, Sinaloa, Mexico. Evaluated by questionnaire Yoshitake discomfort and fatigue that occur over 3 weeks.

## 4. METHODOLOGY

The following research has a descriptive study characterizes as the causes of fatigue on the operator's conduct presented in their job performance.

The research design is quantitative. It is a non-experimental research because there is no manipulation of the study subjects, and are going to observe phenomenal as occur in their natural context for later analysis.

It is descriptive Transversal, because the data will be obtained during the research being collected at one time, in order to describe the causes leading to fatigue.

To carry out this study, the test was applied Yoshitake: This test was built in 1967 and since then applied to further studies of fatigue. This questionnaire subjective symptoms of fatigue Yoshitake evaluates three areas:

a) General symptoms of fatigue (sleepiness and monotony)

b) Mental fatigue (difficulty in mental concentration)

c) Physical Fatigue (projection physical deterioration).

According (Yoshitake, 1978) The concept of fatigue is a common effect to all activities that require effort and strain and appears when the amount of effort required exceeds the possibility of individual response, which translates into a series of physical and mental dysfunctions, accompanied a subjective perception of fatigue and decreased performance. From this concept the committee for the investigation of industrial fatigue, Industrial Health Association of Japan in 1954 developed the test of subjective symptoms of fatigue (PSSF); which it consists of 30 items that explore the presence of symptoms that originally were classified into three sensory physical, mental and neuro groups. Saito, Kogi and Kishigawi in 1970 underwent factorial validity of the instrument getting three factors: drowsiness and heaviness,(Yoshitake, 1978)

Yoshitake in 1978 the first factor associated with undifferentiated work, the second and the third physical work with mental work; further proposed test score through the percentage of positive proposals(Hiroshi Saito, 1970)

The questionnaire consists of 30 questions, 10 in each field (general symptoms, mental fatigue and physical fatigue), you can see the questionnaire in "Annex 1".

When handling the weekly study, the questionnaire is presented as follows each question:

1. Tiene algunas dificultades para pensar cuando realiza sus tareas

| | L | | M | | M | | J | | V | | S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Entrada | S | N | S | N | S | N | S | N | S | N | S | N |
| Salida | S | N | S | N | S | N | S | N | S | N | S | N |

*Figure 1. Example questionnaire Yoshitake.*

The following tables collected and mentioned in the present investigation. *Below is an example of the format of what the Yoshitake questionnaire is and all its sections to be filled out.*

*Table 1. Yoshitake questionnaire.*

SUBJECTIVE PATTERNS FATIGUE (PSF)
Yoshitake, Japan. 1978. Ver. 5, INSAT, Cuba. 1987

Name: ______________________________________ Date: ________ Time: ______
Position: ____________________________________ Age: _____ Sex: _______
Experience since: _________________ Workplace: _________________
RESPOND WITH A CROSS (X) if at the end of workday O
AFTER WORK HAS ONE OF THE FOLLOWING SYMPTOMS:

| **SYMPTOM** | **YES** | **NO** |
|---|---|---|
| 1 feel heaviness in the head? | | |
| 2 Feeling tired in the body? | | |
| 3 Feel tired legs? | | |
| 4 Is yawned desires? | | |
| 5 Do you feel confused, bewildered? | | |
| 6 Do you feel eyestrain? | | |
| 7 Do you feel stiffness or clumsiness? | | |
| 8 Is feeling sleepy? | | |
| 9 When standing is concerned? | | |
| 10 Do you have desire to bed? | | |
| Type 1 | | |
| 11 Feel difficulty thinking? | | |
| 12 Were tired to talk? | | |
| 13 Are you nervous? | | |
| 14 Do you feel unable to focus attention? | | |
| 15 Do you feel unable to pay attention to something? | | |
| 16 Are you easily forget things? | | |
| 17 Have you lost confidence in itself? | | |
| 18 Do you feel anxious? | | |
| 19 Do you keep your body in incorrect positions? | | |
| 20 Is easily lose patience? | | |
| type 2 | | |
| 21 Does it present a headache? | | |
| 22 Do you feel numbness in the shoulders? | | |
| 23 Do you feel pain? | | |
| 24 Do you have trouble breathing? | | |
| 25 Are you thirsty | | |
| 26 Do you feel groggy? | | |
| 27 Do you feel his voice hoarse? | | |
| 28 Would you tremble eyelids? | | |

29 Would you tremble legs or arms?
30 Do you feel sick?

type 3

$$FQF = \frac{NUMERO\ DE\ \text{“}SI\text{”}\ CONTESTADOS}{NUMERO\ DE\ PREGUNTAS\ TOTALES} X100 \quad (1)$$

Below is a set of tables that are part of the questionnaire separated by types, sections or symptoms.

*Table 2. Example of weekly questionnaire*

a) General symptoms of fatigue (sleepiness and monotony)

**1. Feel heaviness in the head?**

| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**2. Feeling tired in the body?**

| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**3. Feel tired legs?**

| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**4. Is yawned desires?**

| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**5. Do you feel confused, bewildered?**

| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**6. Do you feel eyestrain?**

| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**7. Do you feel stiffness or clumsiness**?

| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**8. Is feeling sleepy?**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**9. When standing is concerned?**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**10. Do you have desire to bed?**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

b) Mental fatigue (difficulty in mental concentration)

**11. Feel difficulty thinking?**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**12. Were tired to talk?**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**13. Are you nervous?**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**14. Do you feel unable to focus attention?**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**15. Do you feel unable to pay attention to something?**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**16.** Are you easily forget things?

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

**17. Have you lost confidence in itself?**

| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| 18. Do you feel anxious? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| 19. Do you keep your body in incorrect positions? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| 20. Is easily lose patience? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

c) Physical Fatigue (projection physical deterioration).

| 21. Does it present a headache? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| 22. Do you feel numbness in the shoulders? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| 23. Do you feel pain? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| 24. Do you have trouble breathing? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| 25. Are you thirsty? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| 26. Do you feel groggy? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| 27. Do you feel his voice hoarse? | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
| In | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Out | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| **28. Would you tremble eyelids?.** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| **29. Would you tremble legs or arms?** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

| **30. Do you feel sick?** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Monday** | | **Tuesday** | | **Wednesday** | | **Thursday** | | **Friday** | |
| **In** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| **Out** | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |

## 5. RESULTS

The work of a seamstress who is 46 years old for 3 weeks was analyzed. Dedicates between 4 and 5 hours daily from Monday to Friday to do the tasks, which may vary in intensity depending on the customer's order in question.

*Figure 2. Example costumer.* The person in charge of the work doing ergonomic work.

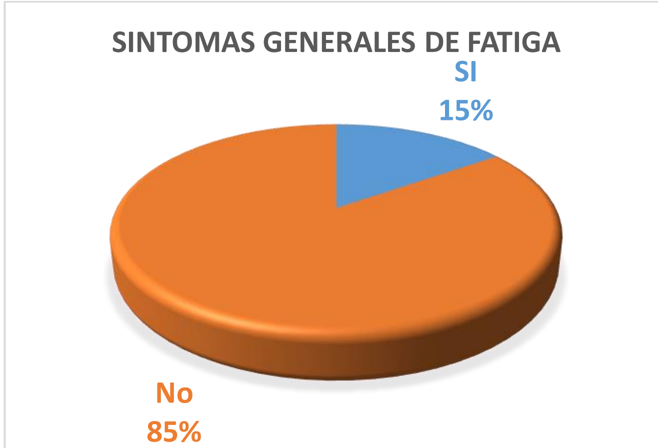
*Figure 3. Example costumer 2.* The person cutting the fabric in an ergonomic way.

Sought to identify the discomfort and symptoms, such as mental fatigue and physical fatigue with the application of the questionnaire Yoshitake. Followed by application of the formula for calculating the frequency Complaint Fatigue (FQF):

$$FQF = \frac{NUMERO\ DE\ \text{SI}\ CONTESTADOS}{NUMERO\ DE\ PREGUNTAS\ TOTALES} X100 \qquad (1)$$

*Figure 4. Filling format.* The worker filling the Yoshitake Format.

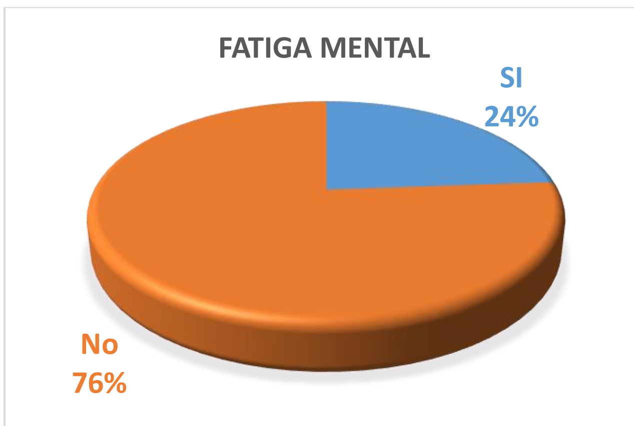
The results of FQF in 3 weeks and the questionnaire Yoshitake according to the number of answers "YES" and "NO" given in each field of evaluation: General symptoms of fatigue (sleepiness and monotony), fatigue Mental (difficulty in concentration mental) and physical fatigue (physical deterioration projection) are presented in the following graphs and equations:




*Graph 1. General symptoms of fatigue*

$$FQF = \frac{54}{300} * 100 \quad (2)$$

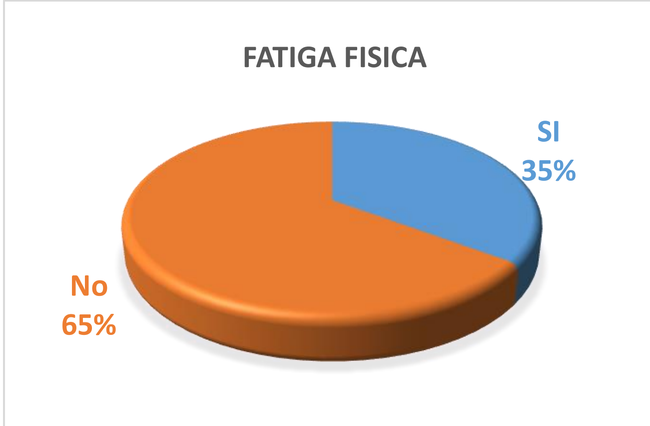
Resulting in 18% frequency complain of fatigue and sleepiness monotony.




*Graph 2. Mental fatigue*

$$FQF = \frac{94}{300} * 100 \quad (3)$$

Resulting in 31.33% of FQF the difficulty of mental concentration.




*Graph 3. Physical fatigue.*

$$FQF = \frac{163}{300} * 100$$
(4)

And finally, it is presented a 54.33% of the projection FQF physical deterioration.

Other situations linked with the position of the operator were also observed. So he commented on acute low back pain, which could result from the time when she are sitting or posture that acquires by making cuts on a table.

## 6. CONCLUSIONS

Thanks to the method implemented and observing the results we can see that the factor predominates negatively on the implementation of the questionnaire Yoshitake is physical fatigue factor or projection of physical deterioration with 35% of answers "YES" with respect to the total found 10 questions in this field. Giving as an example some aspects such as: headache, shoulder tension, back pain and general malaise (feeling ill or sick).

Without neglecting the other two fields: drowsiness and monotony and mental fatigue, where fatigue percentages also presented. Making it clear that there is a relationship between the problems of the seamstress and ergonomics, for the activities in which repetitive tasks are involved, bad posture, the pace of work and hand movements.

## 7. RECOMMENDATIONS

According to the results of the questionnaire Yoshitake, it is recommended in relation to physical fatigue, educate seamstress, in this case, to assume postures to avoid discomfort, exercises to reduce discomfort and pain in the body parts that are predominated.

It is proposed to do stretch and ergonomic exercises and regular breaks throughout your workday. Adapted for not necessary to leave the work area and not to increase fatigue and discomfort in the last hours and tasks of the day.

It also recommends carrying out other methods of assessing ergonomic hazards with postural approach, as might be the RULA (Rapid Assessment of Upper Extremity) method. Because injuries and pains that could be derived from the position adopted by the seamstress to do some of your tasks, such as cutting occurred.

## 8. REFERENCES

Barrientos, M. and. (2004). Construct validity, reliability and cut-off Test subjective symptoms of fatigue in Mexican workers. SciELO - Scientific Electronic Library Online 9..

C., VJ (2002). Fatigue and its synergistic effect on occupational morbidity. Mexico. DF .: Metropolitana- Xochimilco Autonomous University.

Hiroshi Saito, S. (1970). The stability of W / O type emulsions as a function of temperature and of the hydrophilic chain length of the emulsifier. Journal of Colloid and Interface Science, 647-651.

O, G., & A., SC (1997). Association of operators of pathological condesórdenes display screens, fatigue and stress. Vol. 35. Cuban Journal of Hygiene and Epidemiology, 65-73.

Yoshitake, H. (1978). Subjective Characteristics Three patterns of fatigue symptoms. Vol. 21. Ergonomics, 231-233.

# ANALYSIS AND ERGONOMIC EVALUATION OF THE ENGRAVING AREA

**Jacqueline Samara Cerón Aguirre[1], Nancy Karina López Aguilar[1], Arturo Realyvásquez Vargas[1], Guadalupe Hernández Escobedo[1], Karina Cecilia Arredondo Soto[2]**

[1]Department of Industrial Engineering
Instituto Tecnológico de Tijuana
Calzada del Tecnológico S/N
Thomás Aquino
Tijuana, Baja California 22414
Corresponding author's e-mail: arturo.realyvazquez@tectijuana.edu.mx

[2]Chemical Sciences and Engineering Faculty
Universidad Autónoma de Baja California
Calzada Universidad #14418
Parque Industrial Internacional
Tijuana, Baja California 22390

**Resumen:** La Ergonomía es una disciplina científica que se enfoca en adaptar los elementos de un sistema de trabajo a las capacidades y limitaciones de las personas con la finalidad de mejorar sus condiciones de salud, seguridad, bienestar y desempeño. Sin embargo, aún hoy en día, existen diferentes factores de riesgo a los cuales los trabajadores de cualquier sector industrial están expuestos. Esta investigación presenta una evaluación ergonómica en una empresa de fabricación de automóviles localizada en la ciudad de Tijuana, México. Específicamente, se evalúa el nivel de riesgo causado por la postura corporal adoptada por un trabajador en el área de grabado. Para realizar tal evaluación se utiliza el método RULA. Los resultados obtenidos indicaron que, para el lado derecho del trabajador, la puntuación RULA fue de 7, mientras que para el lado izquierdo fue de 6. Con base en estos resultados se puede decir que el trabajador está en riesgo de sufrir desórdenes musculoesqueléticos. Debido a esto, la tarea y/o la estación de trabajo deben ser rediseñadas desde un enfoque ergonómico.

**Palabras clave:** Postura incómoda, RULA, métodos ergonómicos, riesgo ergonómico

**Relevancia para la ergonomía:** En México, las empresas deben cumplir con aspectos ergonómicos que les indica la Norma Oficial Mexicana. Actualmente, muchas empresas en México, específicamente en Tijuana, desconocen los riesgos a los cuales se exponen sus trabajadores por mal diseño de estaciones y métodos de trabajo. Este proyecto aporta a la ergonomía en el hecho de que permite que las empresas tengan un mayor conocimiento sobre el riesgo causado por posturas corporales, cómo evaluar dicho riesgo, y cómo reducirlo.

**Abstract:** Ergonomics is a scientific discipline that focuses on adapting the elements of a work system to the capacities and limitations of people with the modification of improving their health, safety, well-being and performance conditions. However, even today, there are different risk factors to which workers in any industrial sector are exposed. This research presents an ergonomic evaluation in a car manufacturing company located in the city of Tijuana, Mexico. Specifically, this research evaluates the risk level caused by the body posture adopted by a worker in the engraving area. To perform such an evaluation, the RULA method is used. The results obtained indicate that, for the right side of the worker, the RULA score was 7, while for the left side it was 6. Based on these results, it can be said that the worker is at risk of suffering musculoskeletal disorders. Because of this, the task and / or workstation must be redesigned from an ergonomic approach.

**Keywords:** Awkward posture, RULA, ergonomic methods, ergonomic risk

**Relevance to Ergonomics:** Relevance for ergonomics: In Mexico, companies must comply with ergonomic aspects indicated in the Official Mexican Standard. Currently many companies in Mexico, specifically in Tijuana, are unaware of the risks to which their workers are exposed due to poor design of stations and work methods. This project contributes to ergonomics in that it allows companies to have a better understanding of the risk caused by body postures, how to assess this risk, and how to reduce it.

## 1. INTRODUCCIÓN

Ergonomics is a fundamental base in every activity people carry out, both in daily life and in working life. The definition adopted by the council of the International Association of Ergonomics (IEA) in August 2000 is that ergonomics is a scientific discipline of a multidisciplinary nature, which studies the relationships between man, the activity he performs and the elements of the system in which he is immersed, in order to reduce the physical, mental and psychological loads of the individual and to adapt the products, systems, workplaces and environments to the characteristics, limitations and needs of its users; seeking to optimize its effectiveness, safety, comfort and the global performance of the system (Asociación de Ergonomía Argentina, 2016).

The company in which this research is carried out belongs to the automotive manufacturing sector, and its main activity consists in the assembly of shock absorbers. The company is located in the city of Tijuana, and it is dedicated to the assembly of motorcycle shock absorbers, muffler polishing and welding. The market location covered by the company is the United States.

In this project, the operator's working posture will be evaluated, which is at a distance of 60cm from the machine, in which it operates with an inclination of 60 degrees, having a rigid position of both the right and left arm and taking Keep in mind that the position of the wrists are in such a way that the operator tends to force them, while, with the right wrist, it is tightened to work on the positioning of the engraving piece that goes on the shock absorber. The posture adopted by the worker is shown in Figure 1. This research evaluates this posture with the Rapid Upper Limbs Assessment (RULA) method in order to make the necessary recommendations so that the operator does not present injuries in the short or long term, avoiding all physical wear on the operator and discomfort due to the posture that he is forced to take.

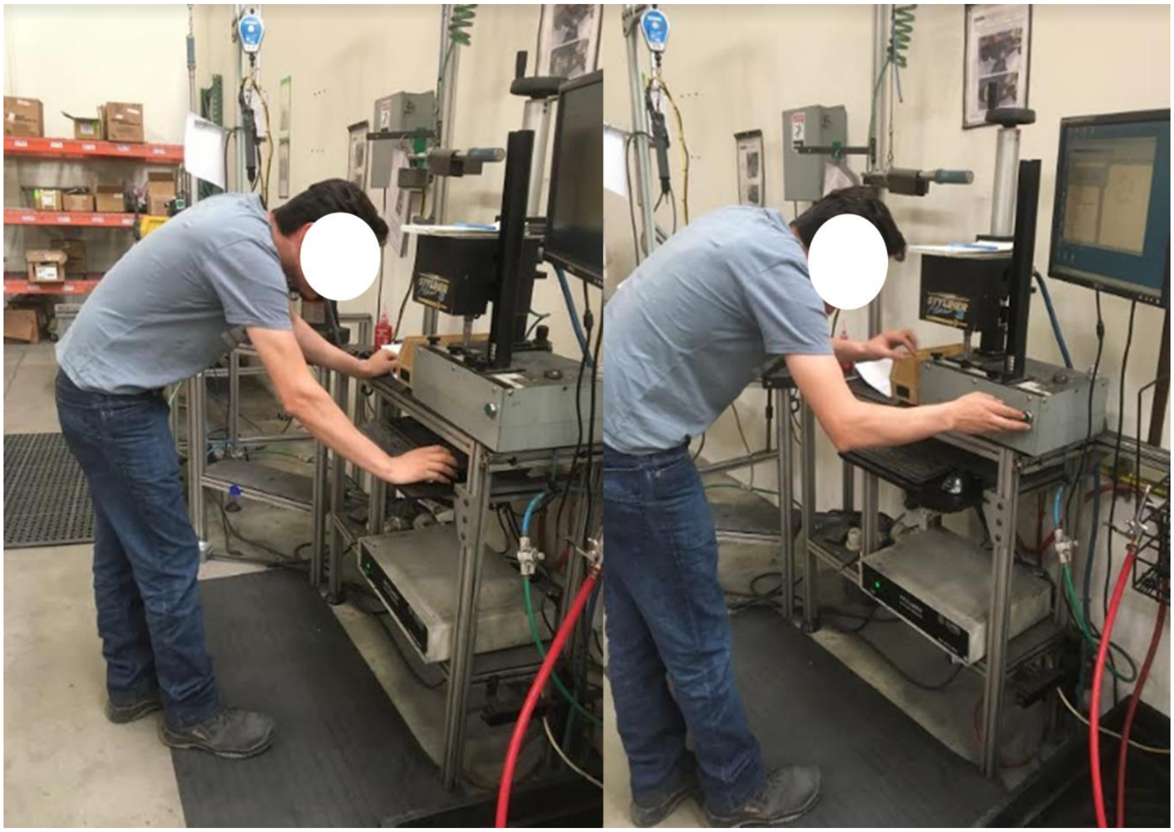


Figure 1. Posture adopted by the worker in engraving area.

## 2. OBJECTIVE

The objective of this research is to determine the level of risk caused by the postural load on the operator of the engraving area.

## 3. DELIMITATION

The project is limited to evaluating the level of risk caused by uncomfortable positions only in the engraving area. It does not assess the level of risk caused by other factors such as repetitive movements, manual handling of loads, environmental conditions, or cognitive aspects.

## 4. METHODOLOGY

The stages into which the project was divided to carry out each of the evaluation points are presented below.

**Stage 1:** Risk Recognition
**Stage 2:** Identification of Ergonomic Risk Factors
**Stage 3:** Position Recognition
**Stage 4:** Assessment of Localized Risk Factors
**Stage 5:** Risk Rating
**Stage 6:** Recommendations

Stages 1 and 2 are materialized by preparing an M.R.E. o Ergonomic risk map. This allows to list all the Sectors, Positions and Tasks of the company, identifying for each one, the type of ergonomic risk present and the level of exposure (using a simple traffic light type identification system), according to the definition of the map. of risks as an informative instrument that, by means of descriptive information and adequate indicators, allows to know the situations of occupational risk and the exposed workers that they affect, in this sense (Copa Arias, 2016).

Stages 3 to 5 comprise the Ergonomic Study Properly said, it is the application of the battery of tools designed for each particular case. It is the massive collection of specific data that after processing in the cabinet derives in the Preparation of the Comprehensive Ergonomic Study Report.

Stage 6 is comprised of the implementation of the Actions, within the framework of the Ergonomics Committee.

Due to the analysis carried out, the ergonomic method to evaluate this task was determined to be RULA due to the postural load that occurs during the execution of the task and the working day. For this, a field study was carried out in which the operator's position was analyzed. According to Diego-Mas, the Rula method was developed in 1993 by McAtamney and Corlett, from the University of Nottingham (Institute of Occupational Ergonomics), with the aim of evaluating the exposure of workers to risk factors that caused a high postural load and that They can cause disorders in the upper limbs of the body. For the evaluation of the risk, the posture adopted, its duration and frequency and the forces exerted when maintaining it are considered in the method (Diego-Mas, 2015).

For the implementation of the RULA method the following will be followed:

- Determine work cycles and observe the worker during several of these cycles.
- Select the positions to be evaluated.
- Determine if the left or right side of the body will be evaluated.
- Take the required angular data.
- Determine the scores for each part of the body.
- Obtain the partial and final scores of the method to determine the existence of risks and establish the Action Level.
- If required, determine what type of measures should be taken.
- Redesign the position or introduce changes to improve posture if necessary.
- If changes have been made, re-evaluate the posture with the RULA method to check the effectiveness of the improvement.

# 5. RESULTS

## 5.1 Evaluation with the RULA Method on the Right Side

Once the corresponding values were inserted in the ergonautas platform, the results were as shown in Figure 2.

Next, the results obtained from the right side in the ergonautas software are presented with the data and affected to the operator's posture, this gives as final score 7 due to the postural load of the operator is high and is always in the same position because the task is repetitive. According to the evaluation of the software, provide us with the postural load and the risk that this entails, based on this, the corresponding measures can be taken.

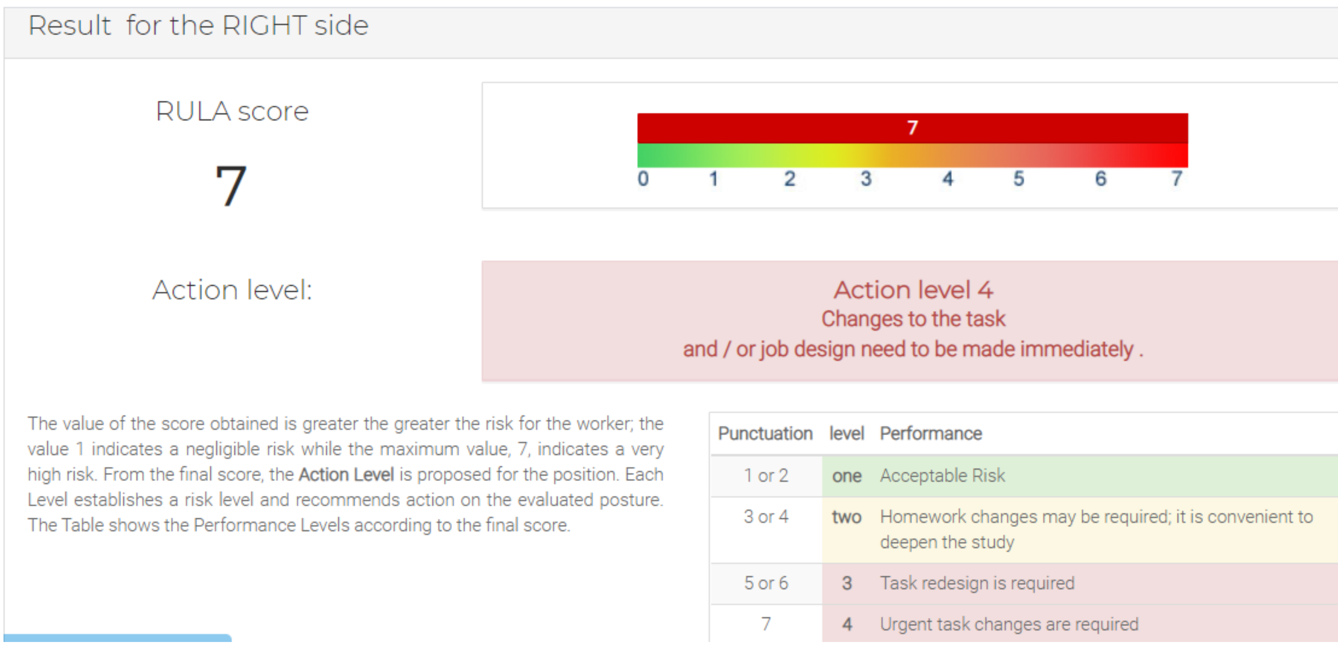



Figure 2. RULA right side results

Table 1 shows the score for group A and group B of the right side. Note that for the group A, the highest score was in the wrist, with 4 points. Similarly, in the group B the highest score was in the trunk with 5 points.

Table 1. RULA evaluation results right side

| Group A | | Group B | |
|---|---|---|---|
| Description | Score | Description | Score |

| | | | |
|---|---|---|---|
| The arm score is obtained from your degree of flexion / extension. | 2 +1 | The neck score is obtained from the flexion / extension measured by the angle formed by the axis of the head and the axis of the trunk. | 3 +1 |
| The forearm score is obtained from its flexion angle. | 1 +1 | The trunk score will depend on whether the worker performs the task sitting or standing. | 4 +1 |
| The wrist score is obtained from the flexion / extension angle, position and twist. | 3 +1 | The score of the legs will depend on the distribution of weight between them | 1 |
| The wrist position score is obtained from pronation or supination. | 1 | | |

Considering these values, the score for the group A is 4, whereas the score for the group B is 7.

Next, the results obtained from the left side in the ergonaut software are presented with the data and affected by the operator's posture, this gives as final score 6 due to the postural load of the operator is high and is always in the same position because the task is repetitive. According to the evaluation of the software, it provides us with the postural load and the risk that it entails, based on this, the corresponding measures can be taken, observing that the risk is high but not as high as the right one.

## 5.2 Evaluation with the RULA Method on the Left Side

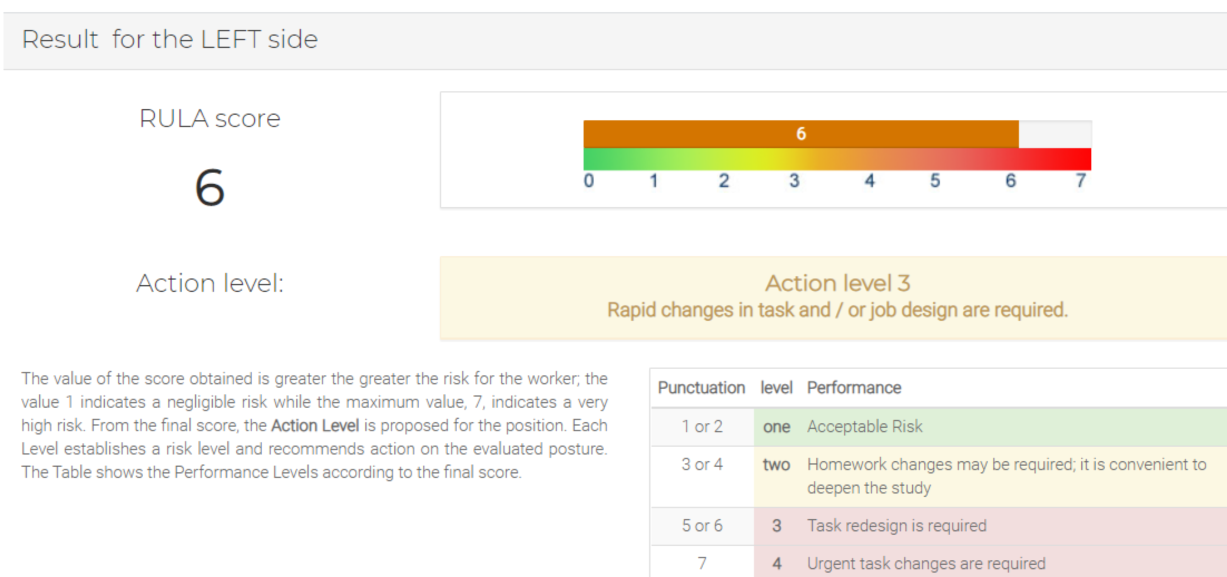



Figure 4. RULE left side results

Table 2 shows the score for group A and group B of the left side. Note that for the group A, the highest scores were in the forearm and the wrist, both with 4 points. Similarly, in the group B the highest score was in the trunk with 5 points.

Table 2. RULA evaluation results left side.

| Group A | | Group B | |
|---|---|---|---|
| Description | Score | Description | Score |
| The arm score is obtained from your degree of flexion / extension. | 2 -1 | The neck score is obtained from the flexion / extension measured by the angle formed by the axis of the head and the axis of the trunk. | 3 +1 |
| The forearm score is obtained from its flexion angle. | 1 +1 | The trunk score will depend on whether the worker performs the task sitting or standing. | 4 +1 |
| The wrist score is obtained from the flexion / extension angle, position and twist. | 2 +1 | The score of the legs will depend on the distribution of weight between them | 1 |
| The wrist position score is obtained from pronation or supination. | 1 | | |

Considering these values, the score for the group A es 4, whereas the score for the group B is 7. Table 3 shows the final RULA scores for the right and left sides. Note that both scores indicate that the task or workstation must be redesigned. Due to the worker does not remain static for more than one minute continuously, nor does he perform repetitive activity, the scores for groups A and B are not affected. In addition, the worker also does not carry material of more than 2 kg, so the score is also not affected by this item.

Table 3. Scores for the left and right side of group A and B

| | Right side | | Left side | |
|---|---|---|---|---|
| Group A | Description | Score | Description | Score |
| | Arm | 2+1 | Arm | 2+1 |
| | Forearm | 1+1 | Forearm | 1+1 |
| | Doll | 3+1 | Doll | 2 |
| Group B | Description | Score | Description | Score |
| | Neck | 3+1 | Neck | 4 |

| | | | | |
|---|---|---|---|---|
| | Trunk | 4+1 | Trunk | 5 |
| | Legs | 1 | Legs | 1 |
| Final score | | 7 | | 6 |

## 6. CONCLUSION

From the results obtained, it is concluded that the main thing is to analyze the workstations and the activity that the workers have when interacting with other elements of the work area. By implementing the RULA method, potential risks were detected, revealing opportunities for improvement and prevention for companies.

## 7. RECOMMENDATIONS

It is recommended to change the structure of the workstation as this causes great deterioration in the physical health of the operator, due to the bad postures that he is forced to take. It would be recommended to add some seat so that the torque of the wrist is less, and the force applied to it decreases, making the tension less. Also, with the seat, the angle of inclination of the neck would decrease considerably since these two factors are the most affected due to the working posture.

## 8. REFERENCES

Asociación de Ergonomía Argentina, 2016, Que es la Ergonomía, Asociación de Ergonomía Argentina en http://adeargentina.org.ar/segun-iea.html

Copa Arias, M., 2016, MAPA DE RIESGO ERGONÓMICO DE GALICIA, Instituto Galego de Seguridade e Saúde Laboral en http://www.oficinadoautonomo.gal/sites/default/files/mapa_de_riesgo_ergonomico_de_galicia_ES.pdf

Diego-Mas, J., 2015, Evaluación postural mediante el método RULA. Ergonautas, Universidad Politécnica de Valencia, en http://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

# STUDY OF 12-HOUR WORKING DAYS IN THE MANUFACTURING INDUSTRY

**Daniela Inzunza Robles, Enrique de la Vega Bustillos, Gilberto Orrantia Daniel, Germán Alonso Ruiz Dominguez, Rodolfo Ulises Rivera Landaverde**

División de Estudios de Posgrado e Investigación
Tecnológico Nacional de México/IT Hermosillo
Av. Tecnológico S/N, Col. El Sahuaro, CP. 83170
Hermosillo, Sonora, México
danniela.inzunza@hotmail.com, orrantiadaniel@hotmail.com, en_vega@ith.mx, gruiz@ith.mx, ulisesriv@yahoo.com.mx

**Resumen** Los trabajos de horas prolongadas, son una condición de trabajo presente en México y otros países en múltiples actividades tales como los servicios de salud, servicios públicos, industria manufacturera y empresas de transportes. Esta forma de organización, es parte de las condiciones laborales cuyo propósito es solventar las demandas de los procesos productivos.

En el presente estudio, se investigan los factores de riesgo de los turnos laborales de 12 horas, mediante un estudio de salud ocupacional, que incluye evaluación de fatiga, de riesgo ergonómico y factores de riesgo psicosocial, en una empresa manufacturera de la región, dedicada a la elaboración de arneses para la industria automotriz. Las evaluaciones del estudio, se realizan al área de transmisiones, contando con hombres y mujeres para el análisis.

La evaluación de fatiga se realiza con el cuestionario subjetivo de fatiga de Yoshitake, para los factores de riesgo psicosocial se emplea la Norma Oficial Mexicana NOM-035-STPS-2018 y, por último, el instrumento denominado ART Tool, para evaluar factores de riesgo ergonómico.

Los resultados del cuestionario de Yoshitake, arrojaron un incremento en el índice de queja de fatiga, entre el medio turno y al finalizar el mismo. Respecto a los factores de riesgo psicosocial se obtuvo un resultado global de riesgo bajo, en el análisis de cada línea de producción se obtuvieron que las líneas A y D presentaron un nivel de riesgo nulo, en las líneas B, E y F se obtuvo un nivel de riesgo bajo. La línea C obtuvo un nivel de riesgo medio, correspondientes a las categorías denominadas “factores propios de la actividad” y “organización del tiempo de trabajo”, según la clasificación del cuestionario aplicado. Respecto a los factores de riesgo ergonómico, se encontró que 12.07% de las operaciones se encuentran con un nivel de riesgo bajo, 24.14% corresponde a un nivel medio y el 63.78% corresponde a un nivel de riesgo alto.

**Palabras clave**: Fatiga, riesgo psicosocial, riesgo ergonómico, Yoshitake, turnos laborales de 12 horas.

**Relevancia para la ergonomía**: después de la palabra clave, escriba la importancia de este artículo para la ergonomía y por qué es importante su publicación

**Abstract:** Long-term jobs are a working condition present in Mexico and other countries in multiple activities such as health services, public services, manufacturing industry, and transportation companies. This form of organization is part of the working conditions whose purpose is to solve the demands of the productive processes.

In the present study, the risk factors of 12-hour work shifts are investigated, through an occupational health study, which includes assessment of fatigue, ergonomic risk and psychosocial risk factors, in a manufacturing company in the region, dedicated to the development of harnesses for the automotive industry.

The evaluations of the study are carried out in the transmission area, with men and women for the analysis. The fatigue evaluation is carried out with the Yoshitake subjective fatigue questionnaire, for psychosocial risk factors the Official Mexican Standard NOM-035-STPS-2018 is used and, finally, the instrument called ART Tool, to evaluate risk factors ergonomic.

The results of the Yoshitake questionnaire showed an increase in the fatigue complaint index between the half shift and at the end of the shift. For psychosocial risk factors, the following results were obtained. As a final global result of the survey, there is a low-risk level. Analyzing each production line, it was obtained that in lines A and D, there is a null risk level, in lines B, E, and F, a score was obtained that the places at a low-risk level. Finally, line C is at a medium risk level. On the other hand, when classifying this questionnaire's domains, the category called "Factors specific to the activity" and " Organization of working time "is in the medium-risk levels.

For ergonomic risk factors, it was found that 12.07% of jobs have a low-risk level, 24.14% corresponds to a medium risk level, and 63.78% corresponds to a high-risk level.

**Keywords**. Fatigue, psychosocial risk, ergonomic risk, Yoshitake, stress.

**Relevance to Ergonomics**: Ergonomics plays a very important role in organizations, due to the search for the best practices to adapt work to man, not only regarding physical issues but also those related to psychosocial issues. That is why organizations must be focused on promoting optimal working conditions and using information, such as that presented in the article to work according to the needs of their workers and identify possible risks in work operations.

## 1. INTRODUCTION

Globalization, the world economy, competitiveness, industry and the information revolution play a primary role in our society. These key elements have set the stage for profound transformations in the living, working and health conditions of the majority of Mexican workers (Villegas et al., 1997).

All these changes have increased the speed of business processes and have established a 24-hour partnership. Due to economic, production or social needs, in some professional groups it has been necessary to establish work shifts that allow offering continuity in the services provided (Mikko Härmä, 2006).

The trend in working hours is alternative work programs, in which there is an increase in the duration of the working day, while there is a reduction in the number of days worked in the week, that is, there are more shifts rotating, night, mixed and working days of more than 8 hours, known as compressed workweek (Paley et al., 1994).

In addition to the different work shifts, a current trend in the schedules is the increase in the duration of the day while the days worked in the week decrease. With this, the worker receives more non-working time. In other words, the same number of hours are worked in the week, but in fewer days. This type of working day is called a “compressed work week” (Arenas-Ortiz & Cantú-Gómez, 2013).

The compressed work weeks have been accepted in the work environment, although they are only applicable in some organizations due to the type of work that is carried out, examples of this are the police and surveillance organizations, hospitals and in some manufacturing where the work does not require an excessive physical effort, such is the case of the maquiladora companies that are dedicated only to assembly (Mikko Härmä, 2006).

For this reason, the objective of this document is to analyze and evaluate the 12-hour workdays of people incorporated into the manufacturing industry.

The information was taken from a company in the region, dedicated to the manufacture of parts and components for the automotive and industrial industries. She is one of the employers of the compressed week system, where the working day is 12 hours a day, working 4 days and resting 3 days, with 2 daily shifts.

### 1.1 Objectives

Evaluate and analyze the 12-hour work days, on the people incorporated into this labor scheme, in the manufacturing industry.

1.1.1 <u>Specific objectives</u>

- Identify if 12-hour work days cause fatigue to workers with this type of shift.
- Determine if 12-hour work days are linked to psychosocial risk factors or ergonomic risk factors.

## 2. METHODOLOGY

### 2.1 Subjects

Twenty-five male and female employees of a manufacturing company in the region participated in this study. Developing activities of assembly, inspection and packaging of material. The staff belongs to the compressed work week shift (12 hours), working from Monday to Thursday from 7:00 am to 7:00 pm. The content of the job, consists of repetitive, monotonous operations, under a production standard that must be met during the working day.

The number of participants was not a random sample, they were employees assigned to a certain department, which the company selected for the data collection of this research.

## 2.2 Instruments

The Yoshitake Fatigue Symptom Questionnaire was applied, with the aim of establishing the fatigue symptoms perceived and exposed by workers. The method will measure the degree of fatigue, during three periods of the work period:

-At the beginning of the work day

-A part-time work

-Before the end of the work day

The symptoms indicated by the items are divided into groups represented by three factors: drowsiness and drowsiness, difficulty concentrating, and physical exhaustion. The questionnaire it was applied to the same person during the three periods of the working day, in their workplace.

The next instrument was the Official Mexican Standard NOM-035-STPS-2018 Psychosocial risk factors at work-Identification, analysis and prevention; this rule is mandatory for all work centers. The content of the questionnaire covers 5 categories, 10 domains and 25 dimensions, for a total of 72 questions.

The evaluation was applied on one occasion during the study, the importance of the questionnaire was pointed out to them to obtain relevant information, which would be duly treated under privacy schemes of their responses and data. Each respondent accessed without any problem, was carried out in their specific job position and each one was evaluated according to the reference guide of the instrument. It should be noted that the employees answered the survey verbally and once it was completed, the information was automatically emptied into the database to proceed with the summation of the scores obtained by the questionnaire. The length of time for each poll was approximately 20 minutes.

For the evaluation of ergonomic risks, the ART Tool method was selected, which is designed to evaluate repetitive tasks that involve the use of the upper extremities, including parameters for the analysis of working hours of more than 8 hours a day and factors of Psychosocial risk.

The analysis consists of analyzing the task performed by the operators, to determine if there is a significant level of risk and if so, reduce that level of risk in the specific task. The information was collected only once during the whole study.

## 2.3 Methodology

During the application of the questionnaire to the workers, the objective of the study was explained to them and they were invited to participate in the research. The importance of the veracity of responses was emphasized. The questionnaires were carried out individually in the workplace. The mean polling time was 5 minutes.

Once the data on workers' perception of fatigue had been obtained, the results of the survey were captured using the Minitab statistical package. Subsequently, statistical treatment was applied, using the method of Analysis of Variance of repeated measures (ANOVA), which serve to study the effect of one or more factors where all levels of the factor are applied to the same subjects.

To analyze the intra-subject samples (pairwise comparisons in the lapses of the shift), the Bonferroni correction test was used, between the factor levels to determine if there is similarity of means between factors (lapses of the shift).

## 3. RESULTS

From the data and information obtained from the study the following results were obtained:

### 3.1 Fatigue

The data obtained by the fatigue questionnaire were subjected to the statistical analysis of the ANOVA model, where the means of each of the factors, called thus, are compared to the periods in which the data were taken: start, middle and end of the shift. In order to test the hypothesis raised in this research, with a confidence level α = 0.05. The results of the means of the 3 periods of the shift in which the evaluation corresponding to day 1, sample 1, week 1 was taken are presented in the following table (see table 1).

Estadísticos descriptivos

| | Media | Desv. Desviación | N |
|---|---|---|---|
| S1D1M1 | 6.60 | 9.866 | 25 |
| S1D1M2 | 10.40 | 9.233 | 25 |
| S1D1M3 | 24.00 | 16.330 | 25 |

Table 1. Descriptive statistics of the means of the lapses of the shift

Within the analysis of variance, we have that μ1 = μ2 = μ3, therefore, the Bonferroni correction test is applied, where the intra-subject samples (pairwise comparisons) between the factor levels are compared. Where the result is that the average of the period at the beginning of the shift and half a shift are equal, but the period between the half-day and at the end of the shift is different (see table 2).

Continuing with the method and to continue testing the research hypothesis, the means test is carried out for the data of a week of work. Where the pairs of factors (lapses of the shift) are compared to determine the existence of similarity or difference between the mean of these factors (see table 3).

Table 2. Table of interval between the means of the lapses of the shift

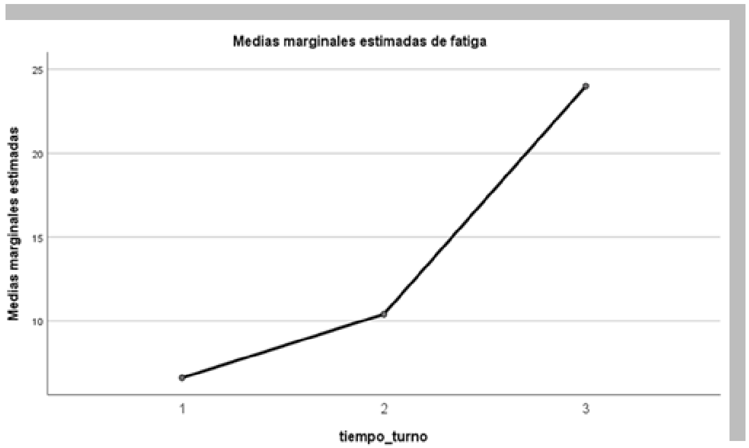
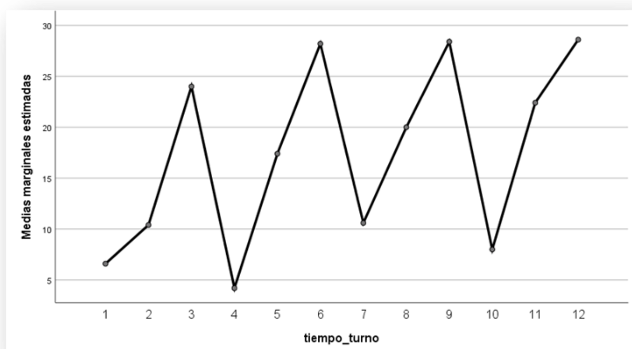



Table 3. Table of interval between the means of the lapses of the shift of a work week

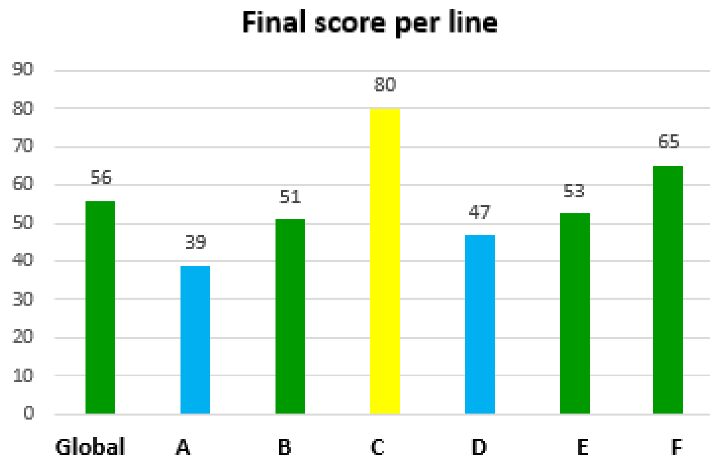



Knowing the level of significance α = 0.05, it can be concluded that the null hypothesis of equal means is not rejected. Because there is similarity of means between factors. That is, the start factor and the mean factor (shift lapses) meet the characteristic of similar means. The previous table (table 3) shows the evolution of the symptoms of fatigue complaint, based on the survey carried out with the workers.

### 3.2 Psychosocial risk factors

The information obtained through the reference guide of the Official Mexican Standard NOM-035-STPS-2018, corresponds as follows. As a final global result of the survey, there is a low-risk level (see table 4).

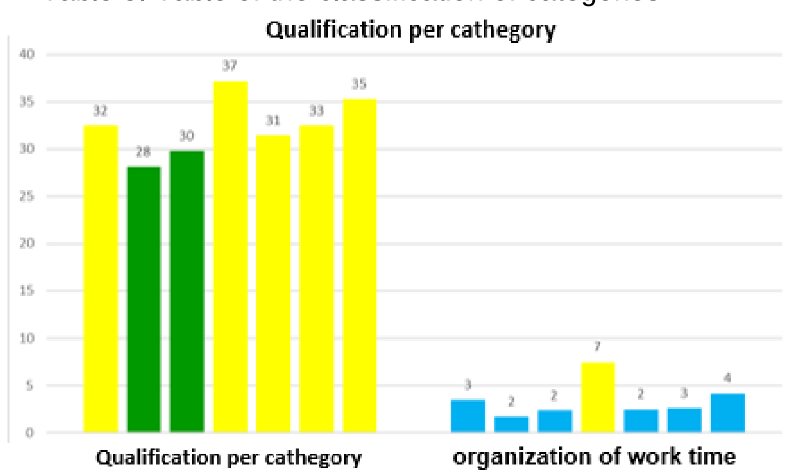
Table 4. Final score per line of the survey




Analyzing each production line, it was obtained that in lines A and D, there is a null risk level, in lines B, E, and F, a score was obtained that the places at a low-risk level. Finally, line C is at a medium risk level (see table 4).

On the other hand, when classifying this questionnaire's domains, the category called "Factors specific to the activity" and "Organization of working time" is in the medium-risk levels (table 5).

Table 5. Table of the classification of categories




## 3.3 Ergonomic risk factor

The results obtained with the application of the ergonomic ART Tool reflect data that can be observed that many activities carried out by the operators seem safe, but the results show that a meticulous adjustment is required to improve the stations of work. it was found that 12.07% of jobs have a low-risk level, 24.14% corresponds to a medium risk level, and 63.78% corresponds to a high-risk level.

## 4. CONCLUSIONS

The results obtained in the present investigation showed that work fatigue is present in this type of work day, also called a compressed work week.

The analysis of this study justifies the objective set, referring to the existence of symptoms and increased work fatigue in workers assigned to this type of shift.

Statistical evidence shows an increase in fatigue between the pairs of factors (half shift and end of shift), that is, there is an increase in the fatigue complaint index during that period.

References should be listed together at the end of the paper. References should be arranged in alphabetical order according to the last name of the author, or the last name of the first-named author for papers with more than one author. Refer to the examples shown below.

In the development of the research, it was confirmed that one of the greatest challenges of ergonomics has been the study of the interaction of man against physical requirements: posture, strength, movement. When these requirements exceed the response capacity of the individual or there is no adequate biological recovery, this effort can be associated with the presence of ailments, injuries or stress, all of them related to work.

The presence of fatigue perceived by the workers was notorious, since the activities they carry out lack the use of their skills, control of tasks, as well as decision-making; factors that influence the mechanical load and physical demands of repetitive operations. Since repetitive and monotonous jobs accumulate much more stress, as noted in studies included in this research.

We can add that the higher demands or demands (cognitive, emotional, quantitative or qualitative), workload and less possibility of control over work, the greater the probability of getting sick as a result of stress and as a result stress is generated.

In short, the human organism, the worker, must be considered as a totality or bio-psychosocial system. Where external elements affect the entire system.

## 5. REFERENCES

Ahsberg, E. (1998). Perceived fatigue related to work National Institute for Working Life.

Arenas-Ortiz, L., & Cantú-Gómez, Ó. (2013). Factores de riesgo de trastornos músculo-esqueléticos Arenas-Ortiz, L., & Cantú- Gómez, Ó. (2013). Factores de riesgo de trastornos músculo- esqueléticos crónicos laborales. Medicina Interna de México, 29(4), 370–379. Retrieved from http://www.medigraphi. Medicina Interna de México, 29(4), 370–379. Retrieved from http://www.medigraphic.com/cgi- bin/new/resumen.cgi?IDARTICULO=43308

Haro, Sánchez, J. (2006). Justificaciones medicas de la jornada laboral máxima de ocho horas, 191-197.

Hernández Arellano, J. L., Castillo Martínez, J. A., & Serratos Pérez, J. N. (2015). Relationship between Workload and Fatigue among Mexican Assembly Operators. International Journal of Physical Medicine & Rehabilitation, 03(06), 6–11. https://doi.org/10.4172/2329-9096.1000315.

María, A., Álvarez, D. J., & Elío, M. N. (n.d.). Repercusiones del proceso laboral en la salud de los trabajadores de producción y administrativos de una empresa de autopartes.

Mikko Härmä. (2006). Norwegian National Institute of Occupational Health in relation and health to work Workhours stress, recovery. Scandinavian Journal of Work, Environment & Health, 32(6), 502– 514.

Moretti A., C. (2015). Duración De La Jornada Laboral: Implicancias Sanitarias y Político-Económicas. Revista Chilena De Terapia Ocupacional, 15(1), 57–64.

Paley, M. J., Herbert, L. B., & Tepas, D. I. (1994). work schedules from an 8 hour rotating shift Schedule to a rotating 0 hour day/14 hour night operating Schedule, 749-753.

Sánchez-román, R., & Arturo, C. (2006). Justificaciones médicas de la jornada laboral máxima de ocho horas, 191–197.

Villegas, J., Noriega, M., Martínez, S., & Martínez, S. (1997). Trabajo y salud en la industria maquiladora mexicana: una tendencia dominante en el neoliberalismo dominado. Cadernos de Saude Publica, 13 Suppl 2, 123–134. ttps://doi.org/10.1590/S0102- 311X1997000600011Mital, A., Nicholson, A.S., and Ayoub, M.M. (1993). A Guide to Manual Materials Handling. Taylor & Francis, Ltd., London, United Kingdom.

Yoshitake H. Three characteristic patterns of subjective fatigue symptoms. Ergonomics 1978;21(3): 231-3.

# ERGONOMIC EVALUATIONS IN ELECTRONIC PACKAGING ORGANIZATION

**Ángel Aviña-Fernández[1]; Daniel Acosta-López[1]; Arturo Realyvásquez-Vargas[1]; Guadalupe Hernández-Escobedo[1], Karina Cecilia Arredondo Soto[2]**

[1]Department of Industrial Engineering
Instituto Tecnológico de Tijuana
Calzada Tecnológico S/N
Fracc. Tomas Aquino
Tijuana, Baja California, MX 22414
Corresponding author's e-mail: angel.avina@tectijuana.edu.mx

[2]Chemical Sciences and Engineering Faculty
Universidad Autónoma de Baja California
Calzada Universidad #14418
Parque Industrial Internacional
Tijuana, Baja California 22390, Mexico

**Resumen** El presente artículo de investigación muestra distintas evaluaciones ergonómicas realizadas en dos plantas de una empresa que fabrica artículos electrónicos de posicionamiento geográfico en la ciudad de Tijuana. La finalidad del trabajo de investigación fue la identificar áreas de oportunidad de la organización en el contexto ergonómico, y proponer alternativas de solución a dichas situaciones. Este trabajo clasifica los hallazgos entre factores físicos y cognitivos para permitir un fácil entendimiento.

**Palabras clave**: RULA, evaluación ergonómica, riesgo ergonómico

**Relevancia para la ergonomía**: Este proyecto funciona como motivación para la comunidad de alumnos universitarios con dificultades en aplicar los conocimientos recién adquiridos en el ámbito ergonómico. Contiene conceptos básicos para generar interés en la creación y aplicación de nuevos proyectos. Esto a su vez, estimula a la iniciativa privada a recurrir a estudiantes e instituciones universitarias para que visiten sus lugares de trabajo y apliquen el conocimiento.

**Abstract:** The following investigation article shows different ergonomic evaluations that took place on industrial plants located in the city of Tijuana, in a company that produces electronic global positioning systems. The objective of this investigation work was to identify opportunity areas regarding ergonomics in general inside the workplace, and propose solution alternatives to said situations. This paper classifies findings between physical and cognitive ergonomics to allow an easier understanding.

**Keywords**: RULA, ergonomic evaluation, ergonomic risk

**Relevance for ergonomics**: This project works as motivation for the community of university students with difficulties in applying the newly acquired knowledge in the ergonomic field. It contains basic concepts to generate interest in the creation and application of new projects. This, in turn, encourages private initiative to turn to students and university institutions to visit their workplaces and apply knowledge.

## 1. INTRODUCTION

The industrial plant where this investigation took place provides reparation and packaging for a mother company with the name of company A. This company sells and installs navigational and truck control systems with a primary focus on distribution fleets.

The plant being studied is called “company B”, and operates on two industrial facilities. One of them focuses on receiving products that require maintenance or restoration. The second one repairs the product, conducts quality testing and then returns them to the first facility, where they will be packaged and shipped back to a distribution facility in the United States of America’. This investigation refers to the testing facility as “21” and to the packaging facility as “24”.

There are records of companies ignoring, or giving low priority to ergonomic indications that prevent health deterioration of workers. In some instances, employees themselves ignore a certain ache (Moreno, 2015). Occasionally, companies are the ones who disregard the direct correlation between quality of life of their worker while doing labor. According to Aponte (2007), paying no heed to ergonomic factors translates to a lower productivity. That opinion is shared by the Sociedad de Ergonomistas de México (SEMAC).

Company B is no exception to this problem. During the evaluation visits, the existence of areas of opportunity regarding occupational ergonomics was perceived, both physical and cognitive. The area where these problems were mostly observed was in facility 24, which is dedicated to packaging and product shipping. This part of the process has a set of manual operations, that when done in repetition for long periods of time without ergonomic support, may result in long term harm for the employee. The work being done in this area requires one to stand for approximately eight hours, supporting uncomfortable temperatures both high and low, and visual concentration.

These types of conditions are common around the country. A study from the Organization for Economic Co-Operation and Development (OECD) indicated that Mexicans worked an average of 2148 hours in 2018. Also, according to the Ley Federal de Trabajo de los Estados Unidos Mexicanos, the Mexican employee working shift is eight hours long. That means, that if an employee works during the day, that person spends a third of his lifespan in the workplace. If that work is being done incorrectly, it harms irreversibly both the body and the mind.

In addition to such a problem, there was also another issue the investigation team noticed and that was the very high temperatures on the facility. Even though the place was assisted by an air conditioning system, the intense heat could not be avoided and based on the workers' testimonies, the temperatures there were difficult to deal with both during the summer and winter.

The last thing the team noticed was the inappropriate use of lift trucks around the shipping and docking area. This was an issue mainly because they appeared not to be following the safety measures as they should, since there was no sound being issued from the trucks as they moved around the place and they were moving at a speed that could potentially cause an accident given such conditions.

## 2. OBJECTIVES

To evaluate the ergonomic conditions in the chosen workplace through physical and cognitive assessments, with a purpose of making recommendations to prevent risks to workers in facility 24 and 21, regardless of their hierarchy level or company position.

### 3.1 Specific objectives

The following statements are established as the specific objectives of this investigation:

- Determine the areas of opportunity regarding the ergonomic field in the workplace.
- Enlist the possible consequences of the ergonomic flaws found.
- Devise possible solutions to the critical ergonomic deficiencies on both facilities.

## 3. REACH AND LIMITATIONS

This investigation mainly took place in facility 24, where the analysts found the most shortcomings. It is apparent that, while both facility 24 and 21 share some flaws in the ergonomic context, resolving the critical ones found in the former will provide the guidelines to resolve the ones in the latter.

Facility 24 belongs to the company B, located in Tijuana, Baja California, Mexico, and has a total of 20 employees, two packaging production lines, two strapping docks, and three trucking unloading platforms. The ergonomic evaluations cover all the equipment previously mentioned.

## 4. THEORETICAL FRAMEWORK

### 4.1 Ergonomics

According to the International Ergonomics Society (2014), the main goal of the Ergonomics discipline is to ensure the existence of harmony between technology and humans when both interact in the same environment.

The work environment is defined as the physical place, site or location where a staff member's activities take place, but also includes the sociocultural context and immediate physical infrastructure that surrounds the man-machine connection.

With this in mind, an ergonomic approach to a problem requires to take into consideration what the body feels as discomfort or not harmonious, as well as with the intellectual capabilities. The following sub-items describe the topics that study ergonomics of the mind and body.

## 4.2 Physical Ergonomics

Ranjana (2016) describes the study of physical ergonomics as the concern with human anatomic, anthropometric, physiological, and biomechanical characteristics as they relate to physical work systems.

Physical ergonomics is mainly focused to adjust workstations and tools to the needs of the user, keeping in mind that both have to be functional and comfortable allowing the individual to perform the task in a safe and healthy way. The topics that are more relevant in the subject are the adoption of inadequate postures, physical charges that are not healthy to the individual, manipulation of heavy elements and, overall, all those movements that can generate muscle-skeletal disorder to the workers.

## 4.3 Evaluation Methods for Physical Ergonomics

### 4.3.1 Posture (RULA)

One of the most common associated risks with muscle-skeletal disorders is the excessive postural charge, which can be evaluated by the Rapid Upper Limbs Assessment (RULA) method. If bad postures are adopted on a continuous or repeated basis in the workplace, fatigue will be generated and in the long term, health problems may arise. Therefore, the evaluation of postural charge or static charge and its reduction in case this is required, is one of the fundamental measures to take in the improvement of the workspaces (Diego-Mas, 2015).

### 4.3.2 Temperature

It was P.O Fanger (Thermal Comfort McGraw-Hill, 1973) who elaborated a procedure that contemplates the different variables that take place in the evaluation of the thermal environment in a workplace. The Fanger method considers the activity level, the clothing type, dry temperature, relative humidity, radiant temperature and the air speed. All the previous variables influence in thermal changes, affecting the comfort sensation. The importance and appliance of this method is made by its inclusion as part of the ISO 7730 rule which talks about the evaluation of the thermal environment.

### 4.4 The Importance of Safety in Ergonomics

Industrial safety is a non-medical method that seeks to avoid accidents in the workplace by creating a safe environment within the organization. Ergonomics is key to this goal, because it allows for the harmonious operations between humans and that environment.

Among the main physical agents that are considered dangerous are: noise, temperature, humidity, vibrations, lighting, and any that could cause physical trauma. Avoiding these factors is key in order to maintain a safe environment (Villarroel, 2011).

4.4.1 Truck Lift Safety

The functions performed by and around a truck lift are dangerous by nature and prone to physical trauma if performed inaccurately. Since the human body is not designed to withstand the amounts of cargo that this machine handles, a mistake while operating the truck lift might result in a serious injury or fatal consequences. Among the most common risks of operating a truck lift, one could mention:

- People falling from dangerous heights
- Objects falling from dangerous heights
- Entrapment

## 5. METHODOLOGY

### 5.1 Suggested methodology

The proposed method to resolve the organization ergonomic problems is the RULA ergonomic method because the team believed that this was the most adequate and helpful to the enterprise's situation allowing the team to give a risk exposure grade of the workers and how their upper body limbs are being affected.

The Fanger method was chosen to evaluate thermal comfort. This method will reveal the status of difficulty to perform the work activities based on a pre-established equation based on humidity, body temperature, as well as the facility where the analysis is taking place.

A trucklift safety checklist was used to address the latent situation in the facility where the lift trucks and other kinds of industrial vehicles might cause an accident and by this checklist the risk could be drastically reduced.

## 6. RESULTS AND RECOMMENDATIONS

In this chapter, the results of the evaluations are presented, as well as the recommendations that were explained to the head managers that could solve the problems in facility 24 of the organization.

To attend the problem regarding the lift trucks, the investigation team proposed that the following improvements:

- Ergonomic shock absorbing seats
- Designated cruising or navigation areas
- Involuntary maneuver immobilizers

With these security measures applied to the lift trucks in facility 24, the risk of an accident can be drastically reduced and the flow of these machines around the place can be both fast and safe.

In order to avoid threats while using the forklift machine, there are ergonomic safety countermeasures. When evaluating the conditions of safety among truck lift usage, the following could be considered:

- Security gantries
- Ergonomic shock absorbing seats
- Involuntary maneuver immobilizers
- Non-Skid wheels
- Safety gear (helmets, suits, footwear)
- Designated navigation areas

The ergonomic evaluations with RULA showed on the first analysis, which was the packaging operation, that there was high risk in that operation, giving a result of 5 in RULA index. Similarly, on a second operation in which the whole order is strapped and prepared for shipping, the ergonomic analysis came out with a score of 7 in RULA index, where technically means that there is high risk. Figure 1 shows these RULA scores. Then, the team suggested an action to reduce that score because it nears the latent risk level.

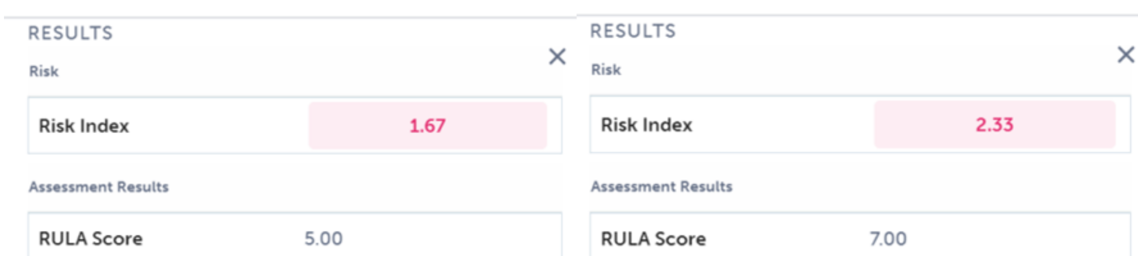



Figure 1. RULA scores for the analyzed operations

Finally, the thermal comfort evaluation showed that a temperature issue is present in facility 24, mainly in summer and winter. However, for in rest of the year (spring and autumn) the temperature is acceptable and causes no discomfort. The score was of 2.67 of PMV (Predicted Mean Vote) and 96.3% PPD (Predicted Percentage Dissatisfied) all this in summer time of the year.

## 7. REFERENCES

Ranjana K. Mehta (2016) Integrating Physical and Cognitive Ergonomics, IIE Transactions on Occupational Ergonomics and Human Factors, 4:2-3, 83-87, DOI: 10.1080/21577323.2016.1207475

Villarroel, N. (2011). *La ergonomia factor clave de la prevencion en el trabajo*. Caracas Venezuela.

# PREPARATION OF A MANUAL OF POSTURES IN SADDLERY APPLYING RULA METHOD

**Jazmín Argelia Quiñonez Ibarra, Dinora Monroy Meléndez, Penélope Guadalupe Álvarez Vega, Cristian Vinicio López del Castillo, Lucero Edith Guevara Ramos**

Department of Engineering and Technologies
Universidad de la Sierra
Carretera Moctezuma-cumpas, Km. 2.5
Moctezuma, Sonora, México 84560

jquinonez@unisierra.edu.mx, dmonroy@unisierra.edu.mx, palvarez@unisierra.edu.mx, div.ingenieria@unisierra.edu.mx, luce_guevara14@hotmail.com

**Resumen** Nuestro proyecto llevado a cabo en una talabartería en el Estado de Sonora, consistió en analizar los posibles problemas que presentaban en la empresa, en relación con las posturas incorrectas de los trabajadores durante su jornada laboral.

Una vez revisadas todas las áreas se realizó un análisis detallado mediante un método ergonómico enfocado específicamente a las actividades realizadas por los trabajadores en la empresa, el cual es denominado método RULA (Rapid Upper Limb Assessment). Con esta metodología buscamos la manera de mejorar las condiciones de trabajo para el trabajador evitándole posibles lesiones musculoesqueléticas y así poder brindarle mayor comodidad en su trabajo con la finalidad de aumentar la producción sin afectar la salud y seguridad laboral

Una vez que se realizó el análisis, a través de visitas y videos de las distintas actividades realizadas en la empresa, se propuso la realización de un manual, que mostrara las posturas correctas de las distintas áreas con las que cuenta la empresa, con el fin de concientizar acerca de los beneficios que se obtendrán con la aplicación de la ergonomía y por lo tanto, la reducción de posibles lesiones de trabajo en los trabajadores.

En este manual nos enfocamos en llevar a cabo una minuciosa investigación sobre cada una de las posiciones de los trabajadores a la hora de realizar su trabajo, esto con el fin de analizar y mejorar las condiciones del mismo.

Dentro de este manual se presentará una serie de pasos para evitar las malas posturas y se dará a conocer las posiciones adecuadas que deben de adoptar los trabajadores, es de vital importancia darle seguimiento a este manual debido que el hacer caso omiso a las recomendaciones plasmadas se seguirán presentando problemas cada vez de mayor intensidad en el trabajo, para finalizar es necesario realizar dicho estudio, ya que se ha comprobado la eficiencia del mismo, mediante otras empresas que lo aplican, donde muestran los beneficios obtenidos para el trabajador.

Una vez que la empresa adopte el manual, se pretende que se disminuyan los problemas en sus trabajadores por malas posturas y así mismo, crear un mejor ambiente de trabajo, con menores lesiones y por ende, incrementar la productividad y las ganancias.

**Palabras clave:** Talabartería, Ergonomía organizacional, lesiones, posturas, concientizar

**Relevancia para la ergonomía:** La realización y aplicación de este tipo de manuales apoya enormemente la reducción de riesgos laborales y la conciencia de la importancia de seguir impulsando e implementando la ergonomía en las diferentes actividades que realiza el ser humano.

**Abstract** This project, carried out in a saddlery in the State of Sonora, consisted of analyzing the possible problems that the company presented, in relation to the incorrect positions of the workers during their working hours.

Once all the areas had been reviewed, a detailed analysis was carried out using an ergonomic method specifically focused on the activities executed by the workers in the company, which is called the RULA method (Rapid Upper Limb Assessment). With this methodology we look for a way to improve working conditions for the worker avoiding possible musculoskeletal injuries and thus be able to provide greater comfort in their work in order to increase production without affecting health and safety at work.

Once the analysis had been follow through visits and videos of the different activities done in the company, it was proposed to create a manual, which would show the correct positions of the different areas that the company has, in order to raise awareness about the benefits that will be obtained with the application of ergonomics and therefore, the reduction of possible work injuries in workers.

In this manual we focus on implementing a thorough investigation of each of the worker´s positions when performing their work, this to analyze and improve the conditions of the same.

Within this manual, a series of steps will be presented to avoid bad postures and the appropriate positions that workers should adopt will be announced, it is vitally important to follow up on this manual because ignoring the recommendations will be that they will continue to present increasingly more intense problems at work, to finish it is necessary to fulfill this study, since its efficiency has been verified, by other companies that apply it, where they show the benefits obtained for the worker.

Once the company adopts the manual, it is intended to reduce the problems in its workers due to bad posture and likewise, create a better work environment with fewer injuries and therefore, increase productivity and profits.

**Keywords:** Saddlery, Organizational Ergonomics, injuries, postures, raise awareness.

**Relevance to Ergonomics:** The realization and application of this type of manuals greatly supports the reduction of occupational hazards and awareness of the importance of continuing to promote and implement ergonomics in the different activities carried out by humans.

## 1. INTRODUCTION

A saddlery is an art of making leather goods. The term is linked to saddleback, the belt used to carry a saber or other type of cold weapon. The person dedicated to its manufacture is known as a saddler. It is called saddlery, therefore, to the trade, the workshop or the saddlery´s business. The concept can be used as a synonym for saddlery, as it is associated with the straps and other leather products (the saddles) that are attached to the horses.

In the most precise sense, saddlery involves the making of saddles, rigging and other elements that are installed in equines. More broadly, the notion includes the development of belts, wallets, purses, bags, berets, key rings, espadrilles, and other leather products.

The possible risks of work in a saddlery were analyzed, taking that into account that work injuries are present every second and anywhere. It was decided to develop a manual of postures that would help to minimize the injuries within that place, correcting the inappropriate postures and improving the ergonomic conditions of the work.

Organizational ergonomics helps us eliminate these incorrect postures to increase production without complicating worker health. It is important to note that a manual of postures, although it is an unbelievably valuable tool, without the participation of workers, has a very low impact. This is the reason of why the workers were made aware of the importance of maintaining a correct posture, letting them know about some risks such as inflammation, musculoskeletal injuries, and many other cumulative injuries.

The RULA method was applied to the people who presented the greatest risk, however, the risks were explained to all personnel and they were trained about the manual.

## 2. OBJECTIVES

Develop and implement a manual of correct postures, through an ergonomic analysis of each area within a saddlery, applying the RULA method, to standardize and ergonomically assess the areas creating a safe work environment, also benefiting the worker's health and the productivity of the company.

Delimitation: Workers of an industrial saddlery in Moctezuma, Sonora

# 3. METHODOLOGY

Base on the observations made, the decision was made to carry out the preparation and implementation of a MANUAL FOR POSTURES applying the RULA method, which was selected due to the problems presented and the current circumstances. It is important to remember that RULA assesses the degree of exposure of the worker to risk due to the adoption of inappropriate positions. Although the method considers other factors such as forces exerted or repeatability, it should only be used to assess postural load.

The forgoing leads to the proposal to redesign some process areas, especially in production, which is where more repetitive movements occur, obviously due to the nature of the work.

The proposed actions make it possible to improve work efficiency, decrease operating times, reduce and, as far as possible, eliminate work risks for the operator. To follow through the, the following steps were carried out, which are detailed below, based on their development.

## 3.1. Know the current situation of the company

The different areas of the company were observed (Reception of raw material, cutting and drawing, production process, assembly, sewing, reduction and packaging) to know the activities that are carried out, the assigned personnel and the products that are handled. Different aspects that required necessary changes could be identified and the way of working was also known in general.

The company realize its products according to the orders made by its different customers by wholesale or retail, the schedule of activities constantly changes depending on the priorities of the orders that they make to the production manager daily.

Each of the product areas is managed depending on the different authorized products, therefore, they maintain different production times.

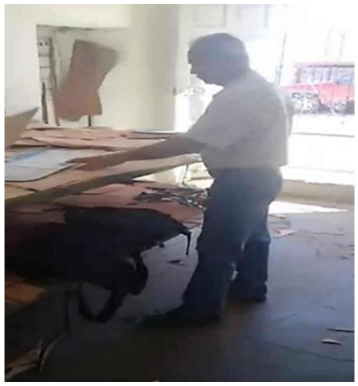
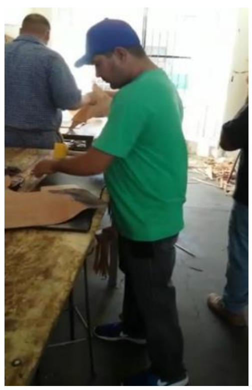
Once the above has been done, the knowing of each one of the areas was proceeded and to take evidence of the incidents that were found, in the same way a very important point was the information provided from the operators, which were complemented with what was observed and with recommendations necessary to fulfill their activities.

One of the important points that were analyzed were the positions in which the work was performed throughout the day and the way in which each operator modifies their body positions for their comfort because they are the ones that adapt themselves to the work area.

The above reflects the null application of ergonomics.

Based on the evidence collected, these annotations were presented to the managers of the company, in which it was concluded that the area needed improvements in general to be able to maintain a better work environment and therefore increase the productivity.

As shown in the following photographs where the workers are standing, stretching by the height of the worktable or the size of the piece to be cur or the final product.

| | |
|---|---|
| <br>Figure 1. Raw material cutting | <br>Figure 2. Raw material measurement |
| <br>Figure 3. Engraved on leather | <br>Figure 4. Engraved on leather |
| <br>Figure 5. Molding | <br>Figure 6. Final assembly |

### 3.2. Proposal of objectives and method to be used to carry out the project

Based on the evidence collected, the information was presented to those in charge of the company, in which it was concluded that the area needed improvements in general in order to maintain a better working environment and, therefore, increase productivity.

In this step, the findings and proposals that would be made for the realization of the posture manual and an ergonomic analysis were reported to production.

### 3.3. Detailed knowledge of the production areas

Visits were made to the different areas to be able to determine more accurately what the activities consisted of, to allow the evaluation of the postures and perform an ergonomic analysis in general.

The production leader explained the way in which they worked, what the job consisted of and the correct way in which it had to be done.

A format was developed to better understand the areas, as shown in Figure 7.


Sonora saddlery
TALABARTERÍA TENERÍA LA INDUSTRIAL MOCTEZUMA, SON.

REGISTRO DE ÁREAS

NÚMERO DE ÁREAS:

NOMBRE Y DESCRIPCIÓN DE LAS ÁREAS

| NOMBRE DEL ÁREA: | DESCRIPCIÓN: |
|---|---|
| | |

Figure 7. Register of saddlery areas.

### 3.4. Ergonomic evaluation of production areas

A particularly important point for the company´s posture manual was the ergonomic evaluation of each work area. Therefore, an investigation of a method to perform the evaluation of the areas was carried out, as part of our investigation we relied on answers provided by the person in charge of production and that corresponded to the analyzed situation. We concluded in selecting the RULA method.

The RULA method evaluates individual postures, dividing the body into two groups, Group A, which includes the upper limbs (arms, forearms, and wrists) and

Group B, which includes the legs, trunk, and neck. Through the tables associated with the method, a score is assigned to each body area (legs, wrists, arms, trunk…) in order, based on these scores, to assign global values to each of groups A and B, also this evaluates the body on the right and left side.

The method organizes the final scores into performance levels that guide the evaluator on the decisions to be made after the analysis. The proposed levels of action range from level 1, which considers that the evaluated position is acceptable, to level 4, which indicates the urgent need for changes in the activity.

This method is easy to use and understand for anyone, helping to visualize the risks both in positions, repeatability, and load.

We elaborate a format where we will apply the RULA method to evaluate the activities of each work area and each saddlery operator as shown in the following figure:

**TALABARTERÍA LA INDUSTRIAL**

**S.A DE C.V**

**TRABAJADOR #:**
**EDAD:**
**ÁREA:**

| AREA | TRABAJADOR | LADO DEL CUERPO | PUNTUACIÓN RULA | NIVEL DE RIESGO | ACTUACIÓN |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

Figure 8. Record of results for each operator and area.

As a complement to the ergonomic evaluation, proposals were made to redesign the chairs so that the worker is more comfortable, with a better posture and thus avoid injuries, fatigue and be more efficient, a mesh for light was also proposed because the light is reflected at the door and it affects the worker´s view, as shown in figure 9.

Another proposal is to perform exercises after every certain time to avoid pain by staying in the same position throughout the working day, especially for those who work directly in the production area, since they constantly perform the same job. It was agreed that for all this to apply, training will be given to all workers.


Figure 9. Area of reception of raw material. a) and b) before RULA method; whereas c) and d) after RULA.

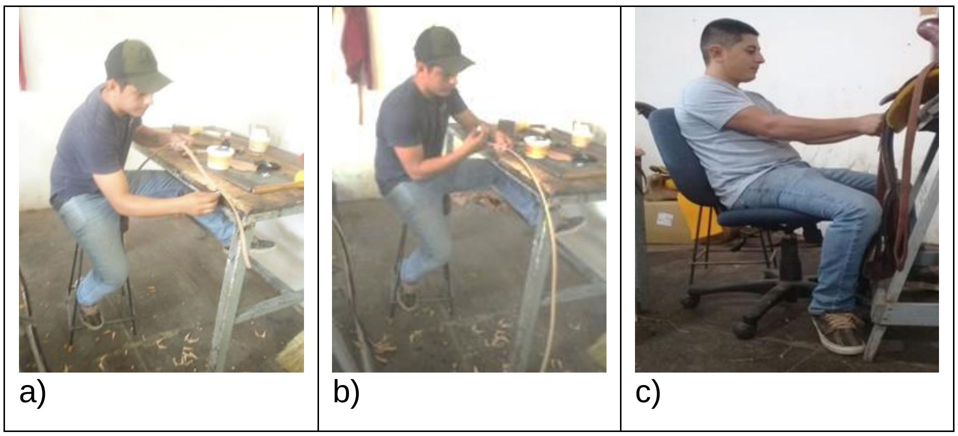



Figure 10. Production area. a) and b) before RULA method; whereas c) after RULA
.


Figure 11. Production area. a) and b) before RULA method; whereas c) and d) after RULA.

### 3.5. Preparation of the posture manual and ergonomic analysis

This is the main point for the Saddlery because there is no manual for postures, and the workers do not know of the great importance of having a good posture, which is why it is the first time that this manual will be carried out. In which the production manager was made aware so that the workers implement it constantly.

The first thing we did for the realization of the manual is the collection of information which is provided by the production leader.

Afterwards, the job profile was requested to fulfill an ergonomic analysis, through observation and the RULA method for the elaboration of the posture manual within the saddlery.

Once the information was collected and the ergonomic analysis was done, the posture manual was prepared, adapting the area to the worker, and improving his posture depending on that area.

The content of the manual consists of the following points:

1. Introduction
2. Description of the company
3. Company history
4. Mission
5. Vision
6. Objective of the company
7. Purpose of the manual
8. Policy
9. General organization chart
10. How to improve postures
11. Incorrect postures
12. Ergonomic recommendations
13. Annexes
14. Bibliographic references

The manual of positions will be a support for the saddlery since the RULA method provides adequate posture and facilitates the work to be performed.

## 4. RESULTS

Applying the RULA method in a saddlery it was observed that the greatest problem is found in some areas and workers, because operators do repetitive work and their posture is not adequate and, therefore, they are at greater risk of having an injury or inflammation in the short term.

Workers were made aware of the importance of ergonomics and the fact of reducing injuries due to improper postures, benefiting the worker's health and improving the company's productivity. Therefore, the posture manual is a tool that greatly supports the work done in this company.

These results can be seen below in the following formats and figures where we have a before and after to raise awareness of the importance of a good posture to the saddlery manager. As shown in table 1.

Table 1. Task log

**REGISTRO DE ÁREAS**

**NÚMERO DE ÁREAS: 8**

**NOMBRE Y DESCRIPCIÓN DE LAS ÁREAS**

| NOMBRE DEL ÁREA: | DESCRIPCIÓN: |
|---|---|
| Recepción de materia prima | Llega el material lo que es la vaqueta |

| NOMBRE DEL ÁREA: | DESCRIPCIÓN: |
|---|---|

| NOMBRE DEL ÁREA: | DESCRIPCIÓN: |
|---|---|
| Proceso de producción | En esta área realizan lo que es la montura de trabajo se hacen Fuste y Argollas |

| NOMBRE DEL ÁREA: | DESCRIPCIÓN: |
|---|---|
| Armado | Ponen aceite a la montura , ponen piezas , tapaderas y látigos |

| NOMBRE DEL ÁREA: | DESCRIPCIÓN: |
|---|---|
| Costura | Costura de las piezas de la montura |

| NOMBRE DEL ÁREA: | DESCRIPCIÓN: |
|---|---|
| Rebajado | Adelgazan la vaqueta |

| NOMBRE DEL ÁREA: | DESCRIPCIÓN: |
|---|---|
| Empacado | Empacan la montura |

We apply the RULA method in saddlery and we observe that in some areas and workers the greatest problem is found, where operators do repetitive work and their posture is not adequate and they are at greater risk that they may have an injury or inflammation, the application of the method was carried out through images, videos and several visits to the saddlery.

Through the application, we analyze the biggest problem that four very tall workers came up with and another two are also at risk but not so much, we make the manager of the SADDLERY aware so that the workers maintain an adequate posture, especially for those who do repetitive work, the others always They are from area to area, but when we are seated we take photos and videos, to also make the manager aware of the correct posture of the other workers and these were our already improved results explaining the problem.

For us, having improved the posture for these people has been a pride because thanks to the analyzed study and the knowledge of ergonomics we are benefiting the health of the worker and improving the productivity of the industrial saddlery. The following figures show results obtained as an example.

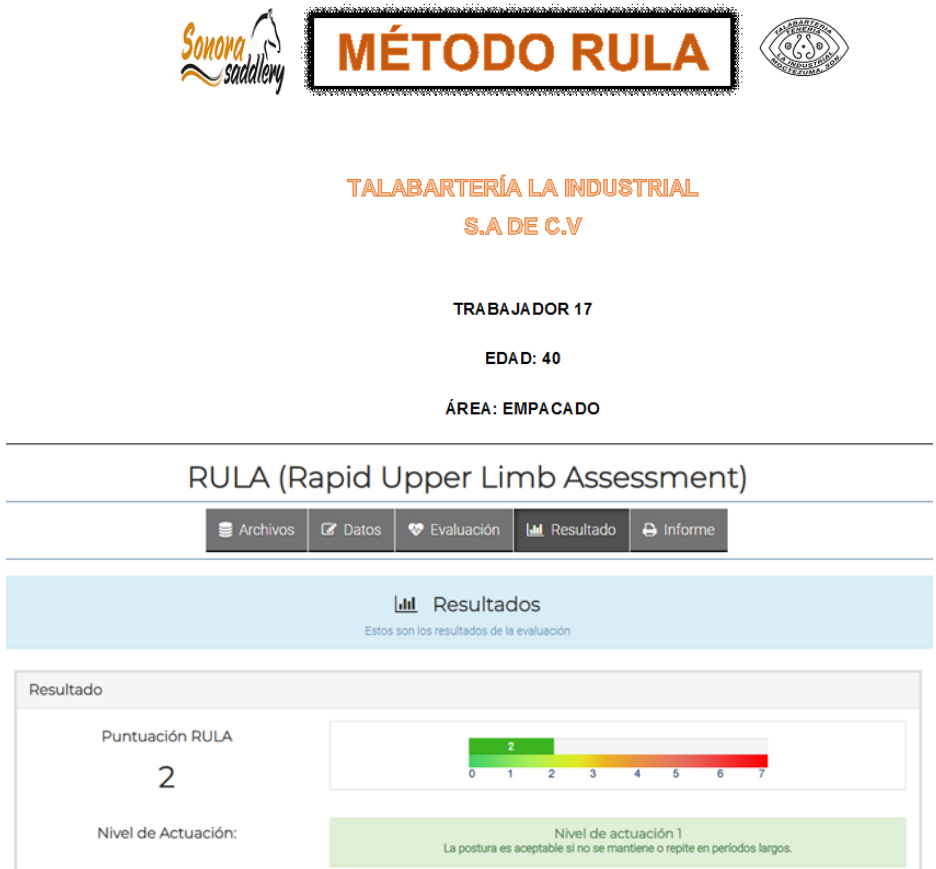



Figure 12. An example of RULA results.

Figure 13. Acceptable worker risk.

# MÉTODO RULA

TALABARTERÍA LA INDUSTRIAL

S.A DE C.V

**AREA: REBAJADO**

**TRABAJADOR 16**

**EDAD: 31**

| AREA | TRABAJADOR | LADO DEL CUERPO | PUNTUACIÓN RULA | NIVEL DE RIESGO | ACTUACIÓN |
|---|---|---|---|---|---|
| REABAJADO | 16 | IZQUIERDO | 2 | 1 | RIESGO ACEPTABLE |


Figure 14. Example of RULA results.

Figure 15. Acceptable risk because his posture is adequate, according to RULA method.

## 5. CONCLUSIONS

The development and implementation of a manual of ergonomic positions is a primary point for a process area, because they help you improve working conditions, train workers and, above all, prevent them from suffering short- and long-term injuries.

These types of activities can produce cumulative injuries, which will generate conditions that will bring problems to the operator and obviously, will affect their quality of life. In addition to this, direct and indirect costs for the company are reduced. Therefore, different actions were proposed that will help the company to reduce these costs and generate benefits for its operators and therefore, the community. The foregoing was strengthened based on NOM-036-1-STPS-2018 Ergonomic Risk Factors at Work-Identification, analysis, prevention, and control.

It is important to point out that the production of this type of manual works as a basis for the company to know and be aware of its possible work risks. However, the most important point is awareness and the correct application of this knowledge to reduce injuries.

## 6. REFERENCES

Argentina, 2016. *Asociación de Ergonomía. Asociación de Ergonomía Argentina*. Retrieved from http://www.adeargentina.org.ar/segun-iea.html

Coelho, Fabian. *Significados*. 2017. Retrieved from https://www.significados.com

Council, IEA. 2000. *Sociedad colombiana de ergonomía*. Retrieved from https://www.sociedadcolombianadeergonomia.com/ergonomia

Diego-Mas, J. A. 2015. *Evaluación Postural mediante el método RULA Ergonautas Universidad Politécnica de Valencia*. Retrieved from https://www.ergonautas.upv.es/

López, B. S. 2016. *Ingeniería Industrial Online*. Retrieved from https://www.ingenieriaindustrialonline.com/herramientas-para-el-ingeniero-industrial/salud-ocupacional/riesgo-ergon%C3%B3mico/

Sagala, M. D. de U. 2007. Retrieved from https://www.navarra.es/NR/rdonlyres/76DF548D-769E-4DBF-A18E-8419F3A9A5FB/145886/TrastornosME.pdf

# EVALUATION OF ERGONOMIC RISKS IN OPERATION 9XXX USING THE REBA METHOD

**Alani Quiñones Betancourt, Dalia Patricia Araujo Victorino, Damaris Barajas Soto, Laura Susana Portugal Osuna, Arturo Realyvásquez Vargas**

Industrial Engineering Departamet
Instituto Tecnológico de Tijuana
Av. Castillo de Chapultepec 562, Tomas Aquino
Tijuana, Baja California 22414
E-mail: damaris.barajas17@tectijuana.edu.mx

**Resumen:** Este proyecto se centra en la evaluación de los riesgos laborales causados por las malas posturas adoptadas en la operación 9XXX en una estación de trabajo en la línea de producción de Barbie Camper, ya que se reciben quejas de los trabajadores debido al dolor en la espalda y las muñecas. Además, la tasa de visitas a la enfermería ha aumentado significativamente en los últimos meses (junio de 2019 - septiembre de 2019). La investigación se llevó a cabo en la empresa Mabamex S.A. de Tijuana, delimitando el problema en el proceso de producción. La operación 9XXX se evalúa en base al método REBA (Evaluación rápida de todo el cuerpo) para identificar el nivel de riesgo al que está expuesto el trabajador. Se realiza un análisis de los resultados para luego evaluar y dar las recomendaciones y / o posibles soluciones para el problema que enfrenta la empresa.

**Palabras clave:** riesgos laborales, malas posturas, nivel de riesgo, REBA

**Relevancia para la ergonomía:** Al evaluar los riesgos a los que está expuesto el trabajador debido a un mal diseño de las estaciones de trabajo o el proceso, hace que las empresas sean conscientes de los daños irreversibles que esto puede causar y son socialmente responsables, comprometiéndose a participar en la mejora que beneficia tanto el trabajador como la empresa.

**Abstract:** This project focuses on the evaluation of the occupational risks caused by performing the bad postures that are adopted in operation 9XXX at a work station on the Barbie Camper production line, since complaints are received from workers due to the pain in the back and wrists. An addition, to the rate of visits to the infirmary has increased significantly in recent months (June 2019 - September 2019). The investigation was carried out at the company Mabamex S.A. of Tijuana, delimiting the problem in the production process. Operation 9XXX is evaluated based on the REBA (Rapid Entire Body Assessment) method to identify the level of risk to which the worker is exposed. An analysis of the results is made to then assess and give the recommendations and / or possible solutions for the problem the company is facing.

**Key words:** occupational risks, bad postures, level of risk, REBA

**Relevance for ergonomics:** Assessing the risks to which the worker is exposed due to a bad design of the workstations or the process, makes companies aware of the irreversible damages that this can cause and are socially responsible, committing themselves to participate in the improvement that benefits both the worker and the company.

## 1. INTRODUCTION

This research work shows a study applied to the “Barbie Camper” line of work, in operation 9XXX within the Mabamex company, in which it is considered that there are risks for the operator and where some or some of the methodologies can be applied. ergonomic.

Mabamex is a toy manufacturing industry. Among some of the products made here are: Barbie Camper, Wheelies, Pottys (Unicorn, Dino, Froddy, Penguin, Catarina, Duck), Jurassic World Dino, Rock A Stack, Lion Walker, Thomas Popper, Flush Potty, Hippo Walker , L&L Car, Pizza Planet, Booster (Vaquita, Osita, Raccoon), Corn Popper, Confort Potty, Bañeras, Smart Home, Baby Block, Food Truck, Mega Block, among others.

Throughout different chapters the different stages of the project are developed and documented. In Chapter 1, Introduction, a brief presentation of the project is given in broad strokes so that the reader can have a better understanding. Chapter 2, Objectives, presents the general and specific objectives. Chapter 3, Methodology, describes in detail how the project was carried out. Chapter 4, Results, shows the results obtained by applying the methodology described in Chapter 3. Finally, Chapter 5 mentions the conclusions and recommendations of the project.

### 1.1 Background

From the international panorama, there are innumerable documents, investigations and studies that have been carried out around the ergonomic risk factors of employees in all known production areas, which is why a detailed description and interpretation of the level of involvement is presented of these risks in different areas and work environments.

To cite just one example of these internationally available studies, the one carried out by Llaneza is cited, which states that musculoskeletal injuries constitute a classic ergonomic risk, therefore susceptible of being evaluated and demonstrated damage through an ergonomic opinion. With many names and definitions, musculoskeletal injuries are an increasingly frequent problem in the workplace (Llaneza, 2004, p.268). In another analysis carried out in this research, it is pointed out that the only cause that explains the global increase in occupational diseases are musculoskeletal pathologies and other factors related to ergonomic risks. Thus, while in 1999 these diseases accounted for 65% of the total number of illnesses suffered by employees, in 2003 this percentage grew to represent 78% (Garzón, 2009, p.30).

## 1.2 Context

Mabamex is a subsidiary company of Mattel Inc., a leading company in the field of toys internationally. It begins operations on December 18, 1981. Mabamex manufactures more than 50 different products, which are exported to 150 countries, whose main clients are commercial chains such as Wal-Mart, Target and Amazon.com.

Mabamex Tijuana's manufacturing experience, as well as its proximity to the US market, makes it attractive for efficient production costs, especially today that labor costs in China have increased.

The plant where the ergonomic risk analysis will be carried out is Mabamex Colonia El Florido - Ciudad Tijuana, Baja California (see Figure 1). The specific production area evaluated at this plant is a station on the Barbie Camper line (see Figure 2).

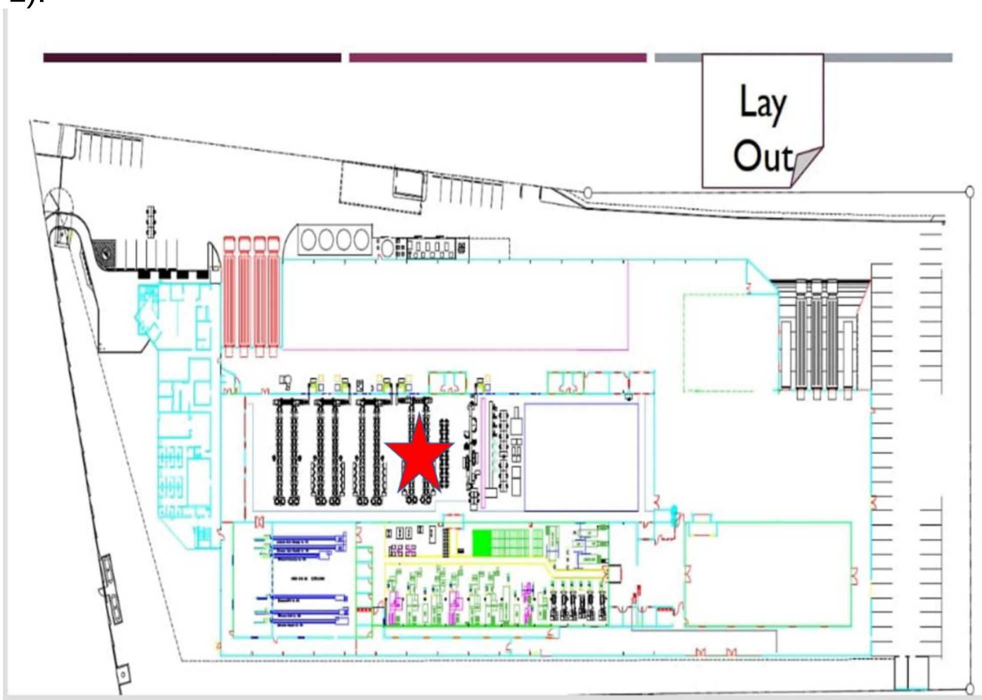



Figure 1. Mabamex S.A. Company layout, production line highlighted in red


Figure 2. Mabamex S.A. Barbie Camper

### 1.3 Problem statement

In the company Mabamex S.A in Tijuana, the engineering department and the assembly department have detected the unnecessary movements that are made in operation 9XXX. Problems have occurred in recent months (June 2019 - September 2019) with a station on the Barbie camper line. The operator has reported wrist pain, fatigue and back pain when loading the individual (finished piece) to pass it to the gum machine. This is derived from the positions that the operator is forced to adopt and those to carry out the activity. Figure 3 shows the positions taken by the operator when performing the 9XXX operation.

Due to the aforementioned about the problems that exist in the Barbie Camper line, it has been detected that the operator presents fatigue before the end of his workday, for which the operator is forced to go to the company's infirmary, notifying discomfort in the wrists and back, as well as physical fatigue (See Figure 4).

## 2. OBJETIVE

The objectives of this project are mentioned in this section, starting with the general objective and later with the specific objectives.

### 2.1 General objective

Assess the level of ergonomic risk in the Barbie Camper line caused by postural load.

Figura 3. Posturas adoptadas por el trabajador al realizar la operación 9XXX

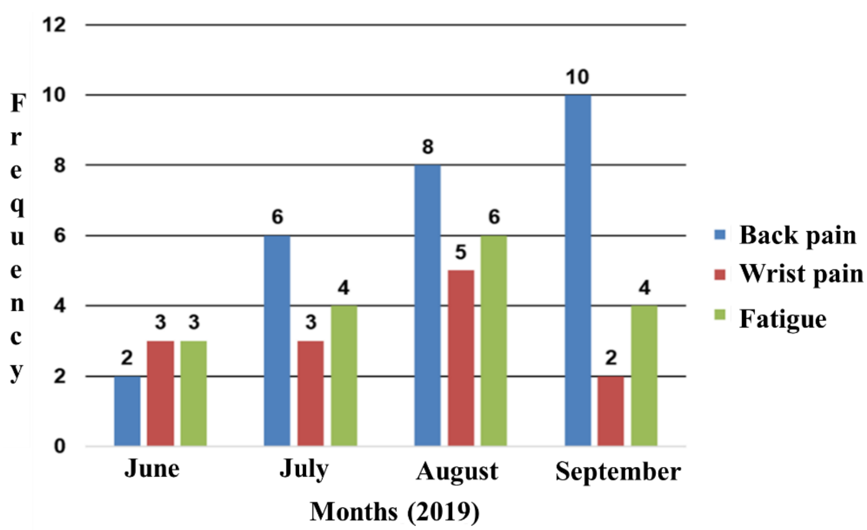



Figure 4. Frequency of visits to the infirmary for back pain, wrists and physical fatigue

## 2.2 Specific objectives

• Assess the workstation to determine ergonomic hazards to which operators are exposed.
• Identify which are the uncomfortable postures that the operators adopt, that may cause a risk to their physical health.
• Implement a methodology to carry out an ergonomic risk assessment.
• Propose alternatives of movements and postures that can benefit the performance and health of the worker.

# 3. METHODOLOGY

The method that will be implemented to carry out an evaluation of the 9xxx operation is REBA (Rapid Entire Body Assessment).

## 3.1 Foundations of the method

Adopting inappropriate postures continuously or repeatedly at work creates fatigue and can eventually lead to health problems. One of the risk factors most commonly associated with the appearance of musculoskeletal-type disorders is precisely excessive postural load. Thus, the evaluation of the postural load or static load, and its reduction if necessary, is one of the fundamental measures to be adopted in the improvement of jobs.

## 3.2 Method implementation

**Work posture analyzed:** Operator performing operation 9xxx (Figure 5).
**Data:**

1. Neck is in flexion> 20º.
2. Legs in unilateral support and flexed between 30º and 60º.
3. Trunk flexed more than 60º and with lateral inclination.
4. The weight / load of the toy that affects the worker is less than 5kg.
5. Forearm flexed to less than 60º.
6. Wrist movement is between 0º-15º flexion -extension with torsion or lateral deviation.
7. Arm flexed between 45º-90º, in abduction and with a posture in favor of gravity.
8. Grip is considered to be regular.
9. It must be taken into account that during this operation uncomfortable postures are adopted with frequencies, for example, more than 4 times per minute, and significant posture changes occur or unstable postures are adopted.

Figure 5. Posture analyzed

The criteria shown in Tables 1-7 are used to obtain the scores for each part of the body.

Table 1. Scores for neck posture

| Movement | Score |
|---|---|
| 0º - 20º Flexion | 1 |
| > 20º flexion, or extension | 2 |

Table 2. Scores for the posture of the trunk (back)

| Movement | Score |
|---|---|
| Straight | 1 |
| 0º - 20º flexion<br>0º - 20º extension | 2 |
| 20º - 60º extension<br>> 20º extension | 3 |
| > 60º flexion | 4 |

Table 3. Scores for leg posture.

| Position | Score |
|---|---|
| Bilateral weight support, walking or sitting | 1 |
| Unilateral weight support.<br>A raised leg or an unstable posture | 2 |

Table 4. Rating of the applied force or load

| Weight | Score |
|---|---|
| < 5 kg | 0 |
| 5-10 g | 1 |
| > 10 kg | 2 |
| Jerking or rapid increase in strength | +1 |

Table 5. Scores for arm posture

| Weight | Score |
|---|---|
| 20º extension a 20º flexion | 1 |
| > 20º extension<br>20º- 45º flexion | 2 |
| 45º-90º flexion | 3 |
| >90º flexion | 4 |

Table 6. Scores for forearm posture.

| Movement | Score |
|---|---|
| 60º-100º flexion | 1 |
| <60º flexion or<br>>100º extension | 2 |

Table 7. Scores for wrist posture

| Movement | Score |
|---|---|
| 0º-15º Flexion/extension | 1 |
| >15º Flexion/extension | 2 |

# 4. RESULTS

## 4.1 Neck

A score of 2 was obtained for the neck, since the neck is at a flexion angle greater than 20º.

## 4.2 Trunk

In the case of the trunk (back) a score of 5 was obtained, since the trunk is flexed more than 60º and has lateral inclination.

## 4.3 Legs

For the legs a score of 3 was obtained, this because the legs are in unilateral support with flexion between 30 ° and 60 °.

## 4.4 Load or applied force

A score of 0 was obtained for this variable, since the weight of the toy inside the box is less than 5 kg.

## 4.5 Arms

The score for the arms was 3, because the arm is flexed between 40º and 50º in abduction and the posture in favor of gravity.

## 4.6. Forearms

For the forearms the score was 2, because it is flexed to less than 60º.

## 4.7 Wrist

The wrist score was 1, because its movement is between 0º and 15º with twisted extension. Table 8 shows the results of the scores by group. As can be seen, the final REBA score (final score c) was 12, which means that the level of risk caused by the task is Very high, and immediate changes in the design of the station or work method are required.

Table 8. Scores by group

| Group | Score |
|---|---|
| Score group A | 8 |
| Score group B | 4 |
| Partial score A | 9 |

| | |
|---|---|
| Partial score B | 5 |
| Final score C | 12 |

## 5. CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Conclusions

The operator has to load the box to take it to the gumming table and although it is not a considerable weight, being a frequent activity implies fatigue at the end of the working day. In this operation the arms, wrists and trunk are affected.

Based on the results obtained, it can be concluded that the stated objectives were achieved. It was possible to determine the different uncomfortable postures that the operator adopts, as well as determine the level of risk of this using the REBA method.

### 5.2 Recommendations

The recommendation is to put another band in conjunction with the one that already has so that the operator does not have to load the box and take it to the gumming table, but only has to press a button when its enteipating operation has finished, so that the band by itself take the box; in this way you would not be suffering any effort on the trunk, arms or wrists.
The current and proposed workstation are shown below (see Figures 6 and 7).

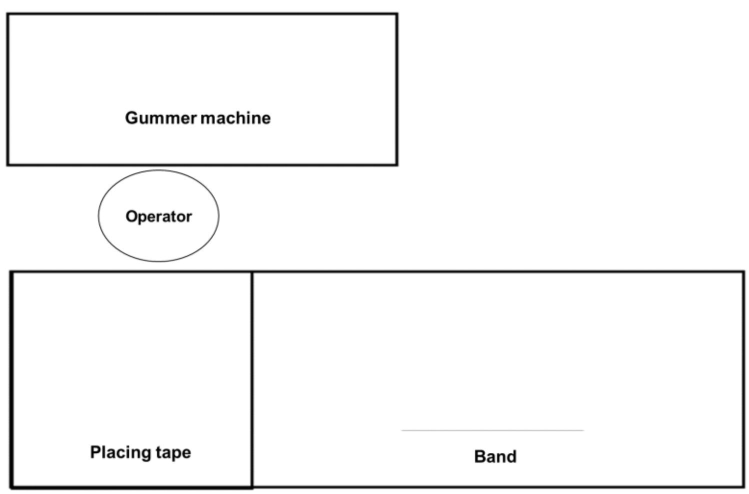



Figure 6. Current Workstation

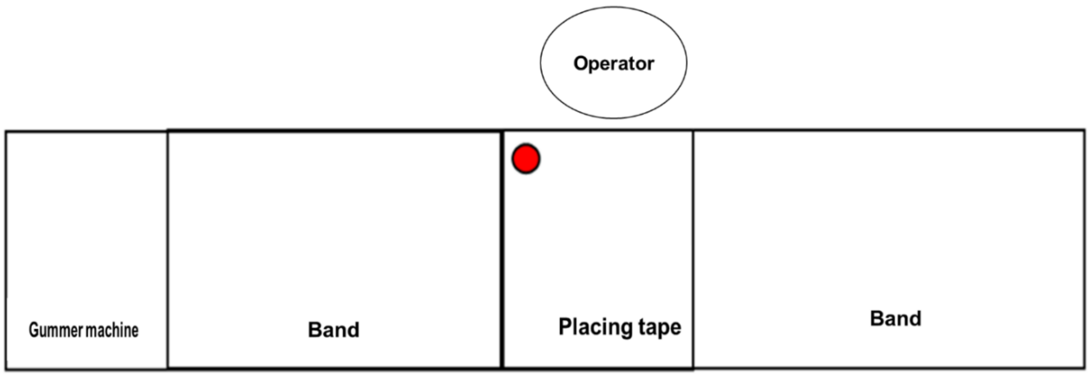



Figure 7. Workstation proposal

The operator does not have an ergonomic mat, and since it is an operation in which he is on his feet all day, it implies greater fatigue and wear, so it is recommended that the operator have an ergonomic mat in his work area.

## 6. REFERENCES

*Diego-Mas, Jose Antonio.* Evaluación postural mediante el método REBA. Ergonautas, Universidad Politécnica de Valencia, 2015. Disponible online: https://www.ergonautas.upv.es/metodos/reba/reba-ayuda.php

Garzón, A. (2009) La naturaleza de la jurisprudencia internacional en materia de derechos humanos y su vinculatoriedad en el ámbito estatal doméstico. P.30

Llaneza, J. (2004). La ergonomía forense. Pruebas periciales en prevención de riesgos laborales. P.268

# POSTURAL IMPROVEMENTS IN THE ELECTRONIC COMPONENTS ASSEMBLY.

**Alejandra Castro Ramos[1], Alberto Verdugo Machado[1], Juan Antonio Moreno Calvillo[1], Rosario Sánchez Tlehuactle[1], Rigoberto Zamora Alarcón[2]**

[1]Ingeniería Industrial
Instituto Tecnológico de Mexicali
Av. Instituto Tecnológico s/n, Plutarco Elías Calles
Mexicali, Baja California, C.P. 21376
rosary_7@hotmail.es, alecastro_2011@hotmail.com juanm_1706@hotmail.com, alberto_verdugo0212@hotmail.com

[2]Ingeniería Industrial/Mecánica
Instituto Tecnológico de Mexicali/ Universidad Autónoma de Baja California
Av. Instituto Tecnológico s/n, Plutarco Elías Calles / Calle Normal s/n Blvd. Benito Juárez Col. Insurgentes Este
Mexicali, Baja California, C.P. 21100
mczamora02@yahoo.com.mx

**Resumen**: El presente proyecto titulado "Ensamble de Componentes Electrónicos" tiene lugar dentro de la empresa de ensamble de tablillas electrónicas en el área de tableros. La empresa cuenta con varias áreas operativas, como lo son "manejo de maquinaria y equipo", "pruebas funcionales" y "ensamble manual", en esta última área es donde tendrá lugar el proyecto, en dicha área se ensamblan manualmente cada componente de la tablilla electrónica, compuesto por 8 componentes, para posteriormente ser ensambladas en las pantallas, para finalizar el proceso de las pantallas.

El producto que se ensambla en esta área de Tableros, son las tablillas electrónicas para las televisiones, siendo estas de diferentes modelos, cada tablilla lleva un proceso de ensamble y de acuerdo al modelo son los componentes que lo conforman.

Se ha seleccionado este proceso como proyecto de análisis por la manera en que se realizan cada uno de los movimientos, el ensamblar cada componente, la postura en la que se trabaja, de esta manera se observan oportunidades para aplicar la ergonomía y normas Mexicanas que son necesarias para que el proceso sea más adecuado y confortable para el trabajador. Para esto, será necesario hacer análisis de riesgos ergonómicos, aplicar 5 S para mejora continua en el proceso y así evitar cualquier inconformidad, enfocando el proyecto al proceso y a los trabajadores que lo apliquen.

**Palabras clave**: Componentes electrónicos, tablillas, 5 S, Normas Mexicanas.

**Relevancia para la ergonomía**: La aplicación de las normas mexicanas, y reglamentos así también como las validaciones ergonómicas, la dimensión de

estaciones y operadores así como las herramientas de mejora continua, permiten validar y mejorar las estaciones para confort de los operadores al verlo como un sistema de mejora para la ergonomía.

**Abstract:** This project entitled "Electronic Components Assembly" takes place within the electronic slat assembly company in the board area. The company has several operational areas, such as "machine and equipment management", "functional tests" and "manual assembly", in the latter area is where the project will take place, in that area each component of the electronic tablet is manually assembled each component of the electronic tablet, composed of 8 components, to be then assembled on the screens, to finish the process of the screens.

The products that are assembled in this area of Boards are the electronic tablets for televisions, being these of different models, each tablet carries a process of assembly and according to the model are the components that make up it.

This process has been selected as an analysis project by the way in which each of the movements are made, the assembling of each component, the position in which we work, in this way we observe opportunities to apply the ergonomics and Mexican standards that are necessary to make the process more suitable and comfortable for the worker. For this, it will be necessary to make ergonomic risk analyses, apply 5 S for continuous improvement in the process and thus avoid any nonconformity, focusing the project on the process and the workers who apply it.

**Keywords:** Electronic components, tablets, 5 S, Mexican standards.

**Relevance for ergonomics:** The application of Mexican standards, and regulations as well as ergonomic validations, the size of stations and operators as well as continuous improvement tools, allow to validate and improve the stations for operators' comfort by seeing it as an improvement system for ergonomics.

## 1. INTRODUCTION

The present project entitled "Electronic Component Assembly" takes place within the electronic board assembly company in the area of boards to improve operator positions in the process of assembling electronic components on the boards, applying an analysis of the Mexican standards and ergonomic evaluations supported by continuous improvement methodologies, to make the process more comfortable and safe for the worker who performs it. The company has several operational areas, such as "machinery and equipment handling", "functional tests" and "manual assembly", in this last area is where the project will take place, in this area each component of the electronic board, composed of 8 components, to be later assembled on the screens, to finish the process of the screens.

The product that is assembled in this area of Boards, are the electronic boards for televisions, being these of different models, each board has an assembly process and according to the model are the components that make it up. This process has been selected as an analysis project for the way in which each of the movements are carried out, the assembly of each component, the posture in which it is worked, in this way opportunities are observed to apply the ergonomics and Mexican standards that are necessary to make the process more suitable and comfortable for the worker. For this, it will be necessary to make analysis of times and movements, apply 5 S for continuous improvement in the process and thus avoid any disagreement, focusing the project on the process and the workers who apply it.

## 2. OBJECTIVE

Improve operator postures in the process of assembling electronic components on the slats, applying an analysis of Mexican standards and ergonomic evaluations supported by continuous improvement methodologies, to make the process more comfortable and safe for the worker who performs it.

## 3. METHODOLOGY

Application of Mexican standards to validate physical conditions of work station NOM-011-STPS-2001 Safety and hygiene conditions in work centers where noise is generated, NOM-015-STPS-2001 High or lowered thermal conditions, safety conditions and hygiene, NOM-025-STPS-2008 lunation conditions in the work centers, as well as the one that allows evaluating the conditions to the operator in the work station.

In a second stage with NOM-017-STPS-2008 Personal protective equipment - selection and use of management in workplaces and NOM-004-STPS-1999 (Protection systems and safety devices in machinery and equipment) and finally in a third stage NOM-035-STPS-2018 Psychosocial Risk Factors, work-identification, analysis and prevention.

2. Analysis of station sizing and operator anthropometry. In which the anthropometry of the operators will be related to the dimensions of the equipment and workstations, to determine and reduce their effect on assembly postures.

3. Analysis and ergonomic evaluation in workstation, with OCRA methodology, Suzanne Rodgers. They will allow us to assess the ergonomic risks due to the bad postures of the operators, the analysis will allow us to detect the risks to work to seek to reduce them and increase operator comfort.

4. Use of continuous improvement methodologies 5 s and International Labor Organization (ILO), to identify the principles of storage of assembly components and the principles of movement of the operator, seeking to evaluate the positions that can be improved by means of spreadsheets for containers. of components.

## 4. RESULTS

### 4.1. Mexican Standards

The physical conditions of the work station were validated, starting with the application of the Mexican Standards where it was observed that they are within the permissible parameters. In a first part, noise, temperature and lighting measurements were carried out in conjunction with the nodes analyzed within the work area.

For NOM-011-STPS-2001 they are within the allowable values of decibels at the station.

A noise measurement process was carried out using the sound level measurement instrument, which validates within the process, and we note that they are within the permissible values of decibels both in the station, obtaining as a result of 45 to 50 dB <80DB which it is the measure that governs the Standard. (STPS, 2002)

For NOM-015-STPS-2001 the Temperature is more critical in summer, however, at this time it is within the permissible parameters of thermal comfort. Workers were informed of occupational hazards from exposure to extreme temperatures.

An analysis was carried out using a thermometer to tell us if it complies with what the standard governs, even when the bands, which transport material and be an automatic assembly line, are in the area, the temperature is more critical in summer, however At this time it is within the permissible parameters of thermal comfort. (STPS, 2002)

For the NOM-025-STPS-2008 corresponding to Lighting, it was found within the necessary lumen of more than 436 lux. The evaluation of the lighting levels was carried out by means of nodes in the work area. Illumination was analyzed using the measurement instrument (luxmeter) to know if we are inside. Corresponding to the Illumination was found within the parameters, necessary greater than 319 lux. (STPS, 2008).

In a second part, with NOM-17-STPS-2008, the conditions of the operator at the work station were evaluated according to the standard, using the necessary protective equipment for the process and work area (STPS, 2008). Determine the appropriate personal protective equipment that workers must use depending on the risks at work. The necessary protective equipment for the process and work area are used, such as antistatic equipment. In the process of assembling the electronic components, the antistatic equipment such as bracelets, sandals, gloves and antistatic gown, among others, is used for the good handling of the components, as shown in Figure 1. This equipment is so that the employee who is assembling the electronic components does not suffer an electric shock or that the component runs the risk of being damaged, since otherwise the integrity of the worker and damage to the work material will be exposed.

That is why this standard is applied at this point in the process to constantly review the use of the equipment.

Figure 1. Protection systems and safety devices in machinery and equipment.

For NOM-004-STPS-1999. Protection systems and safety devices in machinery and equipment, it is observed that there is little handling of machinery; however, personnel must know their risks (STPS, 1999). Give adequate training for the operation of machinery. It is observed that there is little handling of machinery, however, the personnel must know the risks that they may have when using a machine, since, although the process is band, there are buttons that indicate stop or restart of the band, the worker must know the operation of these to avoid damaging any component or having an accident. Within this process a dress code is made to avoid exposing the worker, in this way the worker knew the risk that he is exposed to when working in the assembly process, within this analysis it is observed that the risk that he may suffer is minimal the employee.

Finally, in NOM-035-STPS-2018, a medium risk was found, having no violence and a low-risk work environment, the analysis is carried out through a survey and it is observed that no critical values are manifested (STPS, 2018), according to the norm, the area was analyzed through a survey applied to the workers who carry out the assembly activity of the components, within this survey the treatment, stress, work environment, leadership, development and according to the results are evaluated obtained shown in the Table. 1 it is observed that there are no critical values in the assembly process, so the area is kept out of psychosocial risk, and suitable for workers. Obtaining a low level of risk.

Table 1. Survey results to identify psychosocial risk factors in the workplace, by category

| Calificación de categoría | Nivel de Riesgo1 | Nivel de Riesgo2 |
|---|---|---|
| Ambiente de trabajo | Nulo | Bajo |
| Factores propios de la actividad | Nulo | Nulo |
| Organización del tiempo de trabajo | Nulo | Nulo |
| Liderazgo y relaciones en el trabajo | Bajo | Bajo |
| Necesidad de acción | | Nivel de Riesgo |
| El riesgo resulta despreciable por lo que no se requiere medidas adicionales. | | Nulo |
| Necesario mayor difusión de política de prevención de riesgos psicosociales y programas para: la prevención de los factores de riesgo psicosocial, la promoción de un entorno organizacional favorable y la prevención de la violencia laboral. | | Bajo |

Table 2. Survey result to identify psychosocial risk factors in the workplace, by Domain

| Calificación de Dominio | Nivel de Riesgo 1 | Nivel de Riesgo 2 |
|---|---|---|
| Condiciones en el ambiente de trabajo | Nulo | Bajo |
| Carga de trabajo | Nulo | Nulo |
| Jornada de trabajo | Medio | Nulo |
| Interferencia en la relación trabajo-familia | Nulo | Medio |
| Relaciones en el Trabajo | Bajo | Bajo |
| Violencia | Medio | Nulo |
| **Necesidad de acción** | | **Nivel de Riesgo** |
| El riesgo resulta despreciable por lo que no se requiere medidas adicionales. | | Nulo |
| Necesario mayor difusión de política de prevención de riesgos psicosociales y programas para: la prevención de los factores de riesgo psicosocial, la promoción de un entorno organizacional favorable y la prevención de la violencia laboral. | | Bajo |
| Se requiere revisar la política de prevención de riesgos psicosociales y programas para la prevención de los factores de riesgo psicosocial, la promoción de un entorno organizacional favorable y la prevención de la violencia laboral, así como reforzar su aplicación y difusión, mediante un Programa de intervención. | | Medio |

## 4.2. Analysis of station sizing and operator anthropometry

In the analysis of the dimensions of the stations, according to the anthropometry of the operators, it does not comply with the dimensions of operating comfort on the bench, it was necessary to apply recommendations. The work station, the dimensions and reaches of the components are shown in figure 2, and in figure 3 the working heights in the station.

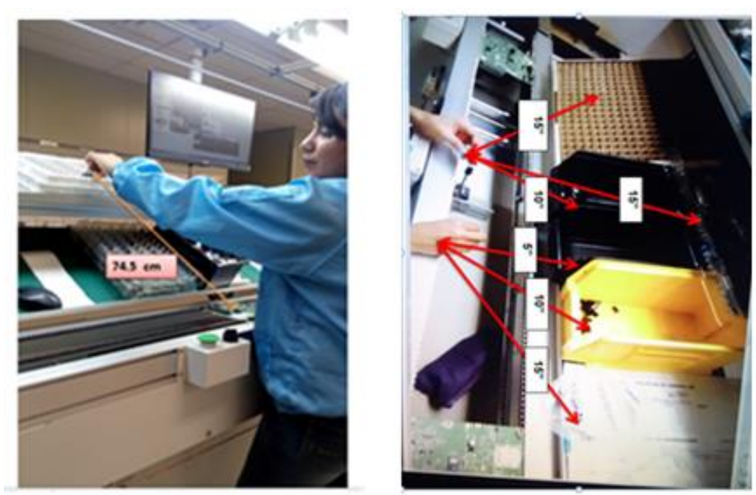



Figure 2. Distribution and dimensioning of the scope of components in the station

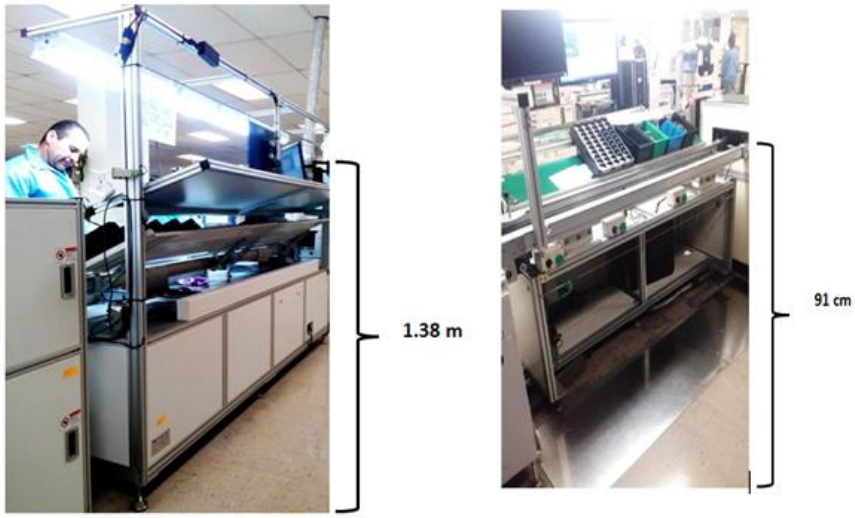



Figure 3. Dimensions of working height in the Station

The anthropometry of the total number of operators was analyzed for sizing and comparison with the existing equipment. It was determined to condition the height of some components that are above the shoulders. Table 3 shows the resulting percentiles to be used in relocating components at the station.

Table 3. Percentiles of study station operators

| Medicion de operadoes | Percentiles | | | Observaciones Relacion |
|---|---|---|---|---|
| | 5 | 50 | 95 | |
| Altura ojos | 133.0 | 146.3 | 159.5 | |
| Altura hombro | 120.0 | 128.7 | 137.4 | Altura maxima de componentes |
| Altura codo | 49.7 | 87.9 | 126.1 | Altura ensamble |
| Altura cintura | 66.1 | 82.8 | 99.4 | |
| Altura rodilla | 39.8 | 44.3 | 48.7 | |
| Ancho codo a codo | 37.6 | 45.0 | 52.4 | Localizacion de componentes |
| Hombro a hombro | 37.2 | 39.5 | 41.8 | Localizacion de componentes |
| Desde piso hasta mano levantada | 160.7 | 184.2 | 207.7 | |
| Brazo extendido hacia arriba | 53.9 | 62.8 | 71.8 | |
| Brazo extendido con mano abierta | 35.3 | 58.3 | 81.4 | |
| Brazo extendido con mano cerrada | 29.6 | 50.8 | 72.0 | |
| Brazo flexionado hacia pecho | 34.8 | 39.3 | 43.8 | |

### 4.3. Analysis and ergonomic evaluation at workstation

### OCRA method (Occupational Repetitive Action)

The analysis that was made is showing in the table a risk and valuation index 19 for the right side (right hand) that is not of an acceptable level because the values are above 14.4-22.5 indicating in the table, as well as the side left (left hand) is the same value 19 is not acceptable since they are above the values 14.1-22.5 as indicated in the rating.

Table 1. OCRA method risk factors in the electronic components assembly process.

| **Factores de riesgo** | **Izquierda** | **Derecha** |
|---|---|---|
| Tiempo de recuperación | 3 | 3 |
| Frecuencia de movimientos | 4.5 | 4.5 |
| Aplicación de fuerza | 6 | 6 |
| Hombro | 1 | 1 |
| Codo | 2 | 2 |
| Muñeca | 4 | 4 |
| Mano-dedos | 2 | 2 |
| Estereotipo | 1.5 | 1.5 |
| Posturas forzadas | 5.5 | 5.5 |
| Factores de riesgo complementarios | 1 | 1 |
| Factor Duración | 0.95 | 0.95 |
| **INDICE DE RIESGO:** | **19** | **19** |
| Lista verificación de Valor | 14.1-22.5 | 14.1-22.5 |
| Índice OCRA | 6-9 | 6-9 |
| Nivel de Riesgo | Riesgo inaceptable Medio | Riesgo inaceptable Medio |

4.4 Suzanne Rodgers Method Analysis

| Parte del cuerpo analizada | Intensidad | | Duración | | Esfuerzo por minuto | | Puntuaje | | Evaluación | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Der | izq. | Der | izq. | Der | izq. | Der. | Izq. | Der | izq. |
| Cuello | 1 | | 2 | | 3 | | 5 | | | |
| Hombros | 1 | 1 | 2 | 2 | 3 | 3 | 5 | 5 | | |
| Espalda | 2 | | 2 | | 3 | | 8 | | | |
| Brazos y codos | 1 | 1 | 2 | 2 | 3 | 3 | 5 | 5 | | |
| Muñeca, manos y dedos | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | | |
| Piernas y tobillos | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | | |

In the table shown the application of the Suzanne Rodgers method shows us, we can see in the area of the back they have a high risk assessment indicating it in red.

**4.5. The 10 principles of movement in 5 S were validated.** [8]

**14 PRINCIPLES OF 5S**

When applying the principles, we evaluated that 4 were not applied correctly, since they were not at the correct height and sequence, leaving a 71.42% acceptance in 5 S.


**Proposals to implement at the workstation. Principle 10**

**4.6 Organización internacional del trabajo (OIT)**

International Labor Office in collaboration with the International Ergonomics Association. (nineteen ninety six). MACHINERY SAFETY. In ERGONOMIC CHECKLIST (78.79). Geneva: OIT.

International Labor Office in collaboration with the International Ergonomics Association. (nineteen ninety six). IMPROVING THE DESIGN OF THE JOB. In ERGONOMIC CHECKLIST (120,121,122,123,124,125,126,127,128,129,132,133,). Geneva: OIT.

International Labor Office in collaboration with the International Ergonomics Association. (nineteen ninety six). USE OF LIGHT. In ERGONOMIC CHECKLIST (152,153,154,155,156,157,158,159,160,161,162,163,). Geneva: OIT.

International Labor Office in collaboration with the International Ergonomics Association. (nineteen ninety six). Protect the workplace from excessive heat or cold from the outside. In ERGONOMIC CHECKLIST (176,177,182,183,184,185,). Geneva: OIT.

International Labor Office in collaboration with the International Ergonomics Association. (nineteen ninety six). ENVIRONMENTAL RISKS. In ERGONOMIC CHECKLIST (188,189,190,191,192,193,194,). Geneva: OIT.

International Labor Office in collaboration with the International Ergonomics Association. (nineteen ninety six). Lamp and equipment cable connections are secure. In ERGONOMIC CHECKLIST (198,199,). Geneva: OIT.

International Labor Office in collaboration with the International Ergonomics Association. (nineteen ninety six). HYGIENIC AND LOCAL REST SERVICES. In ERGONOMIC CHECKLIST (202,203,204,205,206,207,208,209). Geneva: OIT.

International Labor Office in collaboration with the International Ergonomics Association. (nineteen ninety six). INDIVIDUAL PROTECTION EQUIPMENT. In ERGONOMIC CHECKLIST (212,213,214,220,222,224,225,228,230). Geneva: OIT.

International Labor Office in collaboration with the International Ergonomics Association. (nineteen ninety six). ORGANIZATION OF WORK. In ERGONOMIC CHECKLIST (234,235,236,240,242,244). Geneva: OIT.

## 5. CONCLUSIONS

Improvements in the way in which the assembly of the electronic components is made, avoiding the inconvenience of the operators, giving a comfortable area for the worker. The operator was provided with better certainty that the operating conditions were within the criteria for approval of the standards.The workstation was improved with which it was possible to improve the working postures in the process of assembling electronic components on the boards.Operator postures were improved in the process of assembling electronic components on the slats, by applying the analyzes of Mexican standards and ergonomic evaluations supported by continuous improvement methodologies, which allowed the process to be more comfortable and safe for the worker than I did it.

## 6. REFERENCE

5s para todos 5 pilares de la Fábrica Visual Shingeo Shingo
http://publicaciones.eafit.edu.co/index.php/revista-universidad eafit/article/download/1073/965/

Lista de Comprobación Ergonómica OIT
https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/instructionalmaterial/wcms_345646.pdf

Reglamento Federal de Seguridad y Salud en el Trabajo http://www.dof.gob.mx/nota_detalle.php?codigo=5368114&fecha=13%2F11%2F2014

Secretaría del Trabajo y Previsión Social (2002). NOM-011-STPS-2001: en el diario oficial de la federación 17/04/2002 . NORMA Oficial Mexicana NOM-

011-STPS-2001, Condiciones de seguridad e higiene en los centros de trabajo donde se genere ruido. http://www.dof.gob.mx/nota_detalle.php?codigo=734536&fecha=17/04/2002

Secretaría del Trabajo y Previsión Social (2002). NOM-015-STPS-2001: en el diario oficial de la federación 14/06/2002 . http://asinom.stps.gob.mx:8145/upload/noms/Nom-015.pdf

Secretaría del Trabajo y Previsión Social (2008). NOM-025-STPS-2008: en el diario oficial de la federación 30/12/2008 http://asinom.stps.gob.mx:8145/upload/noms/Nom-025.pdf

Secretaría del Trabajo y Previsión Social (2008). NOM-017-STPS-2017 : en el diario oficial de la federación 09/12/2008, proyecto de norma http://dof.gob.mx/nota_detalle.php?codigo=5072773&fecha=09/12/2008

Secretaría del Trabajo y Previsión Social (1999). NOM-004-STPS-1999: en el diario oficial de la federación 31/05/1999 http://www.dof.gob.mx/nota_detalle.php?codigo=4948965&fecha=31/05/1999

# IMPROVEMENT OF POSTURES AND EFFICIENCY IN THE PROCESS OF PREPARING MANUALS

**Alan Alexis Camacho Domínguez[1], Rafael Francisco Espinoza Mendoza[1], Michell Ydaly García Meza[1], David Sánchez Cabrales[1] y Rigoberto Zamora Alarcón[2].**

[1]Ingeniería Industrial
Instituto Tecnológico de Mexicali
Av. Instituto Tecnológico s/n, Plutarco Elías Calles
Mexicali, Baja California, C.P. 21376
Alan.camacho1318@gmail.com

[2]Ingeniería Industrial/Mecánica
Instituto Tecnológico de Mexicali/ Universidad Autónoma de Baja California
Av. Instituto Tecnológico s/n, Plutarco Elías Calles / Calle Normal s/n Blvd. Benito Juárez Col. Insurgentes Este
Mexicali, Baja California, C.P. 21100
mczamora02@yahoo.com.mx

**Resumen:** El presente caso práctico se verán mejoras de posturas ergonómicas en el proceso de elaboración de manuales y el orden de los materiales utilizados, mediante la aplicación de metodologías, evaluación de riesgos ergonómicos, evaluación de mejora aplicando las Normas Mexicanas y metodologías de mejora continua, para cuidar la salud e integridad del asociado, será aplicado en una empresa que manufactura herramientas multiusos. En el proceso realizan unos manuales tomando varias piezas de 4 bines el cual se coloca en una bolsa y con la mano o pie se activa el pedal el cual hace cortar la bolsa que cae en una caja. Se aplicaran las normas oficiales mexicanas, organización Internacional del Trabajo (OIT) se dimensionará estaciones de trabajo, se tomaran las medidas antropométricas de los operadores. Posteriormente se realizaran análisis utilizando la metodología RULA (Valoración Rápida de los Miembros Superiores) y Check list OCRA (Acción repetitiva ocupacional), Sue Rodgers para la evaluación de movimientos repetitivos, alcance, altura y aplicación de metodologías de mejora continua. Se logró mejorar la postura del empleado así como la productividad del proceso.

**Palabras clave:** Manuales, SUE RODGERS, RULA, OCRA y Mejora continua.

**Relevancia para la ergonomía**: Este proyecto tiene un impacto significativo porque se realiza un análisis extenso de ergonomía utilizando las Normas mexicanas y como se aplican en este país, se mejora un problema presentado en una empresa actual, en estaciones de trabajo diseñadas incorrectamente sin tomar en cuenta los aspectos ergonómicos adecuados, causando problemas en el operador. De esta manera cualquier persona que lea el presente artículo podrá tener una idea de los problemas que se presentan actualmente en el mundo laboral y tomar como

referencia los pasos que se realizaron para mejorar una estación de trabajo con movimientos repetitivos.

**Abstract:** This case study will see improvements in ergonomic postures in the process of preparing manuals and the order of the materials used, through the application of methodologies, ergonomic risk assessment, improvement assessment applying Mexican Standards and continuous improvement methodologies, to take care of the health and integrity of the associate, will be applied in a company that manufactures multipurpose tools. In the process they make some manuals taking several pieces of 5 bins which are placed in a bag and the pedal is activated with the hand or foot, which makes the bag that falls into a box cut. The official Mexican standards will be applied, the International Labor Organization (OIT) will size workstations, and the anthropometric measurements of the operators will be taken. Subsequently, analyzes were carried out using the RULA (Rapid Assessment of Upper Limbs) methodology and the OCRA (Occupational Repetitive Action) check list, Sue Rodgers for the evaluation of repetitive movements, reach, height and application of continuous improvement methodologies. It was possible to improve the employee's posture as well as the productivity of the process.

**Key words:** Manuals, SUE RODGERS, RULA, OCRA and Continuous improvement.

**Relevance for ergonomics:** This project has a significant impact because an extensive ergonomics analysis is carried out using the Mexican Standards and as they are applied in this country, a problem presented in a current company is improved in incorrectly designed workstations without taking into account the appropriate ergonomic aspects. , causing operator problems. In this way, anyone who reads this article will be able to get an idea of the problems that currently arise in the world of work and take as reference the steps that were carried out to improve a workstation with repetitive movement.

## 1. INTRODUCTION

The company in which the project is being carried out has different operating areas: wired tools, cordless tools, accessories and manuals, the latter is where the manuals are produced for all the models that are manufactured within the facilities. It was decided to apply the evaluation of the Mexican Standards, ergonomic methodologies, ergonomic risk assessment, and continuous improvement methodologies in one of the accessories and manuals with the highest production demand area, to take care of the health and integrity of the associate.

## 2. OBJECTIVE

Improve ergonomic positions in the process of preparing manuals and the order of the materials used, through the application of methodologies, ergonomic risk assessment, improvement assessment applying Mexican Standards and continuous improvement methodologies, to care for the health and integrity of the associate.

## 3. METHODOLOGY

The methodology that will be applied in this project is the application of Mexican Standards to validate physical conditions of the work station such as: NOM-011-STPS-2001 (Safety and hygiene conditions in work centers where noise is generated) , NOM-025-STPS-2008 (Lighting conditions in workplaces), NOM-035-2018 (Psychosocial risk factors at work: Identification, analysis and prevention), with the application of Mexican standards the physical conditions of the workstation lighting (NOM-025-STPS-2008) and noise (NOM-011-STPS-2001) to confirm that the values are within acceptable values, NOM-035-2018 (Psychosocial risks) Surveys will be carried out to ensure that the associate is satisfied with the environment in his workplace and does not suffer psychosocial harm; The analysis of station sizing and the anthropometry of the associates will be carried out to correct the dimensions that are outside the measures established by the company regulations so that the associate has comfort to carry out the work. After applying the ergonomic analysis and evaluation in the work station with the RULA, OCRA and Sue Rodgers methodologies, it is expected to obtain results that indicate the ergonomic risk in the station and to correct it to guarantee that the employee will not have injuries derived from the work carried out, after obtaining the data of the application of the methodologies, the findings will be followed up if they are found and continuous improvement methodologies such as 5's will be used to increase the productivity of the work station.

## 4. RESULTS

Figure 1 shows the Layout showing the location of the workstation within the company.

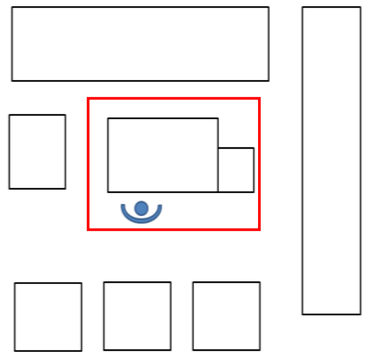


**Figure 1. Layout of the work station**

## 4.1 Application of the Mexican Standards to validate physical conditions.

The results that we will describe below were obtained from the workstation. NOM-011-STPS-2001 (Safety and hygiene conditions in work centers where noise is generated), the work station was evaluated to ensure that the noise conditions generated by the operation due to its characteristics, levels and time of action, did not alter the health of the associates, no evidence was found that indicates that the work station is outside the maximum levels and the maximum permitted exposure times per work day. (STPS, 2002)

We took on the task of applying nodes in the area that allowed us to identify that it is not necessary to install or modify the workstation due to noise since it complies with the appropriate security measures as established in NOM-011-STPS-2001.

Figure 2 shows the graph obtained by measuring each node of the station.

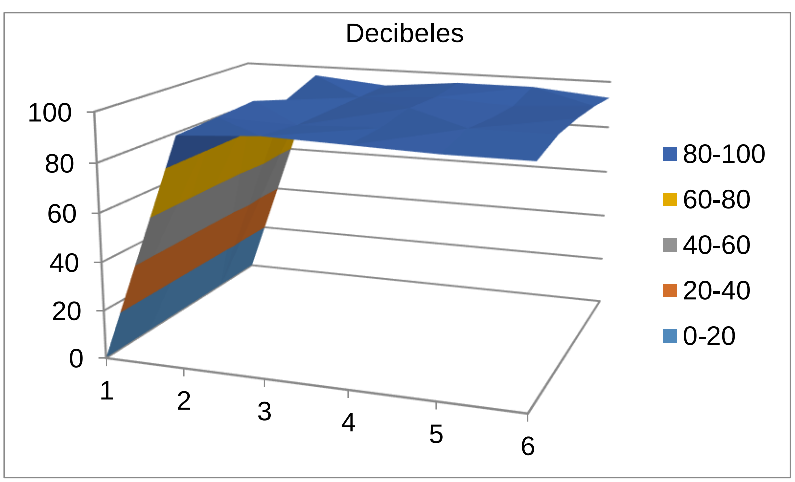



**Figure 2. Decibel graph (proper use of personal protective equipment).**

NOM-025-STPS-2008 (Lighting conditions in work centers), it was verified that the lighting requirements in the work station were adequate in terms of the amount of lighting required to carry out the activities they carry out associates, to provide a safe and healthy environment.

When applying nodes throughout the area, it was identified that in the work area the lighting is adequate for the activities carried out for this reason, it is not necessary to install or modify the work station, since it complies with the lux established in NOM-025- STPS-2008 (STPS, 2008). Figure 3 shows the graph obtained by measuring at each node of the station.

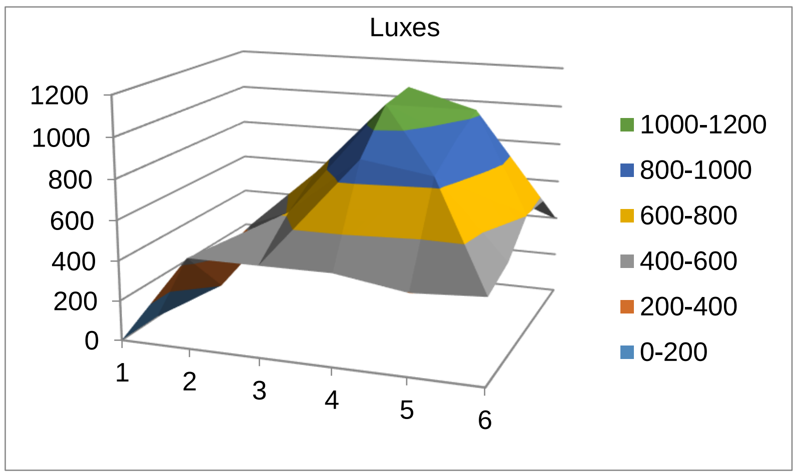



**Figure 3. Graph of lux 1> 1 (Adequate lighting for the activities carried out).**

NOM-035-2018 (Psychosocial risk factors at work: Identification, analysis and prevention), surveys were carried out with associates to achieve actions for the prevention of psychosocial risks if needed, in addition to promoting a favorable environment in the work organization. When the questionnaire was applied, it resulted in the associates being in a workplace free of psychosocial risks.

**4.2 Analysis of station sizing and associated anthropometry.**

Analysis was carried out and it was found that this was outside the measures established by the company's regulations so that the associate has comfort to carry out the work, for this reason the necessary corrections were made. At the end of the application of the analysis and ergonomic evaluation in the workstation with the aforementioned methods, the following results were obtained:

In Table 1, the percentiles can be observed in relation to the working dimensions and the operations performed by the operator.

### 4.3 Ergonomic risk analysis methodologies.

When using the RULA method in order to assess the degree of exposure of the associate to the risk of adopting inappropriate postures, for the evaluation of the risk the posture adopted by the associate, duration and frequency were considered, which was achieved by changing the station dimensions which benefited from this method.

Table 2 shows the results of the RULA method, applied to our Manuals station.

**Table 1. Percentiles in relation to work dimensions and anthropometry.**

| No. | Medición | P | Observación |
|---|---|---|---|
| 4 | Altura al hombro | 1.5 | Alcance para la toma de accesorios |
| 5 | Altura al codo flexionado | 1.25 | Diseño para la altura de trabajo |
| 8 | Alcance brazo frontal | 88 | Alcance para la toma de accesorios |
| 11 | Profundidad Máx. del cuerpo | 41 | Alcance para colocar accesorios en la bolsa |
| 15 | Anchura codo-codo | 60 | Ancho de mesa de trabajo |
| 16 | Anchura de la mano | 15 | Presionamiento de pedal para que selle |
| 17 | Longitud de la mano | 23 | |
| 18 | Longitud de la palma de la mano | 14 | |
| 19 | Diámetro de Empuñadora | 8 | Tomar accesorios para colocar en bolsa |
| 20 | Longitud del pie | 26 | Calzado contra impactos |
| 21 | Anchura del pie | 14 | |
| 22 | Anchura de talón | 8 | |
| 33 | Perímetro de la cabeza | 61 | Equipo de protección |
| 34 | Anchura de la Cabeza | 22 | |
| 35 | Profundidad de la Cabeza | 19 | |
| 36 | Longitud de la cara | 25 | |

**Table 2. Results RULA methodology applied to manual station**

| | | | | |
|---|---|---|---|---|
| | | | Fecha: | 21/02/2020 |
| Puesto de Trabajo : | Operador | | | |
| Num. de Ciclos: | 10 | Lado del cuerpo a evaluar : | | (I D) |
| Grupo A | Posición | Modificación 1 | Modificación 2 | Puntuación global |
| Brazo | 2 | 1 | | 3 |
| Antebrazo | 1 | | | 1 |
| Muñecas | 3 | | | 3 |
| Giro muñeca | 1 | | | 1 |
| | | | Puntuación Global Grupo A | 4 |
| | | | Fuerza aplicada | 0 |
| | | | Actividad muscular | 1 |
| | | | Puntuación global grupo C | 5 |
| Grupo B | Posición | Modificación 1 | Modificación 2 | Puntuación global |
| Cuello | 3 | | | 3 |
| Tronco | 3 | | | 3 |
| Piernas | 1 | | | 1 |
| | | | Puntuación global grupo B | 4 |
| | | | Fuerza aplicada | 0 |
| | | | Actividad muscular | 1 |
| | | | Puntuación global grupo D | 5 |
| | | | Puntuación final | 6 |
| | | | Nivel de actuación | 3 |

| | | | | |
|---|---|---|---|---|
| | | | Fecha: | 21/02/2020 |
| Puesto de Trabajo : | Operador | | | |
| Num. de Ciclos | 10 | Lado del cuerpo a evaluar : | | ( I / D) |
| Grupo A | Posición | Modificación 1 | Modificación 2 | Puntuación global |
| Brazo | 2 | 1 | | 3 |
| Antebrazo | 1 | | | 1 |
| Muñecas | 3 | | | 3 |
| Giro muñeca | 1 | | | 1 |
| | | | Puntuación Global Grupo A | 4 |
| | | | Fuerza aplicada | 0 |
| | | | Actividad muscular | 1 |
| | | | Puntuación global grupo C | 5 |
| Grupo B | Posición | Modificación 1 | Modificación 2 | Puntuación global |
| Cuello | 3 | | | 3 |
| Tronco | 3 | | | 3 |
| Piernas | 1 | | | 1 |
| | | | Puntuación global grupo B | 4 |
| | | | Fuerza aplicada | 0 |
| | | | Actividad muscular | 1 |
| | | | Puntuación global grupo D | 5 |
| | | | Puntuación final | 6 |
| | | | Nivel de actuación | 3 |

Performance level 3 was obtained, which according to Table 3, indicates that the redesign of the task is required.

**Table 3. Risk Assessment (RULA)**

| Puntuación | Nivel | Actuación |
|---|---|---|
| 1-2 | 1 | Riesgo Aceptable |
| 3-4 | 2 | Requiere cambios en la tarea; conviene profundizar el estudio |
| 5-6 | 3 | Requiere rediseño de la tarea |
| 7 | 4 | Requiere cambios urgentes |

The OCRA checklist was used because it is an adequate tool for risk assessments in repetitive work, considering factors such as: repeatability, inappropriate postures, forces, forced movements, lack of breaks, organizational factors, and environmental factors. In Table 4, the results are observed when applying the methodology, which showed an unacceptable level of risk, therefore changes must be made at the workstation. (More, 2015)

The Sue Rodgers methodology was used to identify biomechanical ergonomic factors using quantitative tools to provide both passive and active information on associates at the workstation. The results of the application of the method can be seen in Table 5, and if the scores of the risk assessment are compared, the majority of the muscle group is observed to be at moderate risk, but the area of: Wrists, hands and fingers you are at high risk, for that reason that is the first group that should be corrected on ergonomic issues. (More, 2015)

**Table 4. OCRA methodology results**

| Variable | Mano Izquierda | Mano Derecha |
|---|---|---|
| Tiempo de Recuperación insuficiente | 3 | 3 |
| Frecuencia de Movimientos | 5 | 5 |
| Aplicación de Fuerza | 6 | 6 |
| Hombro | 0 | 0 |
| Codo | 8 | 8 |
| Muñeca | 8 | 8 |
| Mano - dedos | 8 | 8 |
| Estereotipo | 3 | 3 |
| Posturas Forzadas | 11 | 11 |
| Factores de riesgo complementarios | 3 | 3 |
| Factor Duración | 1 | 1 |
| Resultados | 28 | 28 |
| Escala de Valoración de Riesgo | Nivel de riesgo 28. Nivel alto no aceptable | |

**Table 5. Results of the RULA methodology.**

| Grupo de músculos | Puntaje |
|---|---|
| Cuello (Neck) | 5 |
| Hombros (Shoulders) | 5 |
| | 5 |
| Espalda (Back) | 5 |
| Brazos y Codos (Arms and Elbows) | 5 |
| | 5 |
| Muñecas, Manos y Dedos (Wrist, Hands and Fingers) | 5 |
| | 8 |
| Piernas y Tobillos (Legs and Knees) | 5 |
| | 5 |
| Valoración de Riesgo | |
| 1 a 4 | Bajo |
| 5 a 7 | Moderado |
| 8 a 9 | Alto |
| 10 | Muy alto |

The use of continuous improvement methodologies was performed by detecting the opportunities for improvement found with the application of ergonomic methodologies. By helping to correct the findings, the station's output was increased.

## 5. CONCLUSIONS

Finally, with the results obtained, it was possible to improve ergonomic positions in the process of preparing manuals as well as the order of the materials used, through the application of ergonomic risk assessment methodologies, improvement assessment applying Mexican Standards and continuous improvement methodologies that indicated the bad postures of the employee, with the Mexican Standards the station was adapted based on the parameters established in these, reducing the risk in the health of the associate, in addition to improving the posture and getting productivity to increase.

## 6. REFERENCIAS

Días, M. C. (2004). Laboratorio de Ergonomía. Valencia: Alfaomega

Diego-Mas, José Antonio. Evaluación postural mediante el método RULA. Ergonautas, Universidad Politécnica de Valencia, 2015. [consulta 19-03-2020]. Disponible online: http://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

Diego-Mas, José Antonio. Evaluación del riesgo por movimientos repetitivos mediante el Check List Ocra. Ergonautas, Universidad Politécnica de Valencia, 2015. [consulta 20-03-2020]. Disponible online: http://www.ergonautas.upv.es/metodos/ocra/ocra-ayuda.php

Niebel, B. W. (2014). Ingeniería Industrial de Niebel. México, D.F.: Mc Graw Hill.

NOM-011-STPS-2001. Condiciones de seguridad e higiene en los centros de trabajo donde se genere ruido. Diario Oficial de la Federación. 17 de abril de 2002. Sitio web: http://www.dof.gob.mx/nota_detalle.php?codigo=734536&fecha=17/04/2002

NOM-025-STPS-2008. Condiciones de iluminación en los centros de trabajo. Diario Oficial de la Federación. 30 de diciembre de 2008. Sitio web: http://dof.gob.mx/nota_detalle.php?codigo=5076393&fecha=30/12/2008

NOM-035-STPS-2018. Factores de riesgo psicosocial en el trabajo-Identificación, análisis y prevención. Diario Oficial de la Federación. 23 de octubre de 2018. Sitio web: http://www.diariooficial.gob.mx/nota_detalle.php?codigo=5541828&fecha=23/10/2018

# ERGONOMIC ANALYSIS OF THE ASSEMBLY STATION OF AN AUTOMOTIVE RADIATOR PANEL.

**Víctor Manuel Quezada Barajas[1], Gabriela Ramírez Castañeda[1], Víctor Ignacio Guerrero Ferrer[1], Mario Abel Padilla Navarro[1] y Rigoberto Zamora Alarcón2.**

[1]Instituto Tecnológico de Mexicali
Av, Instituto Tecnológico s/n, Plutarco Elías Calles, 21376
Mexicali, B.C.
quezada.victor161197@gmail.com , victorignacioguerrero@hotmail.com ,
gabrielaramirezc.22@gmail.com, maabpana2003 @yahoo.com.mx.

[2]Universidad Autónoma de Baja California
Blvd. Benito Juárez S/N CP 21280 Mexicali, B.C
Instituto Tecnológico de Mexicali
Av, Instituto Tecnológico s/n, Plutarco Elías Calles, 21376
mczamora02@yahoo.com.mx

**Resumen**: Las evaluaciones ergonómicas de estaciones de trabajo son importantes debido a que con ellas se logran detectar los distintos factores de riesgo ergonómico que pudieran surgir y afectar en la salud y seguridad de los empleados y analizan la relación existente entre las herramientas y maquinaria utilizada por los operadores al momento de realizar sus actividades. La finalidad de esta investigación es identificar los factores de riesgo ergonómico del proceso de ensamble de un panal de radiador automotriz a través de la metodología OCRA, Suzanne Rodgers y REBA para evaluar los movimientos repetitivos, posturas, esfuerzos y la duración de los mismos, y con esto asegurar un proceso más cómodo para los trabajadores. Con el análisis anterior se sugirieron acciones de mejora tanto en el proceso como en la estación de trabajo, y como conclusión se tiene que los objetivos se cumplieron al mejorar la calidad de vida de los empleados reduciendo los factores de riesgo a los que estaban expuestos, así como las condiciones generales de la estación.

**Palabras clave**: Radiador automotriz, Método OCRA, Método REBA, Método Sue Rodgers, 5S.

**Relevancia a la ergonomía:** La aplicación de estándares mexicanos, validaciones ergonómicas, el dimensionamiento de estaciones y operadores, así como las herramientas para la mejora continua, permiten la validación y mejora de las estaciones para la comodidad del operador cuando se consideran como un sistema de mejora de la ergonomía.

**Abstract:** Ergonomic evaluations of workstations are important because they manage to detect the different ergonomic risk factors that affect the health and safety of employees and analyze the relationship between the tools and machinery used by operators to perform their activities. The purpose of this investigation is to identify the ergonomic risk factors of the assembly process of an automotive radiator panel through the OCRA, Suzanne Rodgers and REBA methodology to evaluate repetitive movements, postures, efforts and their duration, and this guarantees a more comfortable process for the employees. With the previous analysis, improvement actions were suggested in the process and at the workstation, and as a conclusion, the objectives were achieved by improving the quality of life of employees by reducing the risk factors to which they were exposed, as well as the general conditions of the station.

**Keywords:** Automotive Radiator, OCRA Method, REBA Method, Sue Rodgers Method, 5S.

**Relevance to ergonomics:** The application of Mexican standards, ergonomic validations, the sizing of stations and operators, as well as the tools for continuous improvement, allow the validation and improvement of the stations for operator comfort when viewed as an improvement system for ergonomics.

## 1. INTRODUCTION

The present project named "Ergonomic analysis of the assembly station of an automotive radiator panel" takes place within the assembly area. The automotive radiator before being delivered to the customer goes through several processes such as: cutting of rods, assembly, die cutting and baking.

This project was chosen because of the way the process is carried out, it was decided to review and analyze the way it is done and the physical and environmental conditions of the workstation, and decide what ergonomic methods and standards are necessary for the process to be more suitable.

## 2. OBJECTIVE

Identify the ergonomic risk factors of the assembly process of an automotive radiator panel, analyzing the station by applying ergonomic methods and official Mexican standards and thus suggesting actions that allow the reduction or elimination of possible occupational risks and offer greater comfort for the workers.

## 3. METHODOLOGY

Application of official Mexican standards to validate the physical conditions of the work station: NOM-011 STPS-2001 to assess noise levels when performing the assembly, NOM-025-STPS-2008 to assess whether the station lighting is adequate , as well as the norm that allows evaluating the use of personal protective equipment NOM-017-STPS-2008 and psychosocial risks NOM-035-STPS-2018, application of the 5S methodology for continuous improvement of the workstation, analysis station sizing and operator anthropometry, and ergonomic analysis and evaluation at workstations with OCRA, Suzanne Rodgers and REBA methodology.

## 4. RESULTS

### 4.1 Mexican Official Standards application

In the application of NOM-035-STPS-2018 that deals with psychosocial risk factors at work for their identification, analysis and prevention, high levels of risk are manifested in the lack of control over work, in work relationship interference -family and a medium level of risk in the organization of working time (STPS, 2018).

The results when applying NOM-011-STPS-2001 (noise) were adequate, as shown in Figure 1, since at all points where measurements were taken the results were below the maximum allowed level (90 decibels) (STPS, 2002).

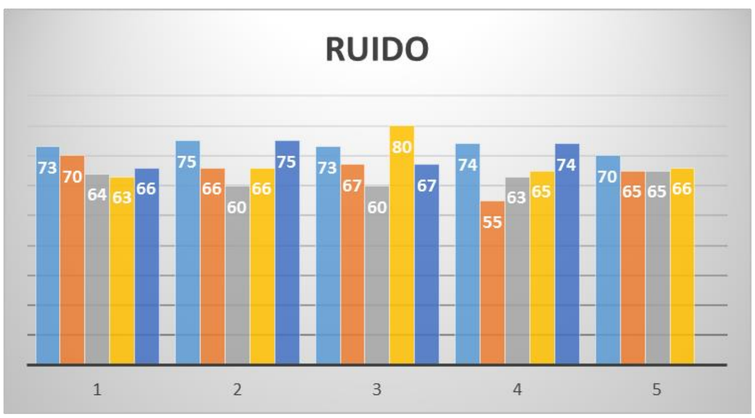



Figure 1. The bar graph shows the noise levels at the measured points.

Although it should be noted that in two of the three work stations with the machines working the measurements have exceeded the limit indicated above. The results are shown in Figure 2.

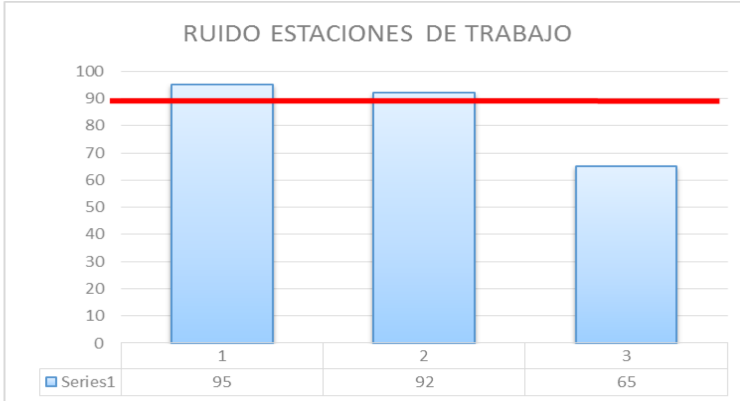



Figure 2. Bar graph of noise levels at workstations.

Regarding the application of NOM-025-STPS-2008 (lighting), the results obtained are worrisome because none of the measures adopted reached the established minimum of 300 lux (STPS, 2008). And even more alarming, at any of the three workstations they were not close to the minimum lux level, which could cause injury to the operator. The results are found in the graph in Figure 3 and the graph in Figure 4.

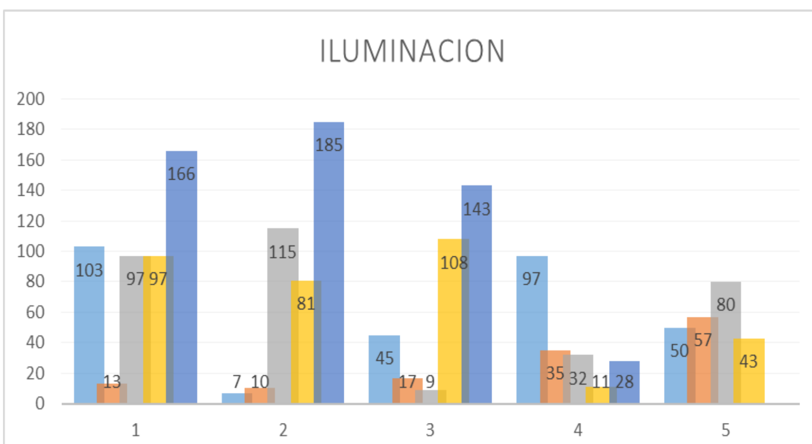



Figure 3. The graph shows the lighting levels at the measured points.

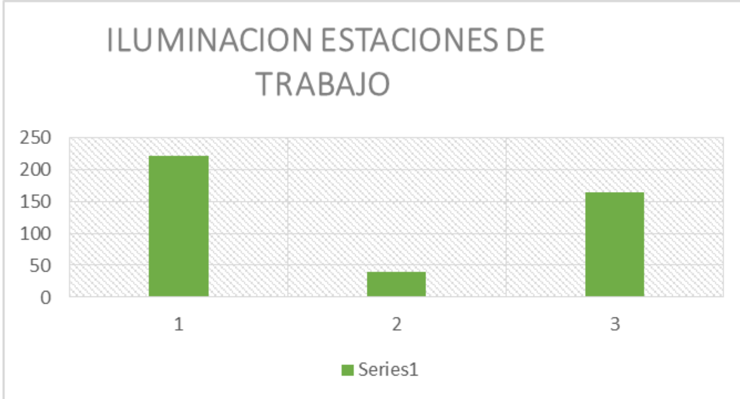



Figure 4. Bar graph of lighting levels at workstations.

### 4.2 Ergonomic risk assessment methods.

The evaluation methods used were OCRA, REBA and Suzanne Rodgers, as well as a video of the station, anthropometric measurements of the operator as ergonomic control points and 5S methodology.

### OCRA Method

The analysis is shown on Table 1. A risk and valuation index of 22.33 for both hands, which is not acceptable medium level, because the values are between 14.1 and 22.5 which are indicated in the rating scale, it is essential to establish changes on both hands when assembling the radiator panel.

Table 1. OCRA Method to analyze the assembly of an automotive radiator panel

| **Método OCRA** | | |
|---|---|---|
| | **Derecha** | **Izquierda** |
| Tiempo de recuperación insuficiente | 2 | 2 |
| Frecuencia de movimientos | 0 | 0 |
| Aplicación de fuerza | 8 | 8 |
| Hombro | 2 | 2 |
| Codo | 8 | 8 |
| Muñeca | 8 | 8 |
| Mano-dedos | 8 | 8 |
| Estereotipo | 1,5 | 1,5 |
| Posturas forzadas | 9,5 | 9,5 |

| | | |
|---|---|---|
| Factores de riesgo complementario | 4 | 4 |
| Factor Duracion | 0,95 | 0,95 |

| Indice de riesgo y valoracion | | |
|---|---|---|
| Indice de riesgo | **22,33** | **22,33** |
| No aceptable nivel medio | 14,1-22,5 | Rojo fuerte |

## REBA Method

On table 2 the results are shown. A final score of 10 shows that the panel assembly has a high risk for the employee, because the values are between 8-10, and an action level of 3 which are indicated in the rating scale, thus it is necessary to act as soon as possible.

Table 2. REBA Method to analyze the assembly of an automotive radiator panel

| Método REBA | | | |
|---|---|---|---|
| **Puntuación 10 Riesgo Alto.** Nivel de actuación 3, es necesaria la actuación cuanto antes | | | |
| Puntuación | Nivel | Riesgo | Actuación |
| 1 | 0 | Inapreciable | No es necesaria actuación |
| 2 o 3 | 1 | Bajo | Puede ser necesaria la actuación |
| 4 a 7 | 2 | Medio | Es necesaria la actuación |
| **8 a 10** | **3** | **Alto** | **Es necesaria la actuación cuanto antes** |
| 11 a 15 | 4 | Muy alto | Es necesaria la actuación de inmediato |

## Suzanne Rodgers Method

The corresponding analysis was performed obtaining results shown on Table 3. Two black color evaluations were obtained, the first one on the wrist, hands and fingers where the rods and copper are being hold to assemble them, and the other one on the legs and knees because the operator is standing the whole time, showing a very high risk, for which is necessary to implement changes.

Table 3. Suzanne Rodgers Method to analyze the assembly of an automotive radiator panel.

|  | Intensidad | Duración | Por minuto | Puntaje | Evaluación |
|---|---|---|---|---|---|
| Cuello (neck) | 1 | 2 | 3 | 5 | Moderado |
| Hombros (shoulders) | 1 | 3 | 3 | 5 | Moderado |
| Espalda (back) | 2 | 2 | 1 | 4 | Bajo |
| Brazos y codos (arms and elbows) | 1 | 3 | 3 | 5 | Moderado |
| Muñecas, manos y dedos (wrist,hands and fingers) | 2 | 4 | 3 | 10 | Muy alto |
| Piernas y tobillos (legs and knees) | 1 | 4 | 3 | 10 | Muy alto |

### 4.3 Analysis of station sizing and anthropometry of operators

The results shown in Table 4 and Figure 5 indicate that most of the dimensions of the station where the radiator assembly is made are adapted to the operator, with the exception of two measures in which the operator has to stretch for above its capacity to achieve the proper assembly of materials.

Table 4. Anthropometry of the operator compared to workstation dimensions.

| Descripción antropométrica | | Dimensión operador Cm | Estación | Dimensión estación Cm |
|---|---|---|---|---|
| 6 | Altura al nudillo | 72 | 1 | 68 |
| 5 | Altura al codo flexionado | 102 | 2 | 93 |
| 5 | Altura al codo flexionado | 102 | 3 | 90 |
| 4 | Altura al hombro | 135 | 4 | 153 |
| 9 | Alcance brazo lateral | 83 | 5 | 79 |
| 9 | Alcance brazo lateral | 83 | 6 | 89 |

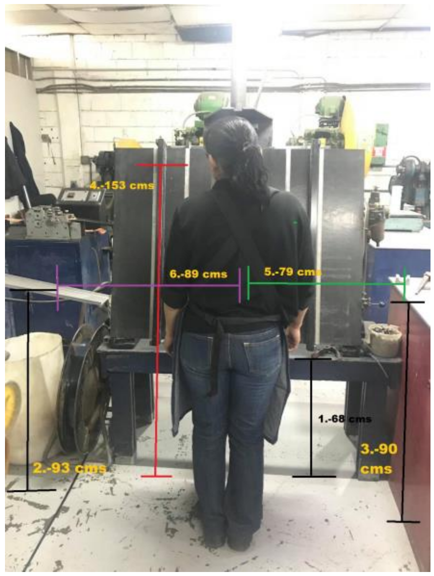


Figure 5. Workstation dimensions.

## 4.4 The principles of the 5S methodology.

When applying the principles, it was detected that 6 of them were not carried out correctly, since the tools were not at the correct height and sequence, and the operator had to make an effort to carry out the operation, leaving an acceptance of 57.15 % in 5 S.

Likewise, unnecessary tools were eliminated in the area where the operator works as shown in figure 6. In addition to eliminating tools that are not necessary, they were organized according to the order of use to accelerate the activity carried out by the operator, such as shown in figure 7.

Figure 6. Elimination of unnecessary tools on the workstation.

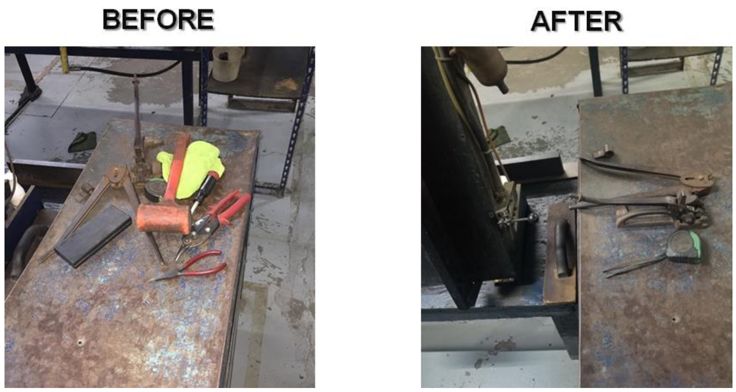



Figure 7. Placement of tools sequentially according to their use during assembly.

## 5. CONCLUSIONS

At the end of the analysis with in the work area it is necessary to make improvements in the work station and in the process directly due to the repetitive movements when assembling.

Urgent lighting changes are suggested, either by adding new lighting or by maintaining existing lighting.

Constant supervision by managers is suggested to verify the use of personal protective equipment (in this case, ear plugs and gloves suitable for assembly) by the operator, reducing possible injuries from exposure to noise within the work station or accidents in the hands due to the handling of rods. It is necessary to adapt the workstation to the measurements of the operator and place the necessary tools within reach to reduce efforts.

The ergonomic risk factors of the assembly process of an automotive radiator panel were identified, the station was analyzed through the application of ergonomic methods and comfort with the application of official Mexican standards, the noise and lighting levels could be evaluated, as well as the psychosocial risks to which the operator is subjected and with this they could suggest actions that allow the reduction or elimination of possible occupational risks and thus offer greater comfort for workers.

## 6. REFERENCES

Dasí, M. C. (2004). *Laboratorio de Ergonomia.* Valencia: Alfaomega.

Niebel, B. W. (2014). *Ingenierìa Industrial de Niebel .*Mèxico, D.F.: Mc Graw Hill.

Organización Internacional del Trabajo O.I.T. (1996). *Lista de comprobación ergonómica*

Secretaria del Trabajo y Previsión Social (STPS), (2002). Diario Oficial de la Federación 17 de abril de 2002. *NORMA Oficial Mexicana NOM-011-STPS-2001: Condiciones de seguridad e higiene en los centros de trabajo. http://www.dof.gob.mx/nota_detalle.php?codigo=734536&fecha=17/04/2002*

Secretaria del Trabajo y Previsión Social (STPS), (2008). Diario Oficial de la Federación. *NORMA Oficial Mexicana NOM-017-STPS-2018, Equipo de protección personal-Selección, uso y manejo en los centros de trabajo.http://www.dof.gob.mx/nota_detalle.php?codigo=5509975&fecha=03/01/2018*

Secretaria del Trabajo y Previsión Social (STPS), (2008). Diario Oficial de la Federación, 30 de diciembre de 2008. *NORMA Oficial Mexicana NOM-025-STPS-2008, Condiciones de iluminación en los centros de trabajo. http://www.dof.gob.mx/nota_detalle.php?codigo=5404572&fecha=20/08/2015*

Secretaria del Trabajo y Previsión Social (STPS), (2018). Diario Oficial de la Federación. *NORMA Oficial Mexicana NOM-035-STPS-2018, Factores de riesgo psicosocial en el trabajo-Identificación, análisis y prevención. https://dof.gob.mx/nota_detalle.php?codigo=5541828&fecha=23/10/2018*

# STUDY OF THE LEVEL OF EFFORT IN THE HANDS OF UNIVERSITY STUDENTS OF THE INDUSTRIAL ENGINEERING CAREER

**Jesús Antonio Martínez Armenta, Rodrigo Víctor Fimbres Ramírez y Ernesto Ramírez Cárdenas**

Department of Industrial Engineering
Instituto Tecnológico de Sonora
Antonio Caso s/n, Villa Itson
Cd Obregón, Sonora

jesusantoniomartinez98@gmail.com

**Resumen:** Los trastornos musculo-esqueléticos (TME) son una de las enfermedades de origen laboral más común, que afectan a millones de trabajadores en todo México, costando así exuberantes cantidades de efectivo a las organizaciones anualmente en el pago de Incapacidades, Aumento en las "Primas de Seguro", contrataciones temporales por remplazo, capacitaciones, servicios médicos, entre otras. Afrontar dicha problemática requiere de la implementación de re-diseños de actividades, nuevos equipamientos y capacitación para mejorar la calidad de vida de los trabajadores . El objetivo del presente proyecto es comprobar si existe relación entre el nivel de esfuerzo y el índice de masa corporal en estudiantes de Ingeniería Industrial. La información obtenida permitirá el diseño y/o asignación oportuna de actividades en el sitio de trabajo y con ello la disminución de TME. Como resultado se tiene el comparativo en tres diferentes posiciones con guante y sin guante concluyendo no haber información significativa que demuestre la relación entre el nivel de esfuerzo y el IMC.

**Palabras claves**: Nivel de esfuerzo, IMC, Información

**Abstract**: Musculoskeletal disorders (MSD) are one of the most common occupational diseases, affecting millions of workers throughout Mexico, thus costing organizations exuberant amounts of cash annually in the payment of Disabilities, Increase in "Insurance Premiums", temporary contracts for replacement, training, medical services, among others. Facing this problem requires the implementation of re-designs of activities, new equipment and training to improve the quality of life of workers. The objective of this project is to check if there is a relationship between the level of effort and the body mass index in Industrial Engineering students. The information obtained will allow the design and / or timely assignment of activities in the workplace and with it the decrease of TME. As a result, there is a comparison in three different positions with a glove and without a glove, concluding that there is no significant information that demonstrates the relationship between the level of effort and the BMI.

**Keywords:** Level of effort, BMI, Information

## 1. INTRODUCTION

The Regional Institute for Occupational Safety and Health defines MSDs as activities or processes that mainly affect the soft parts of the locomotor system; Muscles, tendons, nerves and other structures close to the joints, when performing specific tasks, small aggressions occur, such as: friction, stretching, compressions, etc.
These injuries manifest with pain and functional limitation of the area in question, which make it difficult or impossible to carry out the work. Most work-related MSDs develop over time. Usually there is no single cause, but there are several factors that work together.

According to statistics from the Ministry of Labor and Social Welfare, in Sonora 88% of occupational risks occur in companies related to building, manufacturing and the provision of purchase-sale services. Likewise, it is established that 66% of occupational diseases and 63% of permanent disabilities are caused by ergonomic risk factors (STPS, 2018). Regarding accidents, it is observed that 86% occur in upper extremities and 84% in jobs related to the production, construction and operation of machinery.

Musculoskeletal disorders can affect anyone, regardless of age, gender or origin. If it is true that the prevalence of these increases with age, young people can also present them. At present, there is an increase in the occurrence of MSD in people who have just entered the labor field. This is usually linked to bad execution instructions, lack of security, wrong designs accompanied by a bad method assignment.

Faced with this situation, the following question arises: Is there a relationship between the Body Mass Index (BMI) and the level of effort exerted when operating a manual tool?

## 2. OBJETIVE

To develop a study of effort in the dominant and non-dominant hand in higher education students of the Industrial and Systems Engineering career to see the relationship of the BMI and the effort exerted when operating a manual tool

## 3. METHODOLOGY

The present work seeks to relate the muscle mass index with the maximum effort generated at a time and the operational wear, this in different positions of in young students aged 21 to 24 years of the Instituto technologic de Sonora, in order to define, if said This relationship is a determining factor in the occurrence of a MSD in operations where an effort or grip force is required for a long time.

The measurement will be carried out only to students of the 2016 cohort, belonging to the eighth semester of the Industrial Engineering and Systems career, through the use of an Ergonomic tool (dynamometer). They will make the greatest effort they can exert at a time, in different positions, in order to measure the force in kg. that they can generate with both hands, in those positions, also considering various factors that could affect the result.

The main factor to consider is the BMI, which is a method used to estimate the amount of body fat that a person has, and therefore determine if the weight is within the normal range, or on the contrary, is overweight or thin , so that it can be determined, if the body mass index is proportional to the effort that a person can generate. Effort measures will also be carried out with the use of gloves, in order to find, if this method of "prevention" used by some companies for an MSD, is an influential or impacting factor to avoid or mitigate the effects of a musculoskeletal disorder.

The study was carried out at the Instituto Tecnologíco de Sonora, Nainari campus, focusing on female and male university students enrolled. For its application, a representative sample of 73 of 159 students that make up the population was selected, the sampling used was of the simple random type. However, the abstract only shows 35 subjects studied so far.

Of the 35 subjects studied, 19 are men and 73 women, corresponding to 54 and 44 percent respectively. Regarding age, it is observed that 16 people are 21 years old (46 percent); 17 people are 22 years old (48 percent) and only 2 are 23 years old (2 percent). Finally, with respect to the dominant hand, 34 people are right-handed (97 percent) and only 1 is left-handed (3 percent). It is important to mention that at the time of making the measurements to the subjects, information was provided regarding how to perform the effort technique, on the other hand it was observed that no subject was in poor health or lacking any limb.

To obtain data, a JAMAR brand manual dynamometer was used, which has a handle adjustable to the size of the hand and measures muscle strength between 0 and 90 Kg. in 2 Kg. intervals, as well as the use of an analytical scale for weight. and an anthropometer for the subject's height. The format to be used contemplates the maximum force exerted in three different positions, where in each one the maximum force exerted without gloves and maximum force exerted with gloves of both the dominant and non-dominant hands were obtained. (See figure 1).

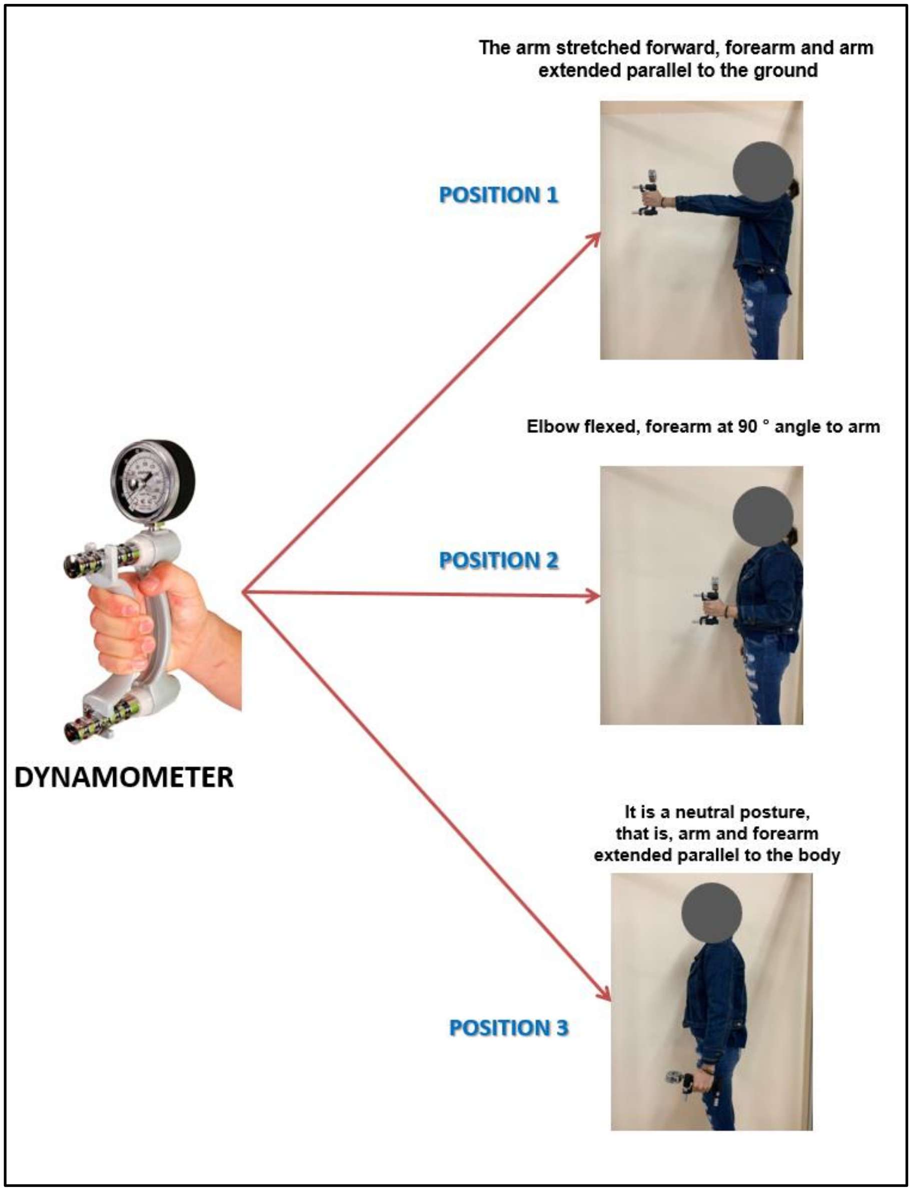



Figure 1: Dynamometer and study positions

After the explanation about the use of the dynamometer, the measurements were carried out within the campus facilities and at the same time the data was recorded according to the aforementioned positions. As a next step, the calculations were carried out to obtain the variables of interest, among which the BMI (Carmona and Sánchez, 2018). the average of the effort in each position, in each hand with and without gloves, as well as the maximum and minimum values obtained (Zea, Caro and Quintana 2016). On the other hand, the correlation index between the subject's BMI with the effort exerted with and without gloves was also obtained.

## 4. RESULTS

Once the data of the 35 individuals had been collected, the information was recorded, sorting it by gender (Man, Women). The results can be seen in tables 1 and 2.

Table 1 shows the level of effort generated in the hands of women. First, the average strength without gloves is shown, where the highest was 33 for the right hand, 31 for the right hand and 32 for the right hand in position 1,2 and 3 respectively. On the other hand, the highest average values of maximum strength with gloves are 29 for the right hand, 27 for the left hand and 27 for the right hand in position 1,2 and 3 respectively. The maximum value obtained in the test without a glove was 42 for the right hand in position 2 and the minimum value was in the left hand with 18 exerted in position two. For the glove test, the maximum value was 37 in the right hand in both position1 and position 3 and the minimum value was 16 in the left-hand position 3.

Table 1: Effort level result in women

| | | EFFORT (Kg.) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Position 1 | | Position 2 | | Position 3 | |
| WOMEN | | LH | RH | LH | RH | LH | RH |
| WITHOUT GLOVE | AVERAGE | 28 | 33 | 27 | 31 | 27 | 32 |
| | MAX | 36 | 40 | 36 | 42 | 34 | 40 |
| | MIN | 22 | 26 | 18 | 24 | 20 | 24 |
| WHIT GLOVE | AVERAGE | 25 | 29 | 24 | 27 | 24 | 27 |
| | MAX | 32 | 37 | 36 | 36 | 32 | 37 |
| | MIN | 19 | 22 | 20 | 21 | 16 | 21 |

Table 2:Effort level result in men

| | | EFFORT (Kg.) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Position 1 | | Position 2 | | Position 3 | |
| MEN | | LH | RH | LH | RH | LH | RH |
| WITHOUT GLOVE | AVERAGE | 48 | 51 | 45 | 48 | 48 | 50 |
| | MAX | 62 | 60 | 61 | 68 | 66 | 67 |
| | MIN | 36 | 42 | 31 | 30 | 32 | 36 |
| WITH GLOVE | AVERAGE | 44 | 48 | 43 | 46 | 45 | 47 |
| | MAX | 62 | 68 | 65 | 70 | 76 | 68 |
| | MIN | 26 | 30 | 30 | 30 | 31 | 34 |

Table 2 shows the level of effort generated in the hands of men. First, the average force without gloves is shown, where the highest was 51 for the right hand, 48 for the right hand and 50 for the right hand in position 1,2 and 3 respectively. On the other hand, the highest average values of maximum strength with gloves are 48 for the right hand, 46 for the right hand and 47 for the right hand in position 1,2 and 3 respectively. The maximum value obtained in the test without a glove was 68 for the right hand in position 2 and the minimum value was in the left hand with 31 exerted in position 2. For the test with a glove, the maximum value was 76 in the left hand. in position 3 and the minimum value of 30 in the right hand of position 1 and both hands in position 2.

Reviewing the record sheet shows that there is not much difference between the effort exerted with a glove compared to the effort exerted without a glove, as well as that there is no direct relationship between the body mass index and the effort exerted. (See figure 2).

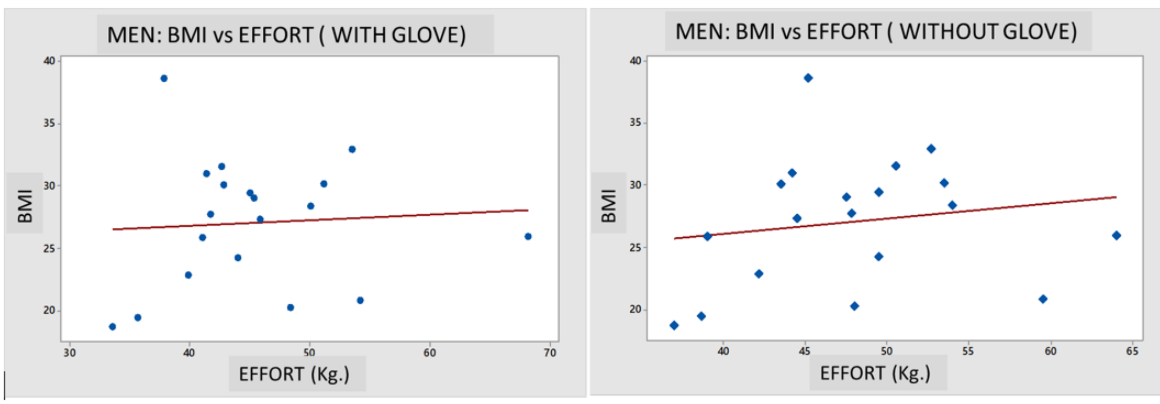



*Figure 2:Scatter diagram of BMI vs Effort with and without gloves in men.*

According to figure 2, there is no correlation between the body mass index with respect to the effort exerted with a glove since the values obtained are very dispersed with respect to the adjustment line, exactly there is a correlation coefficient of 0.067, that is, the variables are not related to each other. With regard to effort without a glove, it is concluded that there is no correlation between the variables evaluated since the values obtained are very dispersed with respect to the adjustment line, presenting a correlation coefficient of 0.166.

Regarding the analysis in women, there is not much difference between the effort exerted with a glove compared to the effort exerted without a glove. And like men it is also appreciated that there is no direct relationship between body mass index and exertion. (See figure 3).

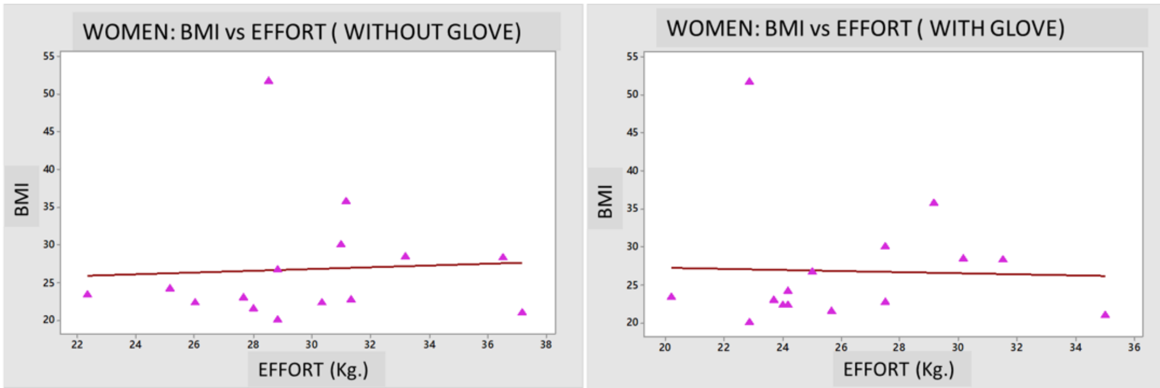



*Figure 3:Scatter diagram of BMI vs Effort with and without gloves in women.*

In figure 3 you can see the distribution of the efforts with respect to the BMI resulting in a correlation of -0.033 for the effort wearing gloves and 0.061 with respect to the effort exerted without a glove, which means that both experiments the variables are not related between yes.

## 5. DISCUSSION/ CONCLUSIONS

With respect to the cards, they produced averages in which it can be observed that in both men and women, the right hand (which is mostly the dominant hand) is the strongest, analyzing the strength of the man without a glove, it was noted that the position in which the highest average effort was presented was in position 1, exactly 48 and 51 kg. in the left and right hands respectively. On the other hand, for the use of gloves, it was identified that position 1 also presented the highest average with respect to the other two positions, exactly with 44 and 48 kg. in the left and right hand respectively. It should be noted that there is no significant difference with the use of gloves and even the force exerted is less.

Regarding the women, in the test without gloves, the position that presented the highest average effort was in position 1, exactly with 28 and 33 kg. in the left and right hands respectively. On the other hand, for the use of gloves, it was identified that position 1 also presented the highest average with respect to the other two positions, exactly with 25 and 29 kg. in the left and right hand respectively. As in men, it should be emphasized that there is no significant difference with the use of gloves and this is less. Which leads to the conclusion that position 1 is the one where the greatest effort is generated and that the use of gloves does not generate much significant difference to be used preventively against an MSD.

Regarding the body mass index, it was concluded that there is no direct relationship between this variable and the effort generated, since the body mass index does not take into account the muscle density or muscle development of people for the generation of forces. Therefore, assuming that a robust-looking person generates the greatest force is wrong, however, it is necessary to carry out a study with a larger sample size in order to obtain more precise data and thus verify the hypothesis raised with greater veracity.

## 6. REFERENCES

Carmona, W., Sánchez, A. (2018). Índice de masa corporal: Ventajas y desventajas de su uso en la obesidad. Relación con la fuerza y la actividad física. Nutrición Clínica en Medicina, v.12, n.3, pp.128-139. Recuperado de http://www.aulamedica.es/nutricionclinicamedicina/pdf/5067.pdf

Secretaria de Trabajo y Previsión Social (2018). Las enfermedades de trabajo y los trastornos músculo-esqueléticos por ejercicio o motivo del trabajo, en México.

Zea, C., Caro, M., Quintana, L. (2016). Análisis de la disminución de fuerza de agarre en la mano por uso de guantes en actividades de aseo y cafetería. Artículos de investigación clínica o experimental. Recuperado de http://www.scielo.org.co/pdf/recis/v14n3/v14n3a05.pdf.

# ERGONOMIC RISKS DUE TO REPETITIVE MOVEMENTS IN THE PRODUCTION OF OFFICE FURNITURE. (NOM-036-1-2018-STPS)

**Raquel Muñoz Hernández, Saúl Rangel Lara, Fernando Pérez Díaz**

División de Ingeniería Industrial.
Universidad Politécnica del Valle de México.
Av. Mexiquense s/n, Col. Villa Esmeralda,
C.P. 54910, Tultitlán, Estado de México.
jael2222@hotmail.com, spolitecnicas@yahoo.com, louis_leithold@hotmail.com

**Resumen**: La investigación se desarrolló en una empresa manufacturera de muebles de oficina en el estado de México municipio de Tultitlan de Mariano Escobedo, específicamente en el proceso de empaque, con el fin de identificar los factores de riesgo a la salud de los trabajadores, así como posible consecuencia de enfermedades profesionales. Se utilizaron deferentes metodologías con las cuales se evaluaron las posturas, fuerzas, y actividades musculares, así mismo, se realizó un estudio de levantamiento antropométrico. Se mencionan algunos principios ergonómicos en el desempeño de la tarea y recomendaciones de la NOM-0036-STPS 2019 para evitar futuras enfermedades o daños acumulativos en los trabajadores. La investigación es parte de un proyecto general sobre accidentes y ausentismo reportados en Memorias del IMSS, 2016, del Estado de México, donde existen aproximadamente 39848 empresas, con 53,414 casos de riesgos de trabajo, ocupando el 2° lugar a nivel nacional, implicando 26,520 incapacidades y de ellas 14,790 son incapacidades permanentes por accidente de trabajo, anteriormente en 2013, se tenían 12,000, en 2014, creció a 12,579 y en 2015, 12,881, con un pronóstico para 2020 de 15,024 incapacidades permanentes por accidente de trabajo. Con base en lo anterior, se realizó esta investigación descriptiva, transversal, con el objetivo de identificar las secciones con alto riesgo mecánico y su relación con las características antropométricas de los trabajadores. Se evaluaron los puestos de trabajo a través del método RULA, se entrevistó a los operarios y se recopilo información de la accidentalidad en la empresa, así como la evaluación de riesgos y diagnóstico de cada máquina. Posteriormente se llevaron a cabo mediciones antropométricas a través del método de siete puntos, para la generación de la base de datos. La propuesta fue optimizar el proceso de forma integral, con la implementación de métodos ergonómicos y la readecuación de la estación de trabajo. La oportuna intervención de la Ergonomía es de vital importancia, en preservación de la integridad del factor humano, además del cumplimiento con la Normatividad vigente.

**Palabras clave**: *Ergonomía, repetitividad, puesto de trabajo*

**Abstract:** The research was carried out in an office furniture manufacturing company in the state of Mexico, municipality of Tultitlan de Mariano Escobedo, specifically in the packaging process, in order to identify risk factors for the health of workers, as well as possible consequence of occupational diseases. Different methodologies were used with which the postures, forces, and muscular activities were evaluated, as well as an anthropometric lifting study. Some ergonomic principles are mentioned in the performance of the task and recommendations of NOM-0036-STPS 2019 to avoid future diseases or cumulative damages in workers. The investigation is part of a general project on accidents and absenteeism reported in Memories of the IMSS, 2016, of the State of Mexico, where there are approximately 39,848 companies, with 53,414 cases of work risks, occupying the 2nd place nationwide, involving 26,520 Disabilities and of these 14,790 are permanent disabilities due to work accidents, previously in 2013, there were 12,000, in 2014, it grew to 12,579 and in 2015, 12,881, with a forecast for 2020 of 15,024 permanent disabilities due to work accidents. Based on the above, this descriptive, cross-sectional investigation was carried out, with the aim of identifying the sections with high mechanical risk and their relationship with the anthropometric characteristics of the workers. The jobs were evaluated through the RULA method, the operators were interviewed and information on accident rates was collected in the company, as well as the risk method and diagnosis of each machine. Subsequently, anthropometric measurements were carried out using the seven-point method, for the generation of the database. The proposal was to optimize the process in a comprehensive way, with the implementation of ergonomic methods and the adaptation of the workstation. The timely intervention of Ergonomics is of vital importance, in preservation of the integrity of the human factor, in addition to compliance with current Regulations. .

**Key words:** *Ergonomics, repeatability, workplace*

**Relevance to Ergonomics:** The study contributes to the dissemination of knowledge and awareness of the importance of Ergonomics in the design of work stations and production processes, highlighting the most important thing is the health and life of operators without neglecting the productivity and functionality part of the company.

## 1. INTRODUCTION

In recent years, the number of companies worldwide has increased in both the manufacturing and services sectors. The International Labor Organization (ILO, 2013) reports that more than 317 million accidents occur at work each year and 6,300 people die each day due to work-related accidents or illnesses.

The cost of this daily adversity is enormous and the economic burden of poor safety and health practices is estimated at 4 percent of the Gross Domestic Product (GDP), global each year, implying in addition to human losses, financial losses. In 2008, the ILO adopted the Occupational Health and Safety and Environment Program, which aims to create global awareness of the magnitude and consequences of accidents, injuries and work-related illnesses and disergonomic risks.

The International Ergonomics Association (IEA, 2016), defines ergonomics as the scientific discipline that deals with the understanding of the interaction between human beings and the other elements of a system, among the objectives of ergonomics is the achievement of the satisfaction at work, considering the responsibilities, attitudes, beliefs and values for personal development as well as individual and cultural differences.

Ergonomics as a scientific discipline, is related to the development of knowledge about the capabilities and limitations of human beings in the process and performance of their activities in the context of interface between people, machines, systems and their environment. For

Organizational Ergonomics the approach is to optimize the functioning of work systems through the interface of organizational design, with technology, the environment and people. (Aguayo & Lama, 2016).

With respect to the modifications, the most recent was carried out on November 13, 2014, when the Federal Regulation of Safety and Health at Work was published in the Official Gazette of the Federation (DOF, 2014), which It came into force on February 13, 2015.

The International Ergonomics Association (IEA, 2016), defines ergonomics as the scientific discipline that deals with the understanding of the interaction between human beings and the other elements of a system, among the objectives of ergonomics is the achievement of the satisfaction at work, considering the responsibilities, attitudes, beliefs and values for personal development as well as individual and cultural differences.

Ergonomics as a scientific discipline, is related to the development of knowledge about the capabilities and limitations of human beings in the process and performance of their activities in the context of interface between people, machines, systems and their environment. For Organizational Ergonomics the approach is to optimize the functioning of work systems through the interface of organizational design, with technology, the environment and people. (Aguayo & Lama, 2016).

In the present work, the approach is oriented towards the Organizational Ergonomics, and for this investigation the definition of Hendrick is considered: "The organizational ergonomics or macro ergonomics is the approach of the socio-technical systems for the organizational design and finally of the systems of work and the design of the related interfaces: man-machine, man-environment and user ". (Hendrick, 1991a, p.77). Occupational safety and health conditions differ enormously among countries, economic sectors and social groups, including between types of work and professions.

In the case of Mexico, the Ministry of Labor and Social Security (STPS) establishes the mechanisms (Laws, Regulations, Standards, among others), through which the Labor and Health and Safety and Health relations are governed, as well as keeping them updated according to society's own needs and monitoring compliance with them. With respect to the modifications, the most recent was carried out on November 13, 2014, when the Federal Regulation of Safety and Health at Work was published in the Official Gazette of the Federation (DOF, 2014), which It came into force on February 13, 2015.

With which the Federal Regulation of Occupational Safety, Hygiene and Environment was repealed on January 21, 1997. With the objective of establishing the provisions on Occupational Safety and Health to be observed in the Work Centers, effect of having the conditions that allow to prevent risks and in this way, guarantee workers the right to carry out their activities in environments that ensure their life and health, based on what is stated in the Federal Labor Law.

On the other hand, also on January 4, 2018, the Official Mexican Standard NOM-036-STPS was published, which states that ergonomic risk factors can lead to physical effort, repetitive movements or forced postures in the work carried out, with the consequent fatigue, errors, accidents and work diseases derived from the design of the facilities, machinery, equipment, tools or work station.

On January 4 of this year, the Draft Standard PROY-NOM-036-STPS-2017 was published. After the project modification process, Part 1 of NOM-036-1-STPS-2018, Ergonomic Risk Factors at Work - Identification, Analysis, Prevention and Control was published. The NOM includes ergonomic risk factors that generate musculoskeletal disorders.

These include manual handling of loads, physical overstrain, repetitive movements and forced postures at work. However, Part 1 focuses on manual handling of loads. In this first part of the document the criteria related to the manual handling of loads greater than 3 kg are established. For this reason, centers where minor loads are handled are excluded. One of the most important criteria established by the Standard is the relationship between the maximum weight that a person can carry and their gender and age.

One of the biggest problems for ergonomics is that it is not part of the work culture, and there is no follow-up to the real figures of injuries, accidents, and occupational diseases caused by disergonomic factors in the work centers, because not all companies have their employees insured or is not documented.

The importance and importance, of the Ergonomics and Psychosocial Factors, lies in the Prevention of Work Risks, promoting its application and disclosure in companies and educational institutions to minimize the accident rate, deterioration of health and underutilization of machinery.

Based on the foregoing in this project, the anthropometric profiles of the northern area of the State of Mexico will be investigated, in order to prepare an analysis to determine if there is a relationship between the accident rate and the anthropometric characteristics of the workers and to document the results to generate a database and with it the construction of Anthropometric Charts of said region for its publication as base of the Anthropometric Atlas of Mexico, due to the fact that none is currently available.

This study is generated from the need to know the causes of the recurrence of complaints by workers with regard to joint pain, back and frequent disabilities for the same reasons in the area of molding a production plant of glass bottles located in the municipality of Tultitlán in the State of Mexico.

One of the factors that were identified from the beginning was that, due to its origin, the dimensions and design of the machines tend to be very different from the morphological characteristics of the users and this has resulted in the operators having to adapt to their station. I work on equipment and machinery, with the risk of acquiring cumulative trauma dysfunction (DTA).

According to the Ministry of Labor and Social Welfare (STPS) derived from the modification in the production processes, machinery, logistics and packaging of the loading units, it is estimated that, to the cement, transportation, wheat and sugar milling industries The implementation of NOM-036 will involve an investment of up to 9,243 million pesos.

Meanwhile, complying with the new measures that companies must adopt will cost about 23,916 pesos to each workplace. However, in case of having to readjust the production processes, machinery, logistics or packaging of the cargo units, the costs could increase by 65,000 pesos more. "The prevention and analysis actions provided in the standard will reduce the high incidence of diseases related to manual handling of cargo," states the STPS in the preliminary opinion presented at the Conamer.

A goal that makes sense for the increase in musculoskeletal disorders, which increased 14% in one year and represent 42% of occupational diseases. The labor authorities have clarified that NOM-036 does not establish specific age requirements for the hiring of personnel, it only sets the maximum mass that a worker can lift or lower based on their age and gender.

The STPS insisted that the new regulation does not determine that when a worker turns 45 years of age, he can no longer perform manual handling of loads up to the maximum limit allowed; on the contrary, it imposes an obligation on the employer to monitor the health of this collaborator in a special way so that it continues to provide its services to the company.

That is why this study aims to make measurements of the anthropometric dimensions to workers in the glass bottle production plant located in the municipality of Tultitlán in the State of Mexico, for future ergonomic evaluations. Anthropometry allows the creation of a suitable working environment for the design of the equipment and its correct distribution, allowing to configure the geometric characteristics of the position, a good furniture design, manual tools, individual protection equipment, among other applications.

In addition to the criteria for the analysis of risk factors, the NOM establishes prevention and control measures to care for the health of workers. Likewise, it indicates safety actions for workers who perform forced postures derived from cargo handling. NOM-036-1-STPS- 2018 entered into force on January 2, 2020.

However, some of its numbers will be in force until 2023. Its publication adds to other significant advances in updating Mexican regulations. on safety and health at work. With its eventual compliance, work centers will have safer conditions for workers.

## 2. OBJETIVES

1. Analyze the conditions under which each activity is performed to identify possible risk of DTA´s
2. To evaluate the relationship between the anthropometric characteristics of the workers and the accident rate.

## 3. METHODOLOGY

The study will be quantitative, observational, descriptive and cross-sectional, it will be carried out to determine the anthropometric profile of the working population of the state of Mexico, northern zone (municipalities of Tultitlán, Coacalco, and Ecatepec).

The population will be divided by age group, gender and sex (it should be noted that the concept of sex refers to the differences and biological, anatomical and physiological characteristics of human beings that define them as men or women; it is born, universal and unmodifiable and gender is the set of ideas, behaviors and attributions that a given society considers appropriate for each sex), of which samples will be taken by groups of 18 to 24 years and 18 to 65 years.

For each sample, 37 of the anthropometric dimensions will be taken, to then capture and analyze the data and finally generate anthropometric tables. Due to the characteristics of the activity, the Plibel method was applied, the standard times were calculated, the learning curve and environmental conditions were evaluated in contrast with Mexican regulations.

The NOM-036 considers some preventive and control measures that companies can implement, the first step is that the manual handling of cargo is carried out by workers who have the physical aptitude guaranteed by a doctor or through a social security institution.

To carry out the loading activities, the work centers must have a procedure that includes the description of the appropriate technique to carry out the tasks safely; the security and control measures that will be applied during the course of the job; the characteristics of the load such as dimensions, shape or weight; environmental conditions that can increase work effort; the trajectory for the transfer of the load, and the specification of the materials that are handled.

But there are also general measures, among which the warm-up exercises before starting the activities stand out; unobstructed transit areas; keep the place in order and clean or establish rest periods, among other recommendations.

1. To comply with NOM 036, work centers must implement new rules, among whichare: Conduct an analysis of ergonomic risk factors
2. Adopt prevention and control measures to reduce or eliminate ergonomic risk factors
3. Monitor the health of exposed workers (application of medical examinations)
4. Inform workers about possible health changes due to manual handling ofloads.
5. Train and train exposed personnel in safety procedures and safe work practices.
6. Record the preventive measures adopted and the examinations applied.

Table 1. Maximum mass that a worker can lift or lower by age and gender
*Fuente:* DOF 2018.

| Maximum mass (kg) | Génder | Age (in year) |
|---|---|---|
| 7 | Female | Unnder de 18 |
| 7 | Male | Under de 18 |
| 15 | Female | Over de 45 |
| 20 | Female | Between 18 y 45 |
| 20 | Male | Over de 45 |
| 25 | Male | Between 18 y 45 |

The work stations were evaluated through the RULA method, the operators were interviewed and information was collected on the accident rate in the company, as well as the risk assessment through the LEST method and diagnosis of each machine. Subsequently, anthropometric measurements were carried out through the seven-point method, for the generation of the database, ending with the evaluation of environmental conditions according to the current regulations. Materials and Equipment, is measurement and analysis module of anthropometric and biomechanical measurements Asia Tech.

The samples will be at convenience and consist of voluntary participants, before making the measurements will be read and explained to the participants an informed consent sheet that will include information about the purpose of the project and those responsible for it, as well as the necessary information on the procedure, the risks, benefits, their rights and the confidentiality of the study, finally the document will be signed by the volunteer, the person in charge and a witness.

Figure 1. Materials and Equipment.

The first activity to be carried out as part of the project will be a certification in Isak Level I anthropometry, to ensure the correct measurement and data collection. After this, an information acquisition will be carried out on the basic economic area in the INEGI to select the companies to be sampled. Once the companies have been selected, the corresponding authorizations of each institution must be obtained. At the same time, the recruitment of members of anthropometric teams will be carried out, and these will be trained in anthropometry to take measurements.

A literature review will be carried out with the objective of knowing which anthropometric dimensions are the most used by the designers, books and articles related to anthropometry will be reviewed for the design of furniture, tools and work stations, once these dimensions are known a format will be created to record the data of each volunteer. Once the above is done, it will begin with the taking of samples. Anthropometric measurements of the population will be taken for each age group and sex (18 to 24 years and 18 to 55 years).

To take the samples will assist the work places with the necessary equipment, an anthropometric and a person in charge of recording the data. The informed consent form will be reviewed with each volunteer, these will include information about the project, the people in charge of it, risks, benefits, rights, obligations and confidentiality, after signing the volunteer, the person in charge of the project and a witness will proceed to the taking of the measurements, using the anthropometric technique of Hertzberg (1968).

At the end of the measurements, the capture, revision, correction and processing of the data will be performed, these will be analyzed in SPSS for Windows in version 15.0, in order to perform the analysis of the variables in said program and in the software Amos 16.0, first an analysis matrix will be elaborated to carry out the statistical analysis, normality tests will be carried out, as well as generating measures of central tendency, dispersion, percentiles (5, 50 and 95) and finally, anthropometric charts will be generated for each age group and sex.

## 4. RESULTS

The results of the analysis showed a correlation of 0.89 between the accident rate and the anthropometric dimensions of the workers. The proposal was to optimize the process in an integral way, with the implementation of ergonomic methods and the readjustment of the work station. The timely intervention of the Ergonomics is of vital importance, in preservation of the integrityof the human factor, in addition to the compliance with the current Regulations.

Due to the characteristics of the activity, the Plibel method was applied, the standard times were calculated, the learning curve and environmental conditions were evaluated in contrast with Mexican regulations. When analyzing the work station it was found that the weight of the molds is between 70 and 90 kg. With which it exceeds the 25 Kg.

That marks the Official Mexican NOM-006-STPS-2014 for Management and storage of materials-Health and safety conditions at work for an operator, without the help of another loading tool. It is suggested the authorization of technologies, processes, equipment, procedures, mechanisms, test methods or alternative materials to those provided in the standards.

The category of older workers varies according to their functional condition, which in turn is influenced by their previous work history. It also depends on the job they occupy and the social, cultural and economic situation of the place where they live. Thus, those workers who perform a purely physical job are often the ones with the lowest level of schooling and professional preparation. They are subject to stress caused by strenuous work, which can be a cause of illness, and exposed to the risk of work accidents. In this context, it is more than probable that their physical capacity will decline at the end of their active life, a fact that makes them more vulnerable workers. It is clear that the benefits of ergonomics can be reflected in many different ways: in productivity and quality, in safety and health, in reliability, in job satisfaction and in personal development. Observe the task and examine the horizontal distance between the worker's hands and the lower part of his back. Always consider the "worst case scenario".

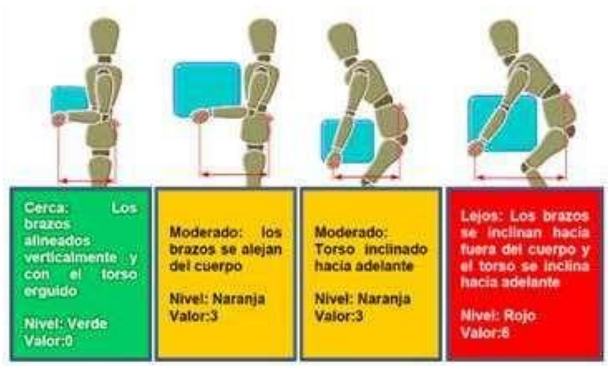



Figure 2. Horizontal distance between hands and lower back

Use the following illustration to guide your evaluation: Observe the position of the worker's hands at the beginning of the survey and as the operation progresses. Always consider the "worst case scenario". Use the following illustrations as a guide:

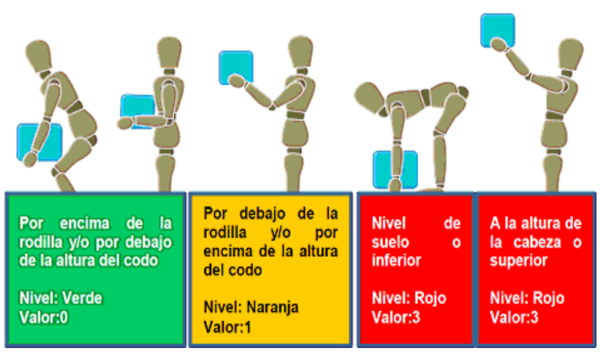



Figure 3. Vertical survey region.

Observe the worker's torso as he lifts the load. If the torso twists relative to the hips and thighs or the worker leans to one side as the load is lifted, the color of the band is orange. If the torso twists and bends to one side as the load is lifted, the color of the band is red.

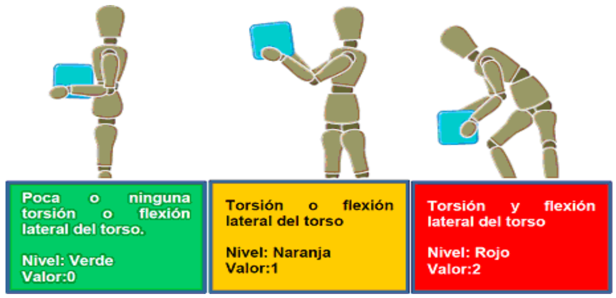



Figure 4. Torso torsion and lateral flexion.
*Fuente:* DOF 2018.

The basic objective of ergonomics is to achieve efficiency in any activity carried out for the purpose of achieving the desired result without wasting resources, without errors and without damage to the person involved or to others. It is not efficient to waste energy or time due to poor design of work, work space, environment or working conditions and ensure that the work environment is in harmony with the activities performed by the worker. Various parts of the body were measured, but only the most relevant for the use of tools and machinery is shown.

Table 2. The phalanges of the human right hand.

| **Average lengths of sector of the phalanges of the human right hand expressed in mm.** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Age** | **L** | **W** | **T** | **L** | **W** | **T** | **L** | **W** | **T** |
| **18-19** | 25.2+- | 30.4+- | 20.1+- | 22.9+- | 22.3+- | 37.3+- | 19+- | 23.1+- | 26.8+- |
| | 3.43 | 4.38 | 0.99 | 3.479 | 2.452 | 4.69 | 1.56 | 3.18 | 2.7 |
| **20-24** | 27.5+- | 31.1+- | 20.7+- | 24+- | 21.29+- | 40.2+- | 19.5+- | 25.3+- | 26.7+- |
| | 3.11 | 4.49 | 2.63 | 2.775 | 3.258 | 3.75 | 1.75 | 2.41 | 3.81 |
| **25-29** | 30+- | 30+- | 21.5+- | 27.5+- | 24.5+- | 42+- | 20+- | 27.5+- | 38+- |
| | 7.07 | 2.83 | 0.71 | 6.364 | 3.536 | 8.49 | 1.41 | 6.36 | 18.4 |
| **30-34** | 27.3+- | 34+- | 21.7+- | 25.33+- | 22.67+- | 41.3+- | 21+- | 25.7+- | 28.3+- |
| | 4.62 | 5.57 | 0.58 | 0.577 | 1.155 | 2.08 | 1 | 0.58 | 1.53 |
| **35-39** | 30+- | 34+- | 22.3+- | 23.67+- | 22.67+- | 39.7+- | 19.3+- | 26+- | 27.3+- |
| | 1 | 6.08 | 0.58 | 1.528 | 4.041 | 0.58 | 1.15 | 1 | 3.06 |
| **40-44** | 30.3+- | 36.3+- | 24+- | 27+- | 30+- | 35.7+- | 23.3+- | 28+- | 28.3+- |
| | 1.53 | 4.51 | 6.93 | 5 | 9.165 | 3.51 | 7.57 | 4 | 4.04 |
| **45-49** | 28+- | 27+- | 20.5+- | 25+- | 27.5+- | 40+- | 21+- | 25.5+- | 27+- |
| | 2.83 | 1.41 | 0.71 | 4.243 | 4.95 | 0 | 1.41 | 0.71 | 1.41 |
| **50-54** | 30+- | 33.3+- | 22.3+- | 26.33+- | 23.67+- | 40+- | 20.3+- | 25.3+- | 29+- |
| | 1.73 | 3.21 | 1.53 | 0.577 | 3.786 | 2.65 | 1.53 | 0.58 | 1 |
| **55-59** | 25.7+- | 31.7+- | 21+- | 22.33+- | 21.67+- | 39+- | 20.7+- | 24.7+- | 24.7+- |
| | 1.53 | 4.62 | 2 | 4.041 | 2.082 | 1 | 1.15 | 3.21 | 5.03 |
| **60-64** | 24.3+- | 27.3+- | 21+- | 23.33+- | 22+- | 34.3+- | 20.7+- | 23+- | 22.7+- |
| | 3.79 | 2.08 | 1 | 0.577 | 1.732 | 8.62 | 0.58 | 2.65 | 1.15 |

## 4. CONCLUSIONS

The anthropometric variables are mainly linear measures, such as height or distance in relation to the reference point, with the subject sitting or standing in a typified posture; widths, such as distances between bilateral reference points; lengths, such as the distance between two different reference points; curved measurements, or arcs, such as the distance on the body surface between two reference points, and perimeters, as measurements of closed curves around body surfaces, generally referred to at least one reference point or at a defined height.

Individual differences can be very large, such as those of physical constitution and strength, are evident, but there are others, such as cultural differences, of style of skills that are more difficult to identify.The RULA method was used to evaluate the postures, forces and muscular activity in which they are working, and the results obtained indicate that the conditions in which the worker is found have improved, since the procedures are respected And in this way you are expected to minimize harmful consequences for your health.

Musculoskeletal disorders not only represent a problem for companies, but also for the State, since the government has to allocate more resources to treat these injuries, says Marco Rojas, an expert in labor practice and compliance at Baker McKenzie

"Every day it is more frequent for workers to go to Social Security to point out that due to the constant and periodic activities carried out they suffer some deterioration in their physical capacities and that generates a greater burden for the government," he explains. In addition, the specialist warns, January 2 should not be interpreted as the date to start complying with NOM-036, but the day when the new regulatory framework can begin to be inspected by the authorities.

In view of the complexity of the situation, it might seem that the solution is to provide a flexible environment, in which the operator can optimize a specifically suitable form of procedures. Unfortunately, the most efficient way is not always obvious and, as a result, the worker can continue to do his job for years in an inadequate way or in unacceptable conditions.

It is concluded that the best ergonomic approach is a comprehensive, long-term study, a restructuring of the workplace in the medium term and the training of supervisors and workers to raise awareness of the risks and the importance of taking care of work risks, in the short term; that is, it is necessary to adopt a systemic approach.

## 4. REFERENCES

A. E. D. N. Y. CERTIFICACIÓN, «Definiciones de las medidas básicas del cuerpo humano para el diseño tecnológico. Parte 1,» UNE-EN ISO 7250-1, de las medidas básicas del cuerpo humano para el diseño tecnológico. Parte 1.

Aguayo, F., & Lama, J. (2016). *La holónica como marco paradigmático para la Ingeniería de la prevención. Aplicación al diseño macro ergonómico*. Extraído 10 de Octubre, 2017, de Biblioteca de la Universidad de Sevilla Sitio web: http://hdl.handle.net/11441/40880

Ávila, R., Prado, L. R., & González, E. L. (2007). Dimensiones antropométricas: Población Latinoamericana. México: CUAAD.

Cornejo, R. & Quiñónez, M. (2007). Factores asociados al malestar/bienestar docente. Una investigación actual. *Red Iberoamericana de Investigación sobre Cambio y Eficacia Escolar (RINACE*), (5) 75-80.

DOF (2020). *Reglamento Federal de Seguridad y Salud en el trabajo.* Extraído 3 de marzo

de 2020 de sitio web: http://www.dof.gob.mx/nota_detalle.php?codigo=5368114&fecha=13/02/2020
Grandjean, E. (1983). Fatiga general. Ergonomía. Suiza. *Enciclopedia de Salud y Seguridad en el Trabajo*. 29(1) 1-12.
Hendrick, H. (1991a). Macroergonomics: A Better Approach to Work System Design. *Revista IEA*, (11) 76-81.
IEA. (2016). *Clasificación de la ergonomía en la Asociación Internacional de Ergonomía.* Extraído el 20 de diciembre de 2016 de Sitio web: www.iea.cc/whats/index.html
IMSS (2016) *Memorias del IMSS 2016*. Extraído el 22 de febrero del 2018 de sitio web: http://www.imss.gob.mx/conoce-al-imss/memoria-estadistica-2016
J. L. Melo, Ergonomía práctica, Granada, España: Mapfre, 2009.
Klamklay, J., Sungkhapong, A., Yodpijit, N., & Patterson, P. E. (2008). Anthropometry of the southern Thai population. International Journal of Industrial Ergonomics, 111–118.
Liu, W. C., Sanchez-Monroy, D., & Parga, G. (1999). Anthropometry of female maquiladora workers. International Journal of Industrial Ergonomics, 273-280.
OIT. (2013). *La prevención de enfermedades profesionales*. Suiza: OIT.
STPS, «NORMA Oficial Mexicana NOM-006-STPS-2014,» SEGOB, México, 2014.

# REVIEW OF THE LATEST RESEARCHES ABOUT ERGONOMICS AND WORK-RELATED MUSCULOSKELETAL DISORDERS.

**Luis Fernando Mesta Carrillo and Beatriz Sibaja Terán**

Laboratory of psychosocial and ergonomic factors
of the Master of Science (MSc) in Occupational Health, Safety and Hygiene
Escuela Nacional de Medicina y Homeopatía,
Instituto Politécnico Nacional (IPN)
lmestac1800@alumno.ipn.mx, mclfernandomc@gmail.com
bsibajat@ipn.mx, bettysibaja@gmail.com

**Resumen:** La manifestación de las molestias, dolores o enfermedades musculoesqueléticas generadas por el sobreesfuerzo o desgaste físico de los tejidos del aparato locomotor es una de las principales preocupaciones del especialista en Ergonomía, por lo tanto, se considera necesario contar con información actualizada sobre los hallazgos recientes con carácter científico para dar soluciones según las urgencias que se presentan en los Centros de Trabajo. Cubriendo ese objetivo se realizó una revisión bibliográfica en PubMed de los últimos tres años para conocer las características específicas de los lugares donde se realizan los estudios, en quiénes están enfocados y en los sitios anatómicos donde se han presentado este tipo de enfermedades.

**Palabras clave**: ergonomía, enfermedades musculoesqueléticas, salud laboral, enfermedades profesionales.

**Relevancia para la ergonomía**: Este trabajo proporciona la concentración bibliográfica de estudios publicados de marzo 2017 a marzo 2020 sobre las enfermedades musculoesqueléticas que se han presentado en los cinco continentes y que nos dan información de la exposición que se genera por riesgos no ergonómicos, lo que puede ser trascendente para los especialistas en esta área para evitar o corregir las fuentes generadoras desde un enfoque basado en la evidencia.

**Abstract:** The manifestation of musculoskeletal discomfort, pain or disease generated by overstrain or physical wear of the tissues of the locomotor system is one of the main concerns of the Ergonomic specialists, therefore, it is considered necessary to have updated information on recent findings with scientific character, to give solutions according to the urgencies that appear in the Work Centers. Covering this objective, a bibliographic review of the last three years was carried out in PubMed to find out the specific characteristics of the places where the studies are undertaken, who they are focused on, and in which anatomical sites this type of disease has occurred.

**Keywords**: Ergonomics, musculoskeletal diseases, occupational health, occupational diseases.

**Relevance to Ergonomics**: This work provides the bibliographic concentration of studies published from March 2017 to March 2020 on musculoskeletal diseases that have occurred in the five continents and that give us information on the exposure that is generated by nonergonomic risks, which can be important for specialists in this area to avoid or correct generating sources from an evidence-based approach.

## 1. INTRODUCTION

In the field of ergonomics, it is important to use data with scientific rigor to make assertive decisions, regarding the measures that could solve the problems faced by the specialists in charge of the worker's musculoskeletal disorders, in the Work Centers. It is remarkable that ergonomics is a multidisciplinary field which objectives include the prevention of occupational risks; this build a relationship with life sciences research that makes possible the understanding of the physiological, biomechanical and psychophysical changes in the worker when is exposed to disergonomic activities (Llaneza Álvarez, 2009a). It is widely recognized that changes in working conditions are the chosen methods to improve productivity, quality and efficiency. However, these changes may have negative, neutral or positive effects on health workers; this makes important to document and evaluate the changes from health perspective (Westgaard & Winkel, 1997).

Among the negative effects for workers there are well known occupational diseases, such as pneumoconiosis, and the raising of relatively new occupational diseases, such as musculoskeletal and mental related to work diseases (International Labour Organization, 2013). On the other hand, the work-related musculoskeletal disorders (WRMD) are widely associated with high costs to employers due to absenteeism, lost productivity, and increased health care, disability, and worker’s compensation costs (Centers for Disease Control and Prevention, 2020). Further recognition and prevention are required, and the aim that allows prevention depends on the scientific knowledge of the mechanical exposure related to musculoskeletal diseases (Westgaard & Winkel, 1997).

The origin of musculoskeletal diseases is multifactorial, and several specific potentially relevant pathological mechanisms have been described, but there currently is no clear and circumscriptive understanding of the pathogenesis of work-related musculoskeletal disorders. One postulation is that musculoskeletal diseases result from cumulative micro damage induced by risk factors on cellular and/or tissue level over time. The World Health Organization (WHO) and the International Labour Organization (ILO) are developing a joint methodology for estimating the national and global work-related burden of disease and injury. This includes a published protocol to systematically review studies on exposure to occupational ergonomic risk factors and systematically review and meta-analyze estimates of the effect of exposure to occupational ergonomic risk factors on musculoskeletal diseases (Hulshof et al., 2019). This is a huge effort that requires the commitment of all the researchers that are interested in providing scientific evidence about occupational health, ergonomics and musculoskeletal disorders.

The type of scientific literature that is produced is important, since the originality, sources, objectives and impact differ among the different types. The primary scientific literature sources consist in authentic publications of an expert´s new evidence, conclusions and proposals; among them, the original research papers, brief reports and case report, are the most used. The secondary scientific literature sources are based on primary resources; systematic review and meta-analyses are the most reliable due to its strict methodology; for example, meta-analysis requires the comprehensive statistical analysis of a determined number of clinical trials. Other forms for secondary sources are clinical practice guidelines, research methodology reports and letter to the editor. The tertiary scientific literature sources are those that consists of collections that compile information from primary and secondary literature, like reference books, narrative reviews (literature reviews) and scientific letters (Jiménez Ávila, 2015; Grewal, Kataria, & Dhawan, 2016).

A convergence point of any definition of ergonomics lies in a user/worker/patient centered perspective (Obregón Sánchez, 2016). Ergonomics also distinguish two components of the human work, task and activity, and all the tasks implies physical and mental demands in different proportions (Llaneza Álvarez, 2009a). This perspective requires that any study made from the perspective of ergonomics should consider those physical and mental manifestations of the worker; in other words, the human body and the human mind are imperative variables that exists there. In this way, since musculoskeletal pain is the most common single type of chronic pain, and is the main clinical manifestation of the WRMD, its presence, or not, and its intensity, is an important aspect to consider before any conclusion in ergonomics (Hernandez & Peterson, 2012). In the other hand, the work is the other part of this interaction, if there is no work, work conditions and occupational health won't exist, and employment neither (Llaneza Álvarez, 2009b). Between these elements, task and worker, there is a constant interaction that allows to perceive the effects on worker’s health because of required changes in the task. This could be mentioned as that, the manifestations on worker´s health, including pain, are an indicator of required changes in work conditions, which include workstation design. At this point, it is irrefutable that disciplines from at least two scientific fields (medicine, engineering, social sciences, etc.) could have a posture that ergonomics should take in account. Pain is the main manifestation of WRMD, and it is the way the worker´s body express that something is wrong, and this could be occasioned by the work tasks.

## 2. OBJECTIVES

### 2.1 Aim

The aim of this work is to review the latest researches made about ergonomics and work-related musculoskeletal disorders that were published on the PubMed database of the US National Library of Medicine of the National Institutes of Health.

### 2.2 Specific objectives

- Search for publications in a scientific database on ergonomics, pain and/or disorders of the musculoskeletal system generated by work.
- Select bibliography with scientific rigor on the presence of musculoskeletal diseases that affect workers by executing their tasks.

- Describe musculoskeletal pain or disease and the type of working population affected.

## 3. METHODOLOGY

3.1 Type of study.

The present work is a review of the scientific literature covering the five continents, where pain or diseases of the musculoskeletal that affect to workers due to the execution of their work, have been studied. We used coping review design of articles published from March 2017 to March 2020 exclusively in the Medline PubMed search engine that is produced by the United States National Library of Medicine.

3.2 Article selection process

The keywords applied to search the articles were “work related musculoskeletal diseases”, “pain” and “ergonomics” which are descriptors of health science and which belong to the thesaurus vocabulary of Medical Subject Headings (MeSH). According to the selection criteria, documents were classified by the article type, study population, country where the study was conducted and main contribution to ergonomics field. They were subsequently labeled and classified in four general groups: original research papers, brief/case reports, systematic review and meta-analyses, and narrative/literature reviews and others; also, according to the type of working population in four groups: medical surgeons, health care providers, administrative, and manufacturing, construction and others. Once the articles were selected, the full text was examined to identify the instruments used for the assessment of musculoskeletal pain or disease, and data on the type of pain or disease and location were also extracted.

3.2 Selection criteria

*Inclusion criteria:* scientific evidence describes the year of publication, exclusive language of English and country-specific, as well as indicates a rigorous methodology to collect and analyze the results, the type of working population appears, the anatomical site, the type specification pain and/or diseases of the musculoskeletal system.

*Exclusion criteria:* publications with missing data of the type of population, country, or missing data in the methodological description. Theses, conference proceedings, manuals or reference guides were not considered, the instrument to explore musculoskeletal discomfort was not specified.

*Elimination criteria:* the article did not include in its methodology any validated instrument to assess pain or measure of the intensity of the ergonomic factors that could be related to the pain.

### 3.3 Analysis of data

A flow chart was constructed to show the article selection process, then comparative tables were made in Excel to concentrate the information, which facilitated the analysis of the information.

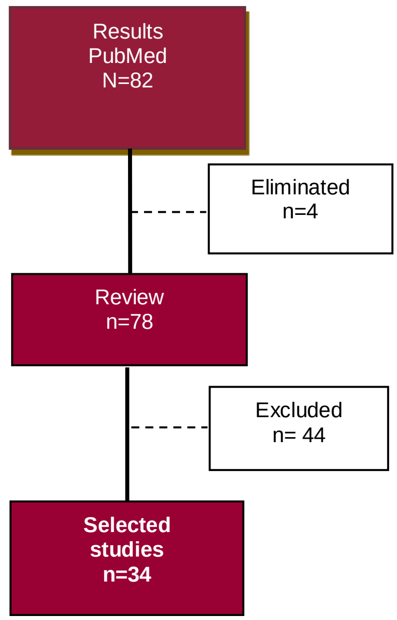



**Figure 1. Description of the selection process**

## 4. RESULTS

According to delimited search criteria, the system showed 78 articles; all the abstracts and cites from those articles were retrieved in an Excel spreadsheet to be included in the review. From the 78 articles, 63 (80.76%) are original researches, including clinical trials, prevalence studies and other interventional studies. In the other hand, 4 articles (5.12%) are case/brief reports, 7 (8.97%) articles are systematic reviews and meta-analyses, and 4 (5.12%) are literature reviews. Regarding the study population, 20.51% (16) were doctors from a wide variety of surgical specialties; 23.07% (18) were made on other health care providers, such as odontologists, nurses and imaging technicians, 14.10% (11) were made on workers of mostly administrative or computer based activities; and 42.30% (33) were made on workers of predominantly physical activities, such as manufacturing, construction or farming. All the included articles in the review are shown on Table 1.

Regarding the country where study population belong to, or where the research was conducted, the most prevalent country was the United States with 23.07% (18) of all the studies, most of them are original researches; European countries account to 24.35% (19) of all the studies, most of them original researches too; Asian countries published 24.35% (19) articles; Middle West countries contributed with 19.23% (15) of all the articles; Australia contributed with 3.84% (3) of all researches; and there was only one Latin American country that appeared on the search, Brazil, with 5.12% (4) of the papers. Complete distribution by country is shown on Table 2.

Among all the included studies in the review, 52.56% were focused on evaluate pain or discomfort related to WRMD in a general basis or several anatomical sites of the body; 21.79% were focused on the back pain or trunk; 14.10% were more related to pain or discomfort in the neck; and 11.53% were focused on study WRMD on upper limbs, including shoulders (Figure 2).

From all the included studies, 47.40% made an evaluation of pain in the study population, but only 37.83% of them, it means 17.94% from the total, applied a validated instrument for measure of pain related to musculoskeletal disorders. It means that from the 78 found articles, 82.05% did not evaluated the pain or discomfort and all the methodology was focused on risk assessment. However, although the 58.97% of the studies shown a clear methodology to assess the risk factor for ergonomics, and even evaluated its intensity, in less than one of every five studies the pain was a clearly quantified outcome.

After this, the elimination criteria were applied, and 34 (43.58%) studies were selected; those articles clearly described a validated method to measure pain or the intensity of ergonomic risk factor studied as probably related to pain in the study population. From those studies, all were original researches, 15 (44.11%) used a validated instrument for assess the risk factor, 10 (29.41%) used a validated instrument for assess the pain, and 9 (26.47%) used a validated method for both variables (Figure 3). From these articles, only four are clinical trials. The most applied validated instrument was the Nordic Musculoskeletal Questionnaire (NMQ), which was used in 14 (41.17%) of the selected studies. However, other validated and well-known instruments that are widely applied in ergonomics, as RULA, OCRA, OWAS and REBA, were applied too. Some technological methods, as surface electromyography and kinematics were applied in 7 (20.58%) of the studies.

**Table 1. Article included in the review by alphabetical order**

| Reference | Country | Type of publication | Study population |
|---|---|---|---|
| (Al-Rawi et al., 2018) | United Arab Emirates | a | x |
| (Alyahya, Algarzaie, Alsubeh, & Khounganian, 2018) | Saudi Arabia | a | x |
| (Bao & Lin, 2018) | United States | a | z |
| (Barros-Gomes et al., 2019) | United States | a | x |
| (Benjamin & Meisinger, 2018) | United States | d | x |
| (Besharati, Daneshmandi, Zareh, Fakherpour, & Zoaktafi, 2018) | Iran | a | y |
| (Botta, Presoto, Wajngarten, Campos, & Garcia, 2018) | United States | a | x |

| | | | |
|---|---|---|---|
| (Brandt et al., 2018) | Denmark | a | z |
| (Bulduk, 2019) | Turkey | a | z |
| (Cardenas-Trowers, Kjellsson, & Hatch, 2018) | United States | b | w |
| (Catanzarite, Tan-Kim, & Menefee, 2018) | United States | d | w |
| (Catanzarite, Tan-Kim, Whitcomb, & Menefee, 2018) | United States | d | w |
| (Celik et al., 2018) | Turkey | a | y |
| (Chatterjee & Sahu, 2018) | India | a | z |
| (Comper, Dennerlein, Evangelista, Rodrigues da Silva, & Padula, 2017) | Brazil | a | z |
| (Coskun Beyan et al., 2018) | Turkey | b | z |
| (Dabholkar, Yardi, Dabholkar, Velankar, & Ghuge, 2017) | India | a | w |
| (Dalager, Hojmark, Jensen, Sogaard, & Andersen, 2019) | Denmark | a | w |
| (Davila, Meltzer, Hallbeck, Stone, & Money, 2019) | United States | a | w |
| (De Sio et al., 2018) | Italy | c | x |
| (Depreli & Angin, 2018) | Cyprus | a | y |
| (Dianat, Bazazan, Souraki Azad, & Salimi, 2018) | Iran | a | w |
| (Epstein et al., 2018) | United States | c | w |
| (Ergan, Baskurt, & Baskurt, 2017) | Turkey | a | x |
| (Fernandez de Grado, Denni, Musset, & Offner, 2019) | France | a | x |
| (Fiodorenko-Dumas, Kurkowska, & Paprocka-Borowicz, 2018) | Poland | a | z |
| (Giagio et al., 2019) | Italy | a | w |
| (Habib, Ziadee, Abi Younes, & Harastani, 2020) | Siria | a | z |
| (Hakim & Mohsen, 2017) | Egypt | a | z |
| (Hallbeck et al., 2017) | United States | a | w |
| (Hoe, Urquhart, Kelsall, Zamri, & Sim, 2018) | Malasya | c | y |
| (Hossain et al., 2018) | Bangladesh | a | z |
| (Howarth, Hallbeck, Lemaine, Singh, & Noland, 2019) | United States | a | w |
| (Howarth, Hallbeck, Mahabir, et al., 2019) | United States | a | w |
| (Intranuovo et al., 2019) | Italy | b | z |
| (Januario, Madeleine, Cid, Samani, & Oliveira, 2018) | Brazil | a | z |
| (Januario, Oliveira, Cid, Madeleine, & Samani, 2017) | Brazil | a | z |
| (Jeong & Choi, 2020) | Korea | a | x |
| (Johnson, Zigman, Ibbotson, Dennerlein, & Kim, 2018) | United States | a | z |
| (Kaup, Shivalli, Kulkarni, & Arunachalam, 2020) | India | a | w |
| (Kee & Haslam, 2019) | Korea | a | z |
| (Koni et al., 2018) | Italy | a | x |

| | | | |
|---|---|---|---|
| (Laal, Mirzaei, Behdani, Mohammadi, & Khodami, 2017) | Tailand | a | z |
| (Labao, Faller, & Bacayo, 2018) | Malasya | a | z |
| (Lallukka et al., 2019) | Finland | a | z |
| (Lin, Barbir, & Dennerlein, 2017) | United States | a | y |
| (Lind, Forsman, & Rose, 2020) | Sweden | a | y |
| (Liu et al., 2019) | China | a | z |
| (Lobo, Gandarillas, Sanchez-Gomez, & Megia, 2019) | Spain | a | w |
| (Luger, Maher, Rieger, & Steinhilber, 2019) | Germany | c | z |
| (Makishima et al., 2018) | Japan | a | z |
| (Meisha, Alsharqawi, Samarah, & Al-Ghamdi, 2019) | Saudi Arabia | a | x |
| (Minghelli, Ettro, Simao, & Mauricio, 2019) | Portugal | a | z |
| (Mulimani et al., 2018) | United States | c | x |
| (Noble & Sweeney, 2018) | United States | d | x |
| (Nourollahi, Afshari, & Dianat, 2018) | Iran | a | x |
| (Oakman, de Wind, van den Heuvel, & van der Beek, 2017) | Australia | a | z |
| (Pandalai, Wheeler, & Lu, 2017) | United States | a | z |
| (Penkala, El-Debal, & Coxon, 2018) | Australia | a | y |
| (Pereira et al., 2017) | Australia | a | y |
| (Petit et al., 2018) | France | a | z |
| (Prasad, Appachu, Kamath, & Prasad, 2017) | India | a | x |
| (Rasim Ul Hasanat, Ali, Rasheed, & Khan, 2017) | Pakistan | a | y |
| (Rasmussen et al., 2018) | Denmark | a | z |
| (Sanaeinasab et al., 2018) | Iran | a | y |
| (Schmalz et al., 2019) | Germany | a | z |
| (Singh & Singh, 2019) | India | b | y |
| (So, Szeto, Lau, Dai, & Tsang, 2019) | China | a | z |
| (Szczygiel, Zielonka, Metel, & Golec, 2017) | Poland | c | z |
| (Thetkathuek & Meepradit, 2018) | Tailand | a | z |
| (Tirloni, Reis, Borgatto, & Moro, 2019) | Brazil | a | z |
| (Tsang, So, Lau, Dai, & Szeto, 2018) | China | a | z |
| (Umer, Antwi-Afari, Li, Szeto, & Wong, 2018) | China | c | z |
| (Vaisbuch et al., 2019) | United States | a | w |
| (Wareluk & Jakubowski, 2017) | Poland | a | x |
| (Wells, Kjellman, Harper, Forsman, & Hallbeck, 2019) | Sweden | a | w |
| (Yan et al., 2017) | China | a | x |
| (Zafar & Almosa, 2019) | Saudi Arabia | a | x |

a=original research papers; b=brief/case reports; c=systematic review and meta-analyses; d=narrative/literature reviews and others; w=medical surgeons; x=health care providers; y=administrative; z=manufacturing, construction and others.

**Table 2. Distribution of found articles according to country, type of article and study population.**

| Country | Total, research | Type of publication | | | | Study population | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | a | b | c | d | w | x | y | z |
| United States | 18 | 11 | 1 | 2 | 4 | 9 | 5 | 1 | 3 |
| China | 5 | 4 | – | 1 | – | – | 1 | – | 4 |
| India | 5 | 4 | 1 | – | – | 2 | 1 | 1 | 1 |
| Brazil | 4 | 4 | – | – | – | – | – | – | 4 |
| Iran | 4 | 4 | – | – | – | 1 | 1 | 2 | – |
| Italy | 4 | 2 | 1 | 1 | – | 1 | 2 | – | 1 |
| Turkey | 4 | 3 | 1 | – | – | – | 1 | 1 | 2 |
| Australia | 3 | 3 | – | – | – | – | – | 2 | 1 |
| Denmark | 3 | 3 | – | – | – | 1 | – | – | 2 |
| Poland | 3 | 2 | – | 1 | – | – | 1 | – | 2 |
| Saudi Arabia | 3 | 3 | – | – | – | – | 3 | – | – |
| France | 2 | 2 | – | – | – | – | 1 | – | 1 |
| Germany | 2 | 1 | – | 1 | – | – | – | – | 2 |
| Korea | 2 | 2 | – | – | – | – | 1 | – | 1 |
| Malasya | 2 | 1 | – | 1 | – | – | – | 1 | 1 |
| Sweden | 2 | 2 | – | – | – | 1 | – | 1 | – |
| Tailand | 2 | 2 | – | – | – | – | – | – | 2 |
| Bangladesh | 1 | 1 | – | – | – | – | – | – | 1 |
| Cyprus | 1 | 1 | – | – | – | – | – | 1 | – |
| Egypt | 1 | 1 | – | – | – | – | – | – | 1 |
| Finland | 1 | 1 | – | – | – | – | – | – | 1 |
| Japan | 1 | 1 | – | – | – | – | – | – | 1 |
| Pakistan | 1 | 1 | – | – | – | – | – | 1 | – |
| Portugal | 1 | 1 | – | – | – | – | – | – | 1 |
| Siria | 1 | 1 | – | – | – | – | – | – | 1 |
| Spain | 1 | 1 | – | – | – | 1 | – | – | – |
| United Arabian Emirates | 1 | 1 | – | – | – | – | 1 | – | – |
| | 78 | 63 | 4 | 7 | 4 | 16 | 18 | 11 | 33 |

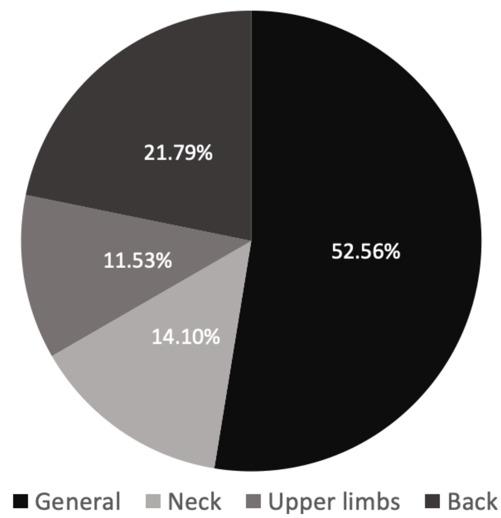



**Figure 2. Main studied anatomical site**

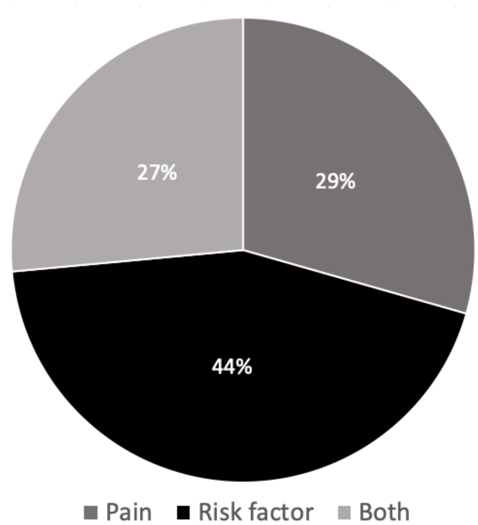



**Figure 3. Assessed variable with a validated instrument**

## 5. DISCUSSION

According to PubMed database, participation of Latin American countries on ergonomics and work-related musculoskeletal diseases is minimal. It is important to notice that many efforts from ergonomists from Latin American countries are done in the last years and it does not mean that there is no research in the field. The *Sociedad de Ergonomistas de México* (SEMAC), *Sociedad Chilena de Ergonomía*, *Asociación de Ergonomía Argentina* (ADEA), and other associations of ergonomics in Latin America, are making important efforts that have been recognized by International Ergonomic Association (IEA) (Llaneza Álvarez, 2009a). However, it is necessary to enrich the scientific literature with research based on the specific necessities in ergonomics of Latin American populations. It is important to produce more research and scientific knowledge, aligned to international scientific methodology standards that make them available on databases of wider scope. In the other hand, this work was based only in PubMed database, but many other databases like Scopus, Web of Science, or Science Direct, could have more research from Latin American countries. Moreover, this work was based only in the publications of the last three years. Nonetheless, the results of this work may reflect a part of the reality; a systematic review based on more databases could give a more reliable point of view about this situation.

The pain is the main clinical manifestation of the work-related musculoskeletal disorders, so this symptom can be a very important element in the assessment of the impact of ergonomics on worker health, from an integral point of view. The relevance of the showed proportions in the results lies in the fact that, all the included studies in the review considered the pain as an inherent consequence of the musculoskeletal disorders, but only a few measured it with a validated method. It could be understandable that research centered on prevention may consider the presence of pain as a fail of the preventive methods, but the only way to assure that there was not pain in the population exposed to the risk is taking a measure. The quantification can be achieved by surveys, but these surveys are not validated methods, as *Visual Analog Scale (VAS)* and *Nordic Musculoskeletal Questionnaire* are. The assessment of pain can be achieved in many ways depending of the discipline that is performing the study. NMQ is a standardized questionnaire used to compare low back, neck, shoulder and general complaints of musculoskeletal system for, and was designated for use in epidemiological studies, not for stablish a clinical diagnosis (Crawford, 2007). Nonetheless, in any case, the perception of the patient/worker is unreplaceable to have reliable quantify the pain, as VAS and other validated methods can do. For example, in the studies that physical exploration is included, a method like VAS could be necessary to make the pain measurable, instead of describing only the presence or absence of the pain; it means, provide accuracy. Other disciplines whose professional scope does not include clinical skills, could anyway measure the pain with a validated method as of the worker saying in a survey, but always with a reliable reproductible quantification of pain. When this methodology is not followed, it may be complicated to approach of the information from an integral point of view that could be applied by many disciplines, health disciplines mainly. Por example, systematic reviews and meta-analysis are very valuable scientific tools for the support of guidelines and epidemiological decisions. However, the lack of validated methods and solid assessment of the considered variables in the studies, make them a risk of bias to be included on systematic reviews. This means that the effort of the researches could result isolated to the study population, instead of being part of a bigger unified new knowledge with clinical value.

As many of the studies included in this review did, assessing the pain could give trustable information to determine if changes in the workstation design or in work environment are really required. However, all the elements that allow to achieve a better level of accuracy, reliability and reproducibility, could help to new researches to determine, in an even higher impact on worker's health, the relation between ergonomics, WRMD and pain.

## 6. REFERENCES

Al-Rawi, N. H., Yousef, H., Khamis, M., Belkadi, O., Ahmed, S., & Ali, S. (2018). Vertebral Malalignment among Male Dentists with Work-related Musculoskeletal Pain in the United Arab Emirates. *The Journal of Contemporary Dental Practice*, *19*(7), 773–777.

Alyahya, F., Algarzaie, K., Alsubeh, Y., & Khounganian, R. (2018). Awareness of ergonomics & work-related musculoskeletal disorders among dental professionals and students in Riyadh, Saudi Arabia. *Journal of Physical Therapy Science*, *30*(6), 770–776. https://doi.org/10.1589/jpts.30.770

Bao, S., & Lin, J.-H. (2018). An investigation into four different sit-stand workstation use schedules. *Ergonomics*, *61*(2), 243–254. https://doi.org/10.1080/00140139.2017.1353139

Barros-Gomes, S., Orme, N., Nhola, L. F., Scott, C., Helfinstine, K., Pislaru, S. V, … Pellikka, P. A. (2019). Characteristics and Consequences of Work-Related Musculoskeletal Pain among Cardiac Sonographers Compared with Peer Employees: A Multisite Cross-Sectional Study. *Journal of the American Society of Echocardiography: Official Publication of the American Society of Echocardiography*, *32*(9), 1138–1146. https://doi.org/10.1016/j.echo.2019.04.416

Benjamin, J. L., & Meisinger, Q. C. (2018). Ergonomics in the Development and Prevention of Musculoskeletal Injury in Interventional Radiologists. *Techniques in Vascular and Interventional Radiology*, *21*(1), 16–20. https://doi.org/10.1053/j.tvir.2017.12.004

Besharati, A., Daneshmandi, H., Zareh, K., Fakherpour, A., & Zoaktafi, M. (2018). Work-related musculoskeletal problems and associated factors among office workers. *International Journal of Occupational Safety and Ergonomics: JOSE*, 1–7. https://doi.org/10.1080/10803548.2018.1501238

Botta, A. C., Presoto, C. D., Wajngarten, D., Campos, J. A. D. B., & Garcia, P. P. N. S. (2018). Perception of dental students on risk factors of musculoskeletal disorders. *European Journal of Dental Education: Official Journal of the Association for Dental Education in Europe*, *22*(4), 209–214. https://doi.org/10.1111/eje.12328

Brandt, M., Madeleine, P., Samani, A., Ajslev, J. Z., Jakobsen, M. D., Sundstrup, E., & Andersen, L. L. (2018). Effects of a Participatory Ergonomics Intervention with Wearable Technical Measurements of Physical Workload in the Construction Industry: Cluster Randomized Controlled Trial. *Journal of Medical Internet Research*, *20*(12), e10272. https://doi.org/10.2196/10272

Bulduk, E. O. (2019). Work-related stress levels and musculoskeletal disorders among municipal solid waste collectors in Ankara. *Work (Reading, Mass.)*, *63*(3), 427–433. https://doi.org/10.3233/WOR-192949

Cardenas-Trowers, O., Kjellsson, K., & Hatch, K. (2018). Ergonomics: making the

OR a comfortable place. *International Urogynecology Journal*, *29*(7), 1065–1066. https://doi.org/10.1007/s00192-018-3674-7

Catanzarite, T., Tan-Kim, J., & Menefee, S. A. (2018). Ergonomics in gynecologic surgery. *Current Opinion in Obstetrics & Gynecology*, *30*(6), 432–440. https://doi.org/10.1097/GCO.0000000000000502

Catanzarite, T., Tan-Kim, J., Whitcomb, E. L., & Menefee, S. (2018). Ergonomics in Surgery: A Review. *Female Pelvic Medicine & Reconstructive Surgery*, *24*(1), 1–12. https://doi.org/10.1097/SPV.0000000000000456

Celik, S., Celik, K., Dirimese, E., Tasdemir, N., Arik, T., & Buyukkara, I. (2018). Determination of pain in musculoskeletal system reported by office workers and the pain risk factors. *International Journal of Occupational Medicine and Environmental Health*, *31*(1), 91–111. https://doi.org/10.13075/ijomeh.1896.00901

Centers for Disease Control and Prevention. (2020). Work-Related Musculoskeletal Disorders & Ergonomics | Workplace Health Strategies by Condition | Workplace Health Promotion | CDC.

Chatterjee, A., & Sahu, S. (2018). A physiological exploration on operational stance and occupational musculoskeletal problem manifestations amongst construction labourers of West Bengal, India. *Journal of Back and Musculoskeletal Rehabilitation*, *31*(4), 775–783. https://doi.org/10.3233/BMR-170935

Comper, M. L. C., Dennerlein, J. T., Evangelista, G. D. S., Rodrigues da Silva, P., & Padula, R. S. (2017). Effectiveness of job rotation for preventing work-related musculoskeletal diseases: a cluster randomised controlled trial. *Occupational and Environmental Medicine*, *74*(8), 545–552. https://doi.org/10.1136/oemed-2016-104077

Coskun Beyan, A., Demiral, Y., Dilek, B., Alici, N. S., Bediz, C., & Cimrin, A. (2018, enero). Skydiving and the risk of cervical disc herniation. *International Journal of Occupational Medicine and Environmental Health*. Poland. https://doi.org/10.13075/ijomeh.1896.01032

Dabholkar, T., Yardi, S., Dabholkar, Y. G., Velankar, H. K., & Ghuge, G. (2017). A Survey of Work-Related Musculoskeletal Disorders Among Otolaryngologists. *Indian Journal of Otolaryngology and Head and Neck Surgery: Official Publication of the Association of Otolaryngologists of India*, *69*(2), 230–238. https://doi.org/10.1007/s12070-017-1106-5

Dalager, T., Hojmark, A., Jensen, P. T., Sogaard, K., & Andersen, L. N. (2019). Using an intervention mapping approach to develop prevention and rehabilitation strategies for musculoskeletal pain among surgeons. *BMC Public Health*, *19*(1), 320. https://doi.org/10.1186/s12889-019-6625-4

Davila, V. J., Meltzer, A. J., Hallbeck, M. S., Stone, W. M., & Money, S. R. (2019). Physical discomfort, professional satisfaction, and burnout in vascular surgeons. *Journal of Vascular Surgery*, *70*(3), 913-920.e2. https://doi.org/10.1016/j.jvs.2018.11.026

De Sio, S., Traversini, V., Rinaldo, F., Colasanti, V., Buomprisco, G., Perri, R., … Guerra, F. (2018). Ergonomic risk and preventive measures of musculoskeletal disorders in the dentistry environment: an umbrella review. *PeerJ*, *6*, e4154.

https://doi.org/10.7717/peerj.4154
Depreli, O., & Angin, E. (2018). Review of scapular movement disorders among office workers having ergonomic risk. *Journal of Back and Musculoskeletal Rehabilitation*, *31*(2), 371–380. https://doi.org/10.3233/BMR-170790
Dianat, I., Bazazan, A., Souraki Azad, M. A., & Salimi, S. S. (2018). Work-related physical, psychosocial and individual factors associated with musculoskeletal symptoms among surgeons: Implications for ergonomic interventions. *Applied Ergonomics*, *67*, 115–124. https://doi.org/10.1016/j.apergo.2017.09.011
Epstein, S., Sparer, E. H., Tran, B. N., Ruan, Q. Z., Dennerlein, J. T., Singhal, D., & Lee, B. T. (2018). Prevalence of Work-Related Musculoskeletal Disorders Among Surgeons and Interventionalists: A Systematic Review and Meta-analysis. *JAMA Surgery*, *153*(2), e174947. https://doi.org/10.1001/jamasurg.2017.4947
Ergan, M., Baskurt, F., & Baskurt, Z. (2017). The examination of work-related musculoskeletal discomforts and risk factors in veterinarians. *Arhiv Za Higijenu Rada i Toksikologiju*, *68*(3), 198–205. https://doi.org/10.1515/aiht-2017-68-3011
Fernandez de Grado, G., Denni, J., Musset, A.-M., & Offner, D. (2019). Back pain prevalence, intensity and associated factors in French dentists: a national study among 1004 professionals. *European Spine Journal: Official Publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society*, *28*(11), 2510–2516. https://doi.org/10.1007/s00586-019-06080-4
Fiodorenko-Dumas, Z., Kurkowska, A., & Paprocka-Borowicz, M. (2018). Spine pain in the firefighter profession. *Medycyna Pracy*, *69*(4), 365–373. https://doi.org/10.13075/mp.5893.00679
Giagio, S., Volpe, G., Pillastrini, P., Gasparre, G., Frizziero, A., & Squizzato, F. (2019). A Preventive Program for Work-related Musculoskeletal Disorders Among Surgeons: Outcomes of a Randomized Controlled Clinical Trial. *Annals of Surgery*, *270*(6), 969–975. https://doi.org/10.1097/SLA.0000000000003199
Grewal, A., Kataria, H., & Dhawan, I. (2016). Literature search for research planning and identification of research problem. *Indian Journal of Anaesthesia*, *60*(9), 635–639. https://doi.org/10.4103/0019-5049.190618
Habib, R. R., Ziadee, M., Abi Younes, E., & Harastani, H. (2020). Syrian refugee child workers: Gender differences in ergonomic exposures and musculoskeletal health. *Applied Ergonomics*, *83*, 102983. https://doi.org/10.1016/j.apergo.2019.102983
Hakim, S., & Mohsen, A. (2017). Work-related and ergonomic risk factors associated with low back pain among bus drivers. *The Journal of the Egyptian Public Health Association*, *92*(3), 195–201. https://doi.org/7.10.21608/EPX.2018.16153
Hallbeck, M. S., Lowndes, B. R., Bingener, J., Abdelrahman, A. M., Yu, D., Bartley, A., & Park, A. E. (2017). The impact of intraoperative microbreaks with exercises on surgeons: A multi-center cohort study. *Applied Ergonomics*, *60*, 334–341. https://doi.org/10.1016/j.apergo.2016.12.006
Hernandez, A. M., & Peterson, A. L. (2012). Work-Related Musculoskeletal Disorders and Pain. En R. J. Gatchel & I. Z. Schultz (Eds.), *Handbook of*

*Occupational Health and Wellness* (1a ed., pp. 63–86). New York: Springer. https://doi.org/10.1007/978-1-4614-4839-6

Hoe, V. C., Urquhart, D. M., Kelsall, H. L., Zamri, E. N., & Sim, M. R. (2018). Ergonomic interventions for preventing work-related musculoskeletal disorders of the upper limb and neck among office workers. *The Cochrane Database of Systematic Reviews*, *10*, CD008570. https://doi.org/10.1002/14651858.CD008570.pub3

Hossain, M. D., Aftab, A., Al Imam, M. H., Mahmud, I., Chowdhury, I. A., Kabir, R. I., & Sarker, M. (2018). Prevalence of work-related musculoskeletal disorders (WMSDs) and ergonomic risk assessment among readymade garment workers of Bangladesh: A cross sectional study. *PloS One*, *13*(7), e0200122. https://doi.org/10.1371/journal.pone.0200122

Howarth, A. L., Hallbeck, M. S., Lemaine, V., Singh, D. J., & Noland, S. S. (2019). Work-Related Musculoskeletal Discomfort and Injury in Craniofacial and Maxillofacial Surgeons. *The Journal of Craniofacial Surgery*, *30*(7), 1982–1985. https://doi.org/10.1097/SCS.0000000000005631

Howarth, A. L., Hallbeck, S., Mahabir, R. C., Lemaine, V., Evans, G. R. D., & Noland, S. S. (2019). Work-Related Musculoskeletal Discomfort and Injury in Microsurgeons. *Journal of Reconstructive Microsurgery*, *35*(5), 322–328. https://doi.org/10.1055/s-0038-1675177

Hulshof, C. T. J., Colosio, C., Daams, J. G., Ivanov, I. D., Prakash, K. C., Kuijer, P. P. F. M., … Frings-Dresen, M. H. W. (2019). WHO/ILO work-related burden of disease and injury: Protocol for systematic reviews of exposure to occupational ergonomic risk factors and of the effect of exposure to occupational ergonomic risk factors on osteoarthritis of hip or knee and selected other musculoskeletal diseases. *Environment International*, *125*(December 2018), 554–566. https://doi.org/10.1016/j.envint.2018.09.053

International Labour Organization. (2013). *The Prevention of Occupational Diseases*. *World Day for safety and health at work.* Switzerland. Recuperado de https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_208226.pdf

Intranuovo, G., De Maria, L., Facchini, F., Giustiniano, A., Caputi, A., Birtolo, F., & Vimercati, L. (2019). Risk assessment of upper limbs repetitive movements in a fish industry. *BMC Research Notes*, *12*(1), 354. https://doi.org/10.1186/s13104-019-4392-z

Januario, L. B., Madeleine, P., Cid, M. M., Samani, A., & Oliveira, A. B. (2018). Can exposure variation be promoted in the shoulder girdle muscles by modifying work pace and inserting pauses during simulated assembly work? *Applied Ergonomics*, *66*, 151–160. https://doi.org/10.1016/j.apergo.2017.08.011

Januario, L. B., Oliveira, A. B., Cid, M. M., Madeleine, P., & Samani, A. (2017). The coordination of shoulder girdle muscles during repetitive arm movements at either slow or fast pace among women with or without neck-shoulder pain. *Human Movement Science*, *55*, 287–295. https://doi.org/10.1016/j.humov.2017.09.002

Jeong, Y.-J., & Choi, J.-S. (2020). The effect of indirect vision skills on head and shoulder posture amongst Korean dental hygienists. *European Journal of*

*Dental Education: Official Journal of the Association for Dental Education in Europe*, *24*(1), 17–25. https://doi.org/10.1111/eje.12463

Jiménez Ávila, J. M. (2015). Tipos de publicaciones científicas. *Orthotips*, *11*(2), 58–67. Recuperado de https://www.medigraphic.com/pdfs/orthotips/ot-2015/ot152b.pdf%0Ahttp://www.medigraphic.com/orthotips

Johnson, P. W., Zigman, M., Ibbotson, J., Dennerlein, J. T., & Kim, J. H. (2018). A Randomized Controlled Trial of a Truck Seat Intervention: Part 1-Assessment of Whole-Body Vibration Exposures. *Annals of Work Exposures and Health*, *62*(8), 990–999. https://doi.org/10.1093/annweh/wxy062

Kaup, S., Shivalli, S., Kulkarni, U., & Arunachalam, C. (2020). Ergonomic practices and musculoskeletal disorders among ophthalmologists in India: An online appraisal. *European Journal of Ophthalmology*, *30*(1), 196–200. https://doi.org/10.1177/1120672118815107

Kee, D., & Haslam, R. (2019). Prevalence of work-related musculoskeletal disorders in agriculture workers in Korea and preventative interventions. *Work (Reading, Mass.)*, *64*(4), 763–775. https://doi.org/10.3233/WOR-193038

Koni, A., Kufersin, M., Ronchese, F., Travan, M., Cadenaro, M., & Larese Filon, F. (2018). Approach to prevention of musculoskeletal symptoms in dental students: an interventional study. *La Medicina Del Lavoro*, *109*(4), 276–284. https://doi.org/10.23749/mdl.v109i4.6841

Laal, F., Mirzaei, R., Behdani, M. S., Mohammadi, M., & Khodami, K. (2017). Evaluation of the influence of ergonomic intervention on the musculoskeletal disorders of Zahedan tailors. *International Journal of Occupational Safety and Ergonomics: JOSE*, *23*(3), 380–385. https://doi.org/10.1080/10803548.2016.1233674

Labao, H. C., Faller, E. M., & Bacayo, M. F. D. (2018). "Aches and Pains" of Filipino Migrant Workers in Malaysia: A Profile of Work-Related Musculoskeletal Disorders. *Annals of Global Health*, *84*(3), 474–480. https://doi.org/10.29024/aogh.2331

Lallukka, T., Hiilamo, A., Oakman, J., Manty, M., Pietilainen, O., Rahkonen, O., … Halonen, J. I. (2019). Recurrent pain and work disability: a record linkage study. *International Archives of Occupational and Environmental Health*. https://doi.org/10.1007/s00420-019-01494-5

Lin, M. Y., Barbir, A., & Dennerlein, J. T. (2017). Evaluating biomechanics of user-selected sitting and standing computer workstation. *Applied Ergonomics*, *65*, 382–388. https://doi.org/10.1016/j.apergo.2017.04.006

Lind, C. M., Forsman, M., & Rose, L. M. (2020). Development and evaluation of RAMP II - a practitioner's tool for assessing musculoskeletal disorder risk factors in industrial manual handling. *Ergonomics*, 1–28. https://doi.org/10.1080/00140139.2019.1710576

Liu, Y. M., Xiao, L. W., Zhou, H., Xie, C. J., Huang, L. L., & Liu, Y. M. (2019). [An analysis of work-related musculoskeletal disorders and ergonomic loads in male welders in shipbuilding industry]. *Zhonghua lao dong wei sheng zhi ye bing za zhi = Zhonghua laodong weisheng zhiyebing zazhi = Chinese journal of industrial hygiene and occupational diseases*, *37*(3), 201–206. https://doi.org/10.3760/cma.j.issn.1001-9391.2019.03.009

Llaneza Álvarez, F. J. (2009a). Ergonomía y Psicosociología Aplicada. En F. J. Llaneza Álvarez (Ed.), *Ergonomía y Psicosociología Aplicada. Manual para la formación del especialista* (15a ed., pp. 27–107). Valladolid, España.: Lex Nova.

Llaneza Álvarez, F. J. (2009b). La ergonomía en la gestión de las organizaciones. En F. J. Llaneza Álvarez (Ed.), *Ergonomía y Psicosociología Aplicada. Manual para la formación del especialista* (15a ed., pp. 355–406). Valladolid, España.: Lex Nova.

Lobo, D., Gandarillas, M. A., Sanchez-Gomez, S., & Megia, R. (2019). Work-related musculoskeletal symptoms in otorhinolaryngology and their relationship with physical activity. A nationwide survey. *The Journal of Laryngology and Otology*, *133*(8), 713–718. https://doi.org/10.1017/S0022215119001452

Luger, T., Maher, C. G., Rieger, M. A., & Steinhilber, B. (2019). Work-break schedules for preventing musculoskeletal symptoms and disorders in healthy workers. *The Cochrane Database of Systematic Reviews*, *7*, CD012886. https://doi.org/10.1002/14651858.CD012886.pub2

Makishima, M., Fujino, Y., Kubo, T., Izumi, H., Uehara, M., Oyama, I., & Matsuda, S. (2018). Validity and responsiveness of the work functioning impairment scale (WFun) in workers with pain due to musculoskeletal disorders. *Journal of Occupational Health*, *60*(2), 156–162. https://doi.org/10.1539/joh.17-0166-OA

Meisha, D. E., Alsharqawi, N. S., Samarah, A. A., & Al-Ghamdi, M. Y. (2019). Prevalence of work-related musculoskeletal disorders and ergonomic practice among dentists in Jeddah, Saudi Arabia. *Clinical, Cosmetic and Investigational Dentistry*, *11*, 171–179. https://doi.org/10.2147/CCIDE.S204433

Minghelli, B., Ettro, N., Simao, J., & Mauricio, K. (2019). Work-related self-reported musculoskeletal disorders in hypermarket cashiers: a study in south of Portugal. *La Medicina Del Lavoro*, *110*(3), 191–201. https://doi.org/10.23749/mdl.v110i3.7771

Mulimani, P., Hoe, V. C., Hayes, M. J., Idiculla, J. J., Abas, A. B., & Karanth, L. (2018). Ergonomic interventions for preventing musculoskeletal disorders in dental care practitioners. *The Cochrane Database of Systematic Reviews*, *10*, CD011261. https://doi.org/10.1002/14651858.CD011261.pub2

Noble, N. L., & Sweeney, N. L. (2018). Barriers to the Use of Assistive Devices in Patient Handling. *Workplace Health & Safety*, *66*(1), 41–48. https://doi.org/10.1177/2165079917697216

Nourollahi, M., Afshari, D., & Dianat, I. (2018). Awkward trunk postures and their relationship with low back pain in hospital nurses. *Work (Reading, Mass.)*, *59*(3), 317–323. https://doi.org/10.3233/WOR-182683

Oakman, J., de Wind, A., van den Heuvel, S. G., & van der Beek, A. J. (2017). Work characteristics predict the development of multi-site musculoskeletal pain. *International Archives of Occupational and Environmental Health*, *90*(7), 653–661. https://doi.org/10.1007/s00420-017-1228-9

Obregón Sánchez, M. G. (2016). Generalidades. En J. E. Callejas (Ed.), *Fundamentos de ergonomía* (1a ed., pp. 1–32). Ciudad de México: Grupo Editorial Patria.

Pandalai, S. P., Wheeler, M. W., & Lu, M.-L. (2017). Non-chemical Risk Assessment for Lifting and Low Back Pain Based on Bayesian Threshold Models. *Safety and Health at Work*, *8*(2), 206–211. https://doi.org/10.1016/j.shaw.2016.10.001

Penkala, S., El-Debal, H., & Coxon, K. (2018). Work-related musculoskeletal problems related to laboratory training in university medical science students: a cross sectional survey. *BMC Public Health*, *18*(1), 1208. https://doi.org/10.1186/s12889-018-6125-y

Pereira, M. J., Johnston, V., Straker, L. M., Sjogaard, G., Melloh, M., O'Leary, S. P., & Comans, T. A. (2017). An Investigation of Self-reported Health-related Productivity Loss in Office Workers and Associations with Individual and Work-related Factors Using an Employer's Perspective. *Journal of Occupational and Environmental Medicine*, *59*(7), e138–e144. https://doi.org/10.1097/JOM.0000000000001043

Petit, A., Bodin, J., Delarue, A., D'Escatha, A., Fouquet, N., & Roquelaure, Y. (2018). Risk factors for episodic neck pain in workers: a 5-year prospective study of a general working population. *International Archives of Occupational and Environmental Health*, *91*(3), 251–261. https://doi.org/10.1007/s00420-017-1272-5

Prasad, D. A., Appachu, D., Kamath, V., & Prasad, D. K. (2017). Prevalence of low back pain and carpal tunnel syndrome among dental practitioners in Dakshina Kannada and Coorg District. *Indian Journal of Dental Research: Official Publication of Indian Society for Dental Research*, *28*(2), 126–132. https://doi.org/10.4103/ijdr.IJDR_672_16

Rasim Ul Hasanat, M., Ali, S. S., Rasheed, A., & Khan, M. (2017). Frequency and associated risk factors for neck pain among software engineers in Karachi, Pakistan. *JPMA. The Journal of the Pakistan Medical Association*, *67*(7), 1009–1012.

Rasmussen, C. D. N., Hendriksen, P. R., Svendsen, M. J., Ekner, D., Hansen, K., Sorensen, O. H., … Holtermann, A. (2018). Improving work for the body - a participatory ergonomic intervention aiming at reducing physical exertion and musculoskeletal pain among childcare workers (the TOY-project): study protocol for a wait-list cluster-randomized controlled trial. *Trials*, *19*(1), 411. https://doi.org/10.1186/s13063-018-2788-z

Sanaeinasab, H., Saffari, M., Valipour, F., Alipour, H. R., Sepandi, M., Al Zaben, F., & Koenig, H. G. (2018). The effectiveness of a model-based health education intervention to improve ergonomic posture in office computer workers: a randomized controlled trial. *International Archives of Occupational and Environmental Health*, *91*(8), 951–962. https://doi.org/10.1007/s00420-018-1336-1

Schmalz, T., Schandlinger, J., Schuler, M., Bornmann, J., Schirrmeister, B., Kannenberg, A., & Ernst, M. (2019). Biomechanical and Metabolic Effectiveness of an Industrial Exoskeleton for Overhead Work. *International Journal of Environmental Research and Public Health*, *16*(23). https://doi.org/10.3390/ijerph16234792

Singh, H., & Singh, L. P. (2019). Musculoskeletal disorders among insurance office employees: A case study. *Work (Reading, Mass.)*, *64*(1), 153–160. https://doi.org/10.3233/WOR-192978

So, B. C. L., Szeto, G. P. Y., Lau, R. W. L., Dai, J., & Tsang, S. M. H. (2019). Effects of Ergomotor Intervention on Improving Occupational Health in Workers with Work-Related Neck-Shoulder Pain. *International Journal of Environmental Research and Public Health*, *16*(24). https://doi.org/10.3390/ijerph16245005

Szczygiel, E., Zielonka, K., Metel, S., & Golec, J. (2017). Musculo-skeletal and pulmonary effects of sitting position - a systematic review. *Annals of Agricultural and Environmental Medicine: AAEM*, *24*(1), 8–12. https://doi.org/10.5604/12321966.1227647

Thetkathuek, A., & Meepradit, P. (2018). Work-related musculoskeletal disorders among workers in an MDF furniture factory in eastern Thailand. *International Journal of Occupational Safety and Ergonomics: JOSE*, *24*(2), 207–217. https://doi.org/10.1080/10803548.2016.1257765

Tirloni, A. S., Reis, D. C. Dos, Borgatto, A. F., & Moro, A. R. P. (2019). Association between perception of bodily discomfort and individual and work organisational factors in Brazilian slaughterhouse workers: a cross-sectional study. *BMJ Open*, *9*(2), e022824. https://doi.org/10.1136/bmjopen-2018-022824

Tsang, S. M. H., So, B. C. L., Lau, R. W. L., Dai, J., & Szeto, G. P. Y. (2018). Effects of combining ergonomic interventions and motor control exercises on muscle activity and kinematics in people with work-related neck-shoulder pain. *European Journal of Applied Physiology*, *118*(4), 751–765. https://doi.org/10.1007/s00421-018-3802-6

Umer, W., Antwi-Afari, M. F., Li, H., Szeto, G. P. Y., & Wong, A. Y. L. (2018). The prevalence of musculoskeletal symptoms in the construction industry: a systematic review and meta-analysis. *International Archives of Occupational and Environmental Health*, *91*(2), 125–144. https://doi.org/10.1007/s00420-017-1273-4

Vaisbuch, Y., Aaron, K. A., Moore, J. M., Vaughan, J., Ma, Y., Gupta, R., & Jackler, R. K. (2019). Ergonomic hazards in otolaryngology. *The Laryngoscope*, *129*(2), 370–376. https://doi.org/10.1002/lary.27496

Wareluk, P., & Jakubowski, W. (2017). Evaluation of musculoskeletal symptoms among physicians performing ultrasound. *Journal of Ultrasonography*, *17*(70), 154–159. https://doi.org/10.15557/JoU.2017.0023

Wells, A. C., Kjellman, M., Harper, S. J. F., Forsman, M., & Hallbeck, M. S. (2019). Operating hurts: a study of EAES surgeons. *Surgical Endoscopy*, *33*(3), 933–940. https://doi.org/10.1007/s00464-018-6574-5

Westgaard, R. H., & Winkel, J. (1997). Ergonomic intervention research for improved musculoskeletal health: A critical review. *International Journal of Industrial Ergonomics*, *20*(6), 463–500. https://doi.org/10.1016/S0169-8141(96)00076-5

Yan, P., Zhang, L., Li, F. Y., Yang, Y., Wang, Y. N., Huang, A. M., … Yao, H. (2017). [Evaluation of ergonomic load of clinical nursing procedures]. *Zhonghua lao dong wei sheng zhi ye bing za zhi = Zhonghua laodong weisheng zhiyebing zazhi = Chinese journal of industrial hygiene and occupational diseases*, *35*(8), 581–584. https://doi.org/10.3760/cma.j.issn.1001-9391.2017.08.006

Zafar, H., & Almosa, N. (2019). Prevalence of Work-related Musculoskeletal Disorders among Dental Students of King Saud University, Riyadh, Kingdom of Saudi Arabia. *The Journal of Contemporary Dental Practice*, *20*(4), 449–453.

# ERGONOMIC ASSESSMENT OF LOADING AND PUSH IN DONUT PREPARATION AREA IN A BAKERY

**Flor Castro Carrillo[1], Iris Yareth Neyoy López[1], Andrea Jemillette Ortiz Cardenas[1], Rigoberto Zamora Alarcón[1], Acela Castillón Barraza[2]**

[1]Departamento de Ingeniería Industrial
Instituto Tecnológico de Mexicali
Av. Instituto Tecnológico s/n Plutarco Elías Calles 21376
Mexicali, B. C, México.

[2]Ingeniería Industrial/Mecánica
Instituto Tecnológico de Mexicali/ Universidad Autónoma de Baja California
Av. Instituto Tecnológico s/n, Plutarco Elías Calles / Calle Normal s/n Blvd. Benito Juárez Col. Insurgentes Este
Mexicali, Baja California, C.P. 21100
mczamora02@yahoo.com.mx

**Resumen**: Este proyecto está enfocado en analizar ergonómicamente el método actual que se aplica para la carga y empuje del estante móvil en una empresa de elaboración de donas, usando la metodología de las Normas Mexicanas, específicamente la NOM-036-1-STPS-2018, con la finalidad de mejorar su área y equipo de trabajo para evitar y prevenir lesiones futuras por el mal manejo de equipo, además de la disposición de la Secretaría del Trabajo y Prevención Social sobre la aplicación de la norma en todos los establecimiento, para lo cual en este trabajo se realizó la aplicación de análisis ergonómicos para la evaluación de las actividades como de carga de charolas y empuje de estante móvil para traslado de donas, específicamente, en el área de freidora, en esta área lleva acabo el freído de donas que serán trasladadas a otra área para ser terminadas. Proponiendo la mejora del proceso mediante los resultados obtenidos reduciendo el nivel de riesgo que puede generar lesiones en los trabajadores que repercute en incapacidades, rotación de personal brindándoles mejores condiciones de trabajo y calidad de vida.

**Palabras clave**: Panadería, norma mexicana, NOM-036-1-STPS-2018, RAPP, WERA

**Relevancia para la ergonomía**: La aplicación de las normas mexicanas, las validaciones ergonómicas, el dimensionamiento de estaciones y operadores, así como las herramientas de mejora continua, permiten validar y mejorar las estaciones para confort de los operadores al verlo como un sistema de mejoramiento para la ergonomía.

**Abstract:** This project is focused on ergonomically analyzing the current method that is applied for the loading and thrust of the mobile shelf in a doughnut processing

company, using the methodology of the Mexican Standards, specifically the NOM-036-1-STPS-2018, with the to improve its area and work team to prevent and prevent future injuries from poor equipment management, in addition to the provision of the Secretariat of Labour and Social Prevention on the application of the standard in all establishments.

In this work the application of ergonomic analysis was carried out for the evaluation of activities such as loading trays and pushing mobile shelf for transfer of doughnuts, specifically, in the frying area, in this area carries out the frying of doughnuts that will be moved to another area to be completed. Proposing the improvement of the process through the results obtained reducing the level of risk that can generate injuries to workers that has an impact on disabilities, turnover of staff giving them better working conditions and quality of life.

**Keywords**: Bakery, Mexican standard, NOM-036-1-STPS-2018, RAPP, WERA

**Relevance to ergonomics**: The application of Mexican standards, ergonomic validations, the sizing of stations and operators, as well as the tools of continuous improvement, allow to validate and improve the stations for thr comfort of the operators seeing it as an improvement system for ergonomics

## 1. INTRODUCTION

This project of loading trays and push of mobile shelf for transfer of doughnuts supported in ergonomics takes place inside a bakery in the frying area, in this area is carried out the frying of doughnuts that will be moved to another area to be finished.

This project was chosen for the ways that the process is carried out, an ergonomic study was carried out to a bakery worker in order to improve the worker's postures in the loading process and pushes from the mobile shelves to provide greater comfort and safety for the worker who performs it.

As it was said, the project is focused on ergonomically analyzing the current method that is applied for the loading of trays and the thrust of the mobile shelf, using the methodology of the Mexican Standards, as well as the application of ergonomic analyses for the evaluation of the afore mentioned activities.

## 2. OBJECTIVE

Reduce the levels of risks that could result in permanent or non-permanent injuries to operators by analyzing and redesign of a mobile shelf by applying an analysis of Mexican standards and ergonomic assessments, to improve worker postures in the process of loading trays and push the mobile shelf to provide greater comfort and safety for the workers, who do it.

# 3. METHODOLOGY

For the development of this Project, it started with an analysis of evaluation of a current process, with the following standards:

1. Application of Official Mexican Standards for valid physical workstation conditions NOM 011 STPS 2018 (noise), NOM 015 STPS 2011 (temperature), NOM 025 STPS 2008 (lighting), as well as those that allow to evaluate the conditions to the operator at the station of NOM 036-1 STPS 2018, NOM 035 STPS 2018
2. Analysis of station sizing and operator anthropometry.
3. Application of ergonomic analysis WERA, RAPP, OIT, NOM 036-1 STPS 2018

Subsequently, the results resulted in the proposal of the redesign of the workstation for the loading of trays and the thrust of the mobile shelf to obtain the reduction of the risk of injury in the workers performing these activities.

# 4. RESULTS

## 4.1 Evaluation of Norms Mexican Official for valid physical workstation conditions.

**In THE NOM-001-STPS-2008**, Buildings, premises, facilities and areas in the centers of work Safety conditions(STPS 2008), the following points are not complied with as the place does not have signs indicating slippery floors because of the flour or oil that is used

- 5.1: Keep the facilities of the work centers in safe condition, so that they do not pose risks (STPS 2008). Since there are unsafe areas in the workstation, the worker should be informed about this condition and work on improving them
- 5.6: Provide information to all workers for the use and conservation of the areas where they carry out their activities in the workplace, including those intended for the service of workers(STPS 2008). Courses, etc., on the conservation of areas should be held together to make them safe.
- 7.1.1: Have permanent order and cleaning in the work areas, as well as in corridors outside the buildings, parking lots and other common areas of the work center(STPS 2008) . The area should be cleaned every time you work with flour as it is left on the floor. Wash and clean utensils whenever they are finished.
- 7.1.2 The areas of production, maintenance, movement of persons and vehicles, risk, storage and service areas for workers in the workplace should be defined in such a way as to ensure that safe spaces are available. Risk areas such as the fryer.  should be delimited.

**In THE NOM-011-STP9S-2001**, Safety and hygiene conditions in work centers where noise is generated (STPS 2002).
Figure 1. It shows us the graph of the noise measurements (decibels) in the fryer area.

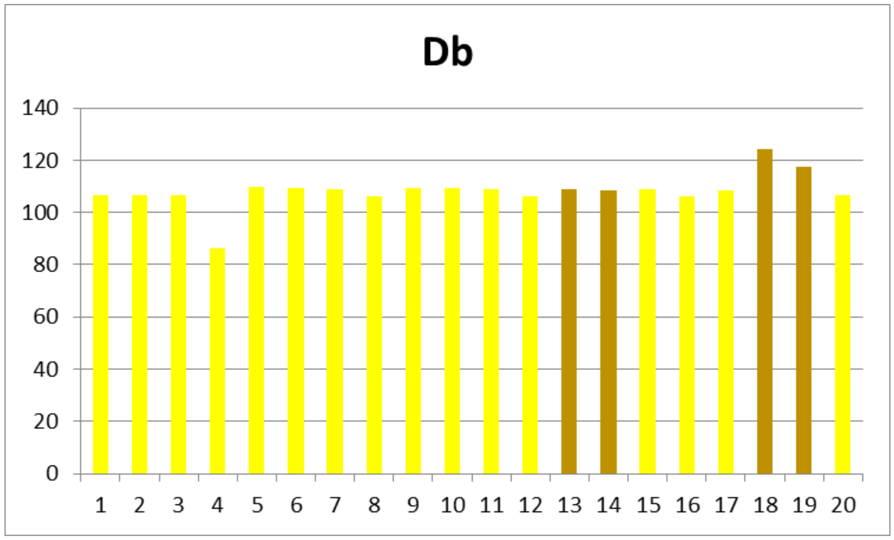



Figure 1. Noise graph

The following points are not complied with:

5.1 To show the labor authority, upon request, the documents that this Standard requires it to prepare or possess. A corrective action for this situation is to make the standard known the temperature rules and thus have the documentation and knowledge necessary for no worker to be exposed. Informing the worker as shown in Table 1 can observe the permissible limits of noise exposure.

**Table 1.** Maximum limits allowable of exposition NOM 011-STPS-2001

| **Límites máximos permitibles de exposición** | | | | | | |
|---|---|---|---|---|---|---|
| **NER** | 90 dB | 93 dB | 96 dB | 99 dB | 102 dB | 105 dB |
| **TMPE** | 8 horas | 4 horas | 2 horas | 1 horas | 30 minutos | 15 minutos |

Source: NOM 011-STPS-2001 Page

**In NOM-015-STPS-2001,** On the occasion of the exposure of workers to extreme thermal conditions high or despondent in the Workplace, the patterns should: Perform the recognition of areas and personnel occupation exposed to extreme temperatures: in the place being evaluated there is no delimited area of frying in which extreme temperatures are present. Areas of risk should be delimited and reported by extreme temperatures.

Assessing areas and occupationally exposed staff: Assessments were carried out to determine whether the temperature at which workers are exposed is adequate. As shown in Figure 2.

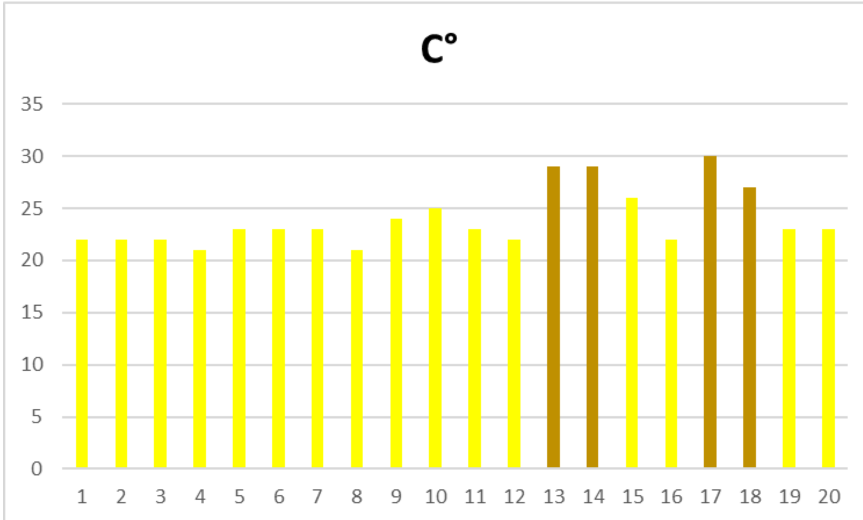



Figure 2. Temperature chart

Comparing the measured results with respect to the permissible limits of exposure to high thermal conditions as shown in Table 2. Seeing as a result that the worker is at a higher temperature exposure than allowed in the standard.

**Table 2.** Maximum permissible limits of exposure to high thermal conditions NOM 015-STPS-2001

| **Maxium temperature in C** | | | | |
|---|---|---|---|---|
| **Régimen de trabajo** | **Ligero** | 30.0 | **% deTiempo con y sin exposición** | 100% de exposición |
| | | 30.6 | | 75 % de exposición; 25% de recuperación |
| | | 31.7 | | 50 de exposición; 50% de recuperación de cada hora |
| | | 32.2 | | 25 de exposición; 75% de recuperación de cada hora |
| | **Moderado** | 26.7 | | 100% de exposición |
| | | 27.8 | | 75 % de exposición ; 25% de recuperación |
| | | 29.4 | | 50 de exposición; 50% de recuperación de cada hora |
| | | 31.1 | | 25 de exposición; 75% de recuperación de cada hora |
| | **Pesado** | 25.0 | | 100% de exposición |
| | | 25.9 | | 75 % de exposición ; 25% de recuperación |
| | | 27.8 | | 50 de exposición; 50% de recuperación de cada hora |
| | | 30.0 | | 25 de exposición; 75% de recuperación de cada hora |

Source: NOM 015-STPS-2001

**IN THE NOM-017-STPS** Official Mexican RULE NOM-017-STPS-2008, Personal Protection Equipment-Selection, Use and Management in Work Centers, indicates: "Provide of personal protective equipment to protect occupationally exposed personnel"(STPS 2008). The worker does not have special gloves or to protect himself from extreme temperatures, nor does he have the right tool to carry out his activities. Worker PPE (Personal Protective Equipment) should be provided to prevent risks when exposed to extreme temperatures.

**NOM-025-STPS-2008, Lighting conditions in work centers.**

Pursuant to NOM-025-STPS, after carrying out an assessment of the physical conditions of the site by taking lighting measures and graphing as shown in Figure 3 it was concluded that in terms of lighting the following points are not met:

- 5.1. Show the labour authority, upon request, the documents that this Standard requires it to prepare or possess(STPS 2008). The standard should be made aware of the lighting standards and thus have the documentation and knowledge necessary for an audit. Inform the worker of the risk.
- 6.1. Inform the employer of unsafe conditions, arising from lighting conditions in your area or workstation (STPS 2008).

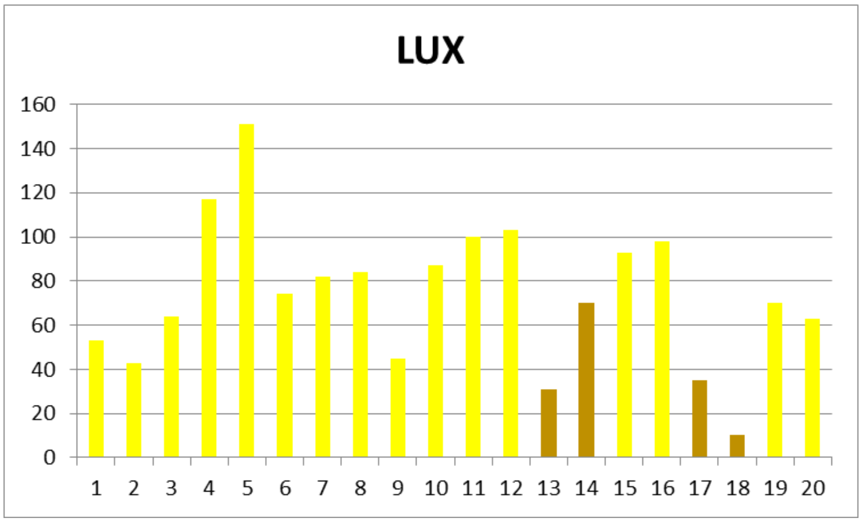



Figure 3. Lighting

## 4.2 Federal safety regulations at work

With regard to the Ergonomic Risk Factors of the Workplace, the employers shall be "I. Have an analysis of the Ergonomic Risk Factors of the jobs exposed to them: Perform an analysis and conclude if there are any ergonomic risks."
"II. Take preventive measures to mitigate the Ergonomic Risk Factors in its facilities, machinery, equipment or tools of the Work Center" (NOM 036-01-STPS), for which the company does not have manuals for the proper use of the facilities, machinery, equipment or tools in the work area so:: Adapt preventive measures to reduce risks in the worker.

"IV. Inform workers of possible health disturbances by exposure to Ergonomic Risk Factors"" (NOM 036-01-STPS). The worker does not have preventive information and makes him aware of working and using the equipment properly, this in order not to alter his health so the worker must be informed of the consequences of not applying ergonomics in the work area.

With respect to **NOM 036-1 STPS 2018**, and stimation of the risk of activities involving lifting/descending and transporting loads, it was determined that the level of risk with a score of 9 is in medium – Possible so the application of short-term corrective actions is required, as shown in Table 3.

Tasks should be examined in detail by applying a specific assessment, or control measures should be implemented through an ergonomics program me for manual load handling. As shown in Table 4

**Table 3.** Risk level estimation NOM-036-1-STPS-2018

| AI.5 Estimacion del nivel de riesgo | | | | | | |
|---|---|---|---|---|---|---|
| Factores de riesgo | Levantar | | Transportar | | Equipo | |
| | Color | Valor | Color | Valor | Color | Valor |
| Peso y ascenso de la carga | | 0 | | | | |
| Distancia horizontal entre las manos desde la parte inferior de la espalda | | 3 | | | | |
| Region de levantamiento vertical | | 1 | | | | |
| Torsion y flexion lateral del torso, carga asimetrica sobre el torso (transporte) | | 0 | | | | |
| Restricciones posturales (posturas incomodas, forzadas o restringidas) | | 0 | | | | |
| Acoplamiento mano-carga (elementos de sujesion) | | 2 | | | | |
| Superficie de trabajo | | 2 | | | | |
| Otros factores ambientales | | 1 | | | | |
| Distancia de transporte | | | | 1 | | |
| Obstaculos en la ruta (Solo en transporte) | | | | 1 | | |
| Comunicacion, coordinacion y control (solo manejo manual de cargas en equipo) | | | | | | |
| Puntuacion | 9 | | 2 | | 0 | |
| Nivel de riesgo | Medio-posible | | Bajo-Aceptable | | | |

Source: NOM-036-1-STPS-

**Table 4.** Level Risk NOM-036-1-STPS-2018

| Nivel de riesgo | | | | |
|---|---|---|---|---|
| | **Bajo a Aceptable** | **Medio a Posible** | **Alto a Significativo** | **Muy Alto - Inaceptable** |
| **Acciones** | Solo se requiere dar seguimiento a los grupos mas vulnerables, como mujeres en periodo de gestacion o trabajadores menores de edad | Se debe examinar las tareas con mayor detalle, mediante la aplicacion de una evaluacion especifica, o bien implantar medidas de control mediante un programa de ergonomia para el manejo manual de cargas | Se requiere una accion rapida, por lo que se deben establecer medidas de control mediante un programa de ergonomia para el manejo manual de cargas | Se deben detener la actividades e implementar medidas de control mediante un programa de ergonomia para el manejo manual de cargas |

Source: NOM-036-1-STPS-

Estimated the risk level of activities involving thrust or dragging of loads with the use of auxiliary equipment, determining that the risk level with a score of 19 is at High – Significant as shown in Table 5 so the application of corrective actions is required soon..

Rapid action is required, so control measures must be established through an ergonomics program for manual load handling. As Table 6 shows

**Table 5.** Risk level estimation NOM-036-1-STPS-2018

| AII.6 Estimacion del nivel de riesgo de actividades que impliquen empuje o arrastre de cargas con el uso de equipo auxiliar. | | | | | | |
|---|---|---|---|---|---|---|
| Factores de riesgo | Equipo Pequeño | | Equipo mediano | | Equipo grande | |
| | Color | Valor | Color | Valor | Color | Valor |
| Peso de la carga | | 0 | | | | |
| Postura | | 3 | | | | |
| Acoplamiento mano-carga | | 1 | | | | |
| Patron de trabajo | | 3 | | | | |
| Distancia por viaje | | 0 | | | | |
| Condicion del equipo auxiliar | | 4 | | | | |
| Superficie de trabajo | | 4 | | | | |
| Obstaculos a lo largo de la ruta | | 2 | | | | |
| Otros factores | | 2 | | | | |
| Puntuacion | | 19 | | | | |
| Nivel de riesgo | Alto significativo | | | | | |

Source: NOM 036-STPS

**Table 6.** Risk Level NOM-036-1-STPS-2018

| PRIORIDAD | NIVEL DE RIESGO | | | |
|---|---|---|---|---|
| | **Bajo a Aceptable** | **Medio a posible** | **Alto a Significativo** | **Muy Alto - Inaceptable** |
| | No se requieren acciones correctivas | Se requieren acciones correctivas a corto plazo | Se requieren acciones correctivas pronto | Se requieren acciones correctivas inmediatamente |
| **PUNTAJE TOTAL** | **0 a 4** | **5 a 12** | **13 a 20** | **21 a 32** |

Source: NOM-036-1-STPS-

## 4.3 OF STATION SIZING AND OPERATOR ANTHROPOMETRY

To carry out the dimensioning evaluation of the station, firstly, anthropometric measures were taken to the worker who works in the area, whereby was initiated with the anthropometric id as shown on the table 7.

## 4.3 Ergonomic analysis application

### WERA method

With the application of the ergonomic analysis could be observed as shown in Table 8, this gives us a total of 30 with a higher score in the area of the neck, shoulder, wrists and back this parts part of the body is being the most affected when performing this activity.

**Table 7.** Example of Anthropometric Code

| **Cédula antropométrica** | **Sexo:** Masculino |
|---|---|
| **Fecha:** 27/02/2020 | **Edad:** 32 años |
| **Nombre:** Flavio Miguel Medina Avalos | **Ocupación:** Panadería |
| **Lugar de nacimiento:** Mexicali B.C | **Nivel educativo:** Secundaria |
| **Medida antropométrica** | **Resultado** |
| **1.** Peso | 79.77 kg |
| **2.** Estatura | 174.03 cm |
| **3.** Altura al ojo | 163.94 cm |
| **4.** Altura al hombro | 146.11 cm |
| **5.** Altura al codo flexionado | 110.34 cm |
| **6.** Altura al nudillo | 68.5 cm |
| **7.** Altura a la rodilla | 53.41 cm |
| **8.** Alcance brazo frontal | 84.58 cm |
| **9.** Alcance brazo lateral | 95.2 cm |
| **10.** Profundidad de tórax | 20.1 cm |
| **12.** Alcance brazo vertical | 198.7 cm |
| **13.** Anchura máxima bideltoidea | 41.2 cm |
| **14.** Anchura del tórax | 46.6 cm |
| **15.** Anchura codo-codo | 65.2 cm |
| **16.** Anchura de la mano | 7.9 cm |
| **17.** Longitud de mano | 18.4 cm |
| **18.** Longitud de la palma de la mano | 10.3 cm |
| **19.** Diámetro de empuñadura | 4.1 cm |
| **20.** Longitud del pie | 28.1 cm |
| **21.** Anchura del pie | 10.46 cm |
| **22.** Anchura de talón | 7.8 cm |
| **33.** Perímetro de la cabeza | 15.82 cm |
| **34.** Anchura de la Cabeza | 15.82 cm |
| **35.** Profundidad de la cabeza | 21.5 cm |
| **36.** Longitud de la cara | 19 cm |

Source: Own elaboration

**Table 8.** WERA method results

| Metodo wera | |
|---|---|
| **Factor de riesgo** | **Puntuación** |
| Hombro | 4 |
| Muñecas | 4 |
| Espalda | 4 |
| Cuello | 5 |
| Piernas | 4 |
| Fuerzas | 2 |
| Vibración | 3 |
| Éstres por contacto | 2 |
| Duración de la tarea | 2 |
| TOTAL | 30 |

Source: Own elaboration

Taking into account the action level of the Wera method and Table 8 of the results of the analysis performed was compared with Table 9, corresponding to the action level of the same method.

**Table 9.** level of action of the WERA method

| Nivel de acción | | |
|---|---|---|
| **Nivel de riesgo** | **Puntuación final** | **Acción** |
| Bajo | 18-27 | La tarea es aceptable |
| Medio | 28-44 | La tarea necesita ser investigada y requerir cambios |
| Alto | 45-54 | La tarea es inaceptable y se requieron cambios inmediatos |

Source: Own elaboration

With the study of risk factors using the WERA method, it was determined that the sum of the activities with which the work is carried out is a level of average risk, i.e. activities need to be investigated and require changes in them, putting priority shoulders, wrists, back, neck, legs, as these have a high score, as shown in Tables 8 and 9.

The RAPP method was also implemented by determining the following points of its application:

- Push and drag, with 2 hands, individual, does not exceed 12 hours.
- Tool designed to help assess risks in manual push and/or drag tasks that involve the effort of the whole body, for example, mobilization of loaded forklifts, mares, pallet trucks, or drag, slide or roll loads.

- Method based mainly on observation, does not require dynamometer.

Analyzing the data in Table 10 tells us that trunk twisting and lateralization and postural restrictions mean that it needs improvement early, in case this or is improved, could expose a risk to workers.

**Table 10.** RAPP method results

| | |
|---|---|
| A. Peso manejado y frecuencia: | 1 |
| B. Distancia horizontal entre las manos y la espalda (región lumbar): | 3 |
| C. Distancia vertical | 0 |
| D. Torsión y lateralización de tronco | 2 |
| E. Restricciones posturales | 3 |
| F. Acoplamiento mano-objeto | 1 |
| G. Superficie de trabajo | 1 |
| H. Otros factores ambientales complementarios | 0 |
| **TOTAL** | **11** |

Source: Own elaboration

Observing that the point A, B, F y G correspond to a moderate risk level and corrective actions are required , although there is no high risk level, is necessary examine the task elaborately. The points D and E correspond a high risk level and require corrective actions soon, with respect a the points C and H ,it refers a low risk level and no corrective actions are required.

## 4.4 PROPPOSITE

Following the analysis of the Official Standards and the ergonomic analysis of activities, the proposal is carried out on the basis of the International Labour Office (ILO 1996),

CHECK POINT 81 Clean the windows and perform maintenance of the light sources. Cleaning and good maintenance of luminaires and windows reduces energy consumption thanks to a greater contribution of natural light and the emission of more light with less electrical power.

• Make cleaning windows and luminaires a regular part of weekly activities. Assign responsibility for cleaning to a trained person who also understands the danger of electric shock accidents.

• Ensure that maintenance personnel have adequate cleaning utensils and ladders at their disposal to reach luminaires and windows.

• Add replacement of depleted fluorescent lamps and tubes to the maintenance program. Encourage workers to inform maintenance workers about lighting problems and molten or depleted lamps.

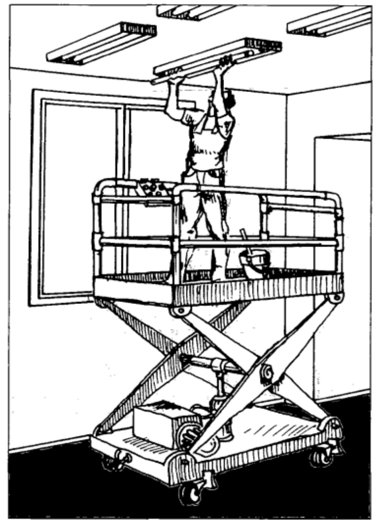


Figura 81. La limpieza de las ventanas y el buen mantenimiento de las fuentes de luz ayuda a incrementar la iluminación

Figura 4. Fuente:

CHECK POINT 82 Protect the worker from excessive heat.

In places where exposure to excessive heat is unavoidable, minimizing exposure time and wearing protective clothing can protect workers from radiant heat.

• Avoid heavy physical work for workers who are simultaneously exposed to high temperatures or strong heat radiation as shown in Figure 5. Machine such work or introduce worker rotation to reduce the duration of each worker's exposure to excessive heat.

• Increase air velocity around 1 working area using fans.

• If possible, build a small air-conditioned cab or production room within the workplace so that operators can be there for most of their working time.

• Minimize the time during which workers are exposed to high temperatures or high-intensity radiant heat (e.g., proposing the existence of an area where only the above conditions are met if absolutely necessary, or creating an area working behind a heat barrier so that it can be carried out without workers having to be exposed to excessive radiation; enabling a resting corner with good natural ventilation or fans; resorting to worker rotation or frequent breaks).

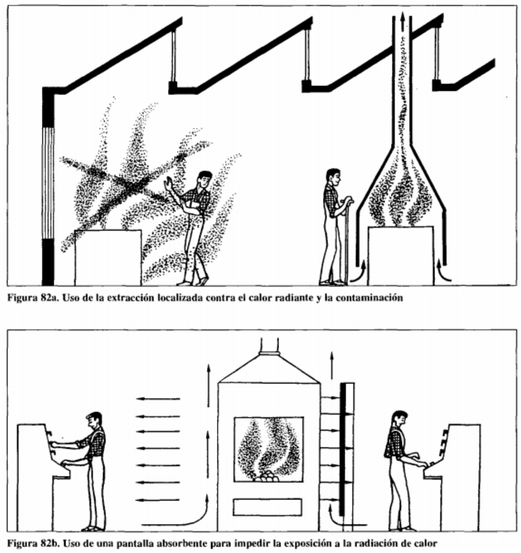



Figure 5. Source: ILO

CHECK POINT 6: Use trolleys, forklifts or other mechanisms equipped with wheels, or rollers, when moving materials with the following suggestions:

• It is important to have transport routes clear and free of obstacles at all times. Clear transport routes are essential for getting around with a car.

• Choose large diameter wheels, especially when moving materials over long distances or on uneven surfaces.

• If possible, choose rubber wheels or wheels to reduce noise, as shown in Figure 6.

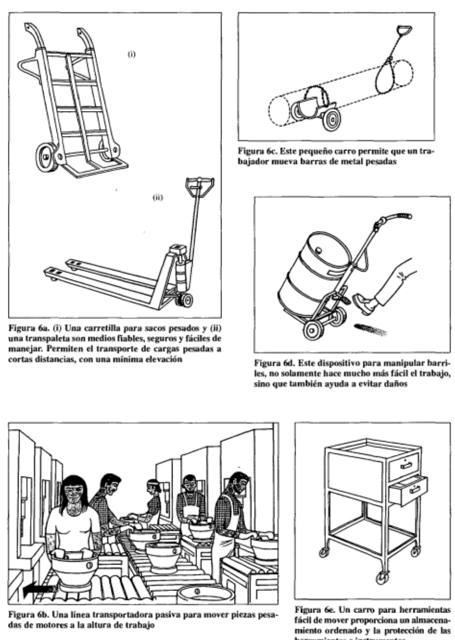



Figure 6. Source: ILO

## 5. CONCLUSIONS

In analysing the physical conditions of the site, there were points to improve in terms of lighting and temperature, as mentioned in the proposal section, these proposals will bring a benefit to workers and provide them with greater safety at the time of activity and reducing the risk of accidents.

Analyzing the mobile shelf improved operator postures in the loading process and pushed mobile shelves, providing greater comfort and safety for the worker doing so.

Finally, the objective was achieved to reduce the levels of risks that could result in permanent or non-permanent injuries to operators by analyzing and redesigning a mobile shelf by applying an analysis of Mexican standards and ergonomic assessments,

The worker's postures in the tray loading and moving shelf thrust process were improved to provide greater comfort and safety for the worker who performs it.

As regards the analysis of environmental physical measurements with respect to noise, the adaptation of reusable ear buffers for daily use was achieved and thus minimize noise exposure. On the other hand, as regards the lighting of the place the measurements were found well below those suitable for a good working condition so it was chosen to install lamps of greater luminosity and training to employees in terms of maintenance of lamps.

## 6. REFERENCES

CARLOS MARIA ABASCAL CARRANZA,, C. M. A. C. (2002a, 14 junio). NORMA Oficial Mexicana NOM-015-STPS-2001, Condiciones térmicas elevadas o abatidas-Condiciones de seguridad e higiene.. Recuperado de http://asinom.stps.gob.mx:8145/upload/noms/Nom-015.pdf

CARLOS MARIA ABASCAL CARRANZA,, C. M. A. C. (2002, 17 abril). NORMA Oficial Mexicana NOM-011-STPS-2001, Condiciones de seguridad e higiene en los centros de trabajo donde se genera ruido. Recuperado de http://www.economia-noms.gob.mx/normas/noms/2002/011stps.pdf

Ergonomic checkpoints: Practical and easy-to-implement solutions for improving safety, health and working conditions ISBN 92-2-109442-1, Ginebra, 1996

JAVIER LOZANO ALARCON,, J. L. A. (2008, 30 diciembre). NORMA Oficial Mexicana NOM-025-STPS-2008, Condiciones de iluminación en los centros de trabajo.

Recuperado de http://asinom.stps.gob.mx:8145/upload/noms/Nom-025.pdf

ROBERTO RAFAEL CAMPA CIFRIÁN, R. R. C. C. (2018, 23 octubre). NORMA Oficial Mexicana NOM-035-STPS-2018, Factores de riesgo psicosocial en el trabajo-Identificación, análisis y prevención. Recuperado de https://dof.gob.mx/nota_detalle.php?codigo=5541828&fecha=23/10/2018

ROBERTO RAFAEL CAMPA CIFRIÁN, R. R. C. C. (2018b, 23 noviembre). NORMA icial Mexicana NOM-036-1-STPS-2018, Factores de riesgo ergonómico en el Trabajo-Identificación, análisis, prevención y control. Parte 1: Manejo manual de cargas. Recuperado de http://www.diariooficial.gob.mx/nota_detalle.php?codigo=5544579&fecha=23/11/2018

# ERGONOMIC EVALUATION OF JOBS BASED ON NOM-036-1-STPS-2018

**Mauricio López Acosta*, Itzana Melo Flores, Jesús Gerardo Campoy Esquer, Allán Chacara Montes, José Manuel Velarde Cantú.**

Departamento de Ingeniería Industrial
Instituto Tecnológico de Sonora,
Ramón Corona y Aguascalientes
Navojoa, Sonora. México 85860
Corresponding author's e-mail: mauricio.lopez@itson.edu.mx

**ABSTRACT:** The present investigation was carried out in a company dedicated to the assembly of automotive harnesses, which seeks to solve the problem regarding manual handling of loads and compliance with current regulations; Aiming to evaluate and analyze jobs in accordance with the criteria of NOM-036-1-2018, in order to keep workers safe within a risk-free environment, thus complying with the regulations. All plant personnel were considered, which consists of a population of 2,971 employees, which from these, 179 were found that perform manual handling of loads located in 17 different positions that involve the manual handling of loads, which carry out a total of 38 activities. It was obtained from the risk assessment that from the 38 activities, 15 are low risk, 22 are medium risk and 1 of them are high risk. Based on these results, the ergonomics program for manual load handling was developed, in which the description of the correct technique to perform the activities of the positions in which manual load handling is performed, the control measures is presented. to be taken and prevention actions.

**KEYWORDS**: Manual handling, Risk assessments, assessment law

## 1. INTRODUCTION

Currently, industries are immersed in a continuous process of change, where they must be competitive to stay in the market, achieving not only quality products and services, but also promote the care and development of their staff,(Sibaja,2020).Due to rapid industrialization in some developing countries, worldwide, occupational accidents and diseases claim over 2.78 million lives and 374 million non-fatal work-related injuries annually, with more than 4 days of absenteeism, this situation is considered to have an economic burden of about 3.94% of the global Gross Domestic Product each year.(OIT,2019). In low and middle income countries in the Americas, 11 daily occupational ergonomic risk factors per 100,000 workers were recorded in 2004, according to the WHO (2016).

The presence or absence of risks depends largely on the process or service being performed, and the health and safety conditions in the workplace, building, equipment, tools, raw materials, products in process and finished products, (Ferre, 2009). The ILO (2019) presents records from Mexico, which show that in 2015 there were 236 cases of fatal occupational injuries in manufacturing industries and 152,133 cases of non-fatal occupational injuries in manufacturing industries. This situation for Mexico is complicated, since the data present increases in the diseases produced in the works, being the musculoskeletal diseases the most common, followed by hyperacusis.

Various communications (WHO, 2005; NOHSC, 2004; Howard, 2008; Manuele, 2008b; Creaser, 2008; Manuele, 2008a; Schulte, et al., 2008), conclude that despite significant improvements in safety and health in many parts of the world in recent decades, the global challenge of providing safety and health to workers is greater today than ever before. They further argue that significant and lasting health improvements could be achieved by emphasizing the adoption of effective primary prevention policies and programs, as well as selecting appropriate means and methods to establish controls on those identified risks and hazards that could not be eliminated during design in order to reduce their impact. For the above reasons, in order to reduce these rates, it is necessary to establish and implement appropriate measures to the right physical characteristics of the workers, analyzing all the factors present in the work area: body postures at work, continuous movement, strength, direct pressure from any part of the body, environmental risk factors and existing work organization (Ferre, 2009):, Kudo, Yamada, and lto (2019) they mention that from low back pain, environmental risk factors and the existing work organization, (Ferre, 2009); Kudo, Yamada, and Ito (2019) low back pain is one of the main occupational diseases that need to be addressed since it is considered that manual lifting of loads can increase its risk and it occurs in several occupational fields, hence the importance of elaborating this type of studies using tools for its solution such as; industrial safety and hygiene, anthropometry, biomechanics and ergonomics.

Due to the need to safeguard the life and health of workers, laws and regulations on occupational health have been formulated in order to dictate the legal norms that both employers and workers must comply with for the prevention of the various risks at work. The normative valid in México is the NOM-036-1-STPS-2018: Ergonomic risk factors in the work-Identification, analysis, prevention and control. Part 1: Manual Handling of Loads, which aims to establish the elements to identify, analyze, prevent and control ergonomic risk factors in workplaces derived from the manual handling of loads, in order to prevent alterations to the health of workers. Likewise, in order to comply with this regulation, the obligations of the workers and the employer are also established, as well as prevention measures, training and education. While it is true that there are laws, regulations and standards, as well as public institutions that are responsible for implementing actions for occupational health, the reality is that these actions are not sufficient to prevent occupational risks. To achieve this, it is necessary to have the commitment and support of workers and employers to create a culture of prevention, and thus have a healthier working environment,(Sibaja,2002).

In the company under study, starting from the premise that knowing the ergonomic conditions of the worker is fundamental to guarantee the safety and health of the workers, the evaluation of the compliance with the applicable norms for the evaluation of risks by manipulation of loads was carried out, this because the nature of the company as a manufacturer presents activities of manual handling of loads, repetitive movements and other situations of ergonomic risks, which have given rise to accidents, injuries and/or illnesses; being predominant the falls, tendinitis, lumbago, neck and shoulder pains. In view of this situation, there has been a program for 5 years to implement strategies such as staff rotation every 3 or 6 months in some of the positions where there are risks. However by the entry into force of the new regulations is questioned What is the level of ergonomic risk for manual handling load according to NOM-036-STPS?.

### Objective

Evaluate and to analyze the jobs according to the criteria of the NOM-036-1-2018, in order to keep the workers safe inside an environment free of risks, giving this way fulfillment to the regulation.

## 2. MHETODS AND MATERIALS

### Subject under Study

The subject under study is a company dedicated to the manufacture of automotive harnesses, considering all those operators whose tasks involve manual handling of loads, being a total of 179 people, located in 17 different positions, which perform a total of 38 activities involving manual handling of loads.

### Procedure

In order to achieve the objectives set out, the order of the steps to be followed is presented below:

*System characterization*

At this stage, the identification of the activities that involve ergonomic risk factors due to manual handling of loads is carried out, meaning that they must involve lifting, lowering, transporting, pushing, pulling and/or stacking materials.

*Description of the activities*

Make a description of the identified activities, involving the exposed workers, the frequency in which they perform the activity and the duration of the activities.

*Risk level estimation*

The estimation of the risk level due to manual handling of loads should be made for: a) activities that involve lifting, lowering or transporting loads and b) activities that involve pushing and pulling or dragging materials, with or without the aid of auxiliary equipment, should be considered:

1. Risk assessment of manual load handling operations with a single worker.
a) Weight of the load and frequency.
b) Horizontal distance between hands and lower back.
c) Vertical lifting region.
d) Torsion and lateral flexion of the torso
e) Postural restrictions
f) Hand-load coupling (fastening elements)
g) Work surface
h) Other environmental factors

2. Estimation of the risk of cargo transport operations.
a) Weight of the load and frequency.
b) Horizontal distance between hands and lower back.
c) Asymmetric load on the torso.
d) Postural restrictions.
e)Hand-load coupling (fastening elements)
f) Work surface.
g) Other environmental factors.
h) Transport distance.
i) Obstacles on the route.

3. Risk assessment of manual handling operations of loads in equipment.
a) Load weight.
b) Horizontal distance between hands and lower back.
c) Vertical lifting region.
d) Torsion and lateral bending of the torso
e) Postural restrictions
f) Hand-load coupling (fastening elements)
g) Work surface
h) Other environmental factors
i) Communication, coordination and control.

4. In case of activities that involve pushing or pulling loads without the use of auxiliary equipment, perform the risk assessment considering:
a) Activity and weight of the load (kg)
b) Posture
c) Hand-load coupling
d) Work pattern
e) Distance per trip
f) Work surface
g) Obstacles along the route
h) Other factors

5. In case of activities that involve pushing or pulling loads with the use of auxiliary equipment, perform the risk assessment considering:
a) Type of auxiliary equipment and weight of the load (kg)
b) Posture
c) Hand-load coupling
d) Work pattern
e) Distance per trip
f) Condition of auxiliary equipment
g) Work surface
h) Obstacles along the route
i) Other factors

For any type of activity you should:

a) Register the color and value obtained in each of the factors analyzed for each type of activity.
b) Determine the risk level.
c) Define the actions, according to the level of risk obtained.

**Materials**

For the purposes of this research, it is necessary to have ergonomic database files of the work stations, MAC method evaluation formats and NOM-036-1-STPS-2018.

## 3. RESULTS AND DISCUSSIONS

The characterization of the work stations and the analysis of the activities allowed us to identify that of the total number of existing stations in the plant, there are 17 stations that present ergonomic risk factors due to manual handling of loads, that is, that involve lifting, lowering, transporting, pushing, pulling and/or stowing materials. In table 1, an example of the evaluation of the risk level for an activity is presented. This same exercise was carried out for all the activities of the analyzed posts.

Table 1. Evaluation of the risk level of manual loading of the Material Receiving Station

| **AREA:** | **1** | | | | | |
|---|---|---|---|---|---|---|
| **WORK:** | **Material Receiving (task 1)** | | | | | |
| **Risk Factors** | **Levantar** | | **Transportar** | | **Equipo** | |
| | **Color** | **Value** | **Color** | **Value** | **Color** | **Value** |
| Load weight and load lifting/frequency of transport | Orange | 4 | - | - | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Horizontal distance between the hands from the lower back | Orange | 3 | - | - | - | - |
| Vertical lift región | Red | 3 | - | - | - | - |
| Torsion and lateral bending of the torso; Asymmetrical load on the torso (transport) | Orange | 1 | - | - | - | - |
| Postural restrictions (uncomfortable, forced, or restricted postures) | Green | 0 | - | - | - | - |
| Hand-load coupling (clamping elements) | Green | 1 | - | - | - | - |
| Work Surface | Green | 0 | - | - | - | - |
| Other environmental factors | Green | 0 | - | - | - | - |
| Transport distance | - | - | - | - | - | - |
| Obstacles in the route (only in transport) | - | - | - | - | - | - |
| Communication, coordination and control (only manual handling of loads in equipment) | - | - | - | - | - | - |
| SCORING | 12 | | - | | - | |
| LEVEL OF RISK | POSSIBLE MEDIUM | | - | | - | |

Figure 1 shows a summary of the results of activities involving lifting, lowering or transporting loads

After the analysis of these activities, they were detected:

- 8 low acceptable risk activities
- 12 Medium-Possible risk activities
- 1 high-significant risk activity

Figure 2 shows the summary results of activities that involve pushing and pulling or dragging materials without the aid of auxiliary equipment.

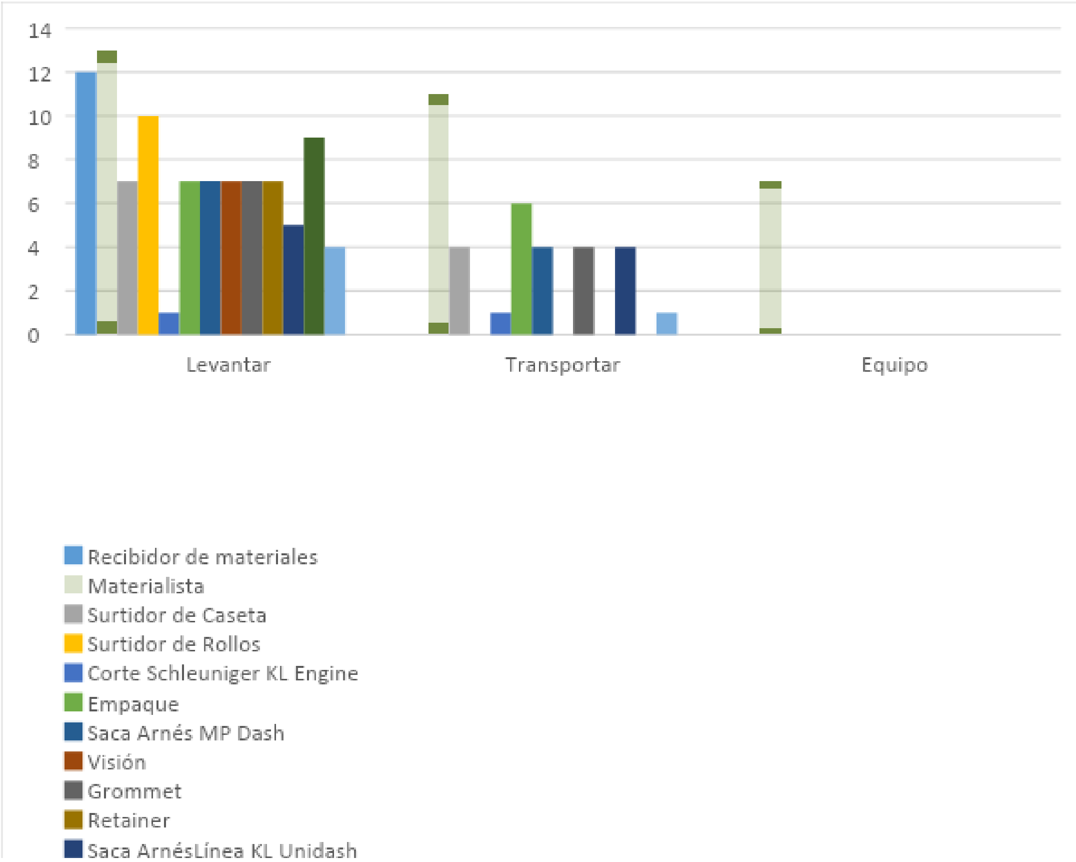



Figure 1. Results of risk levels of activities that involve manually lifting, lowering or transporting loads

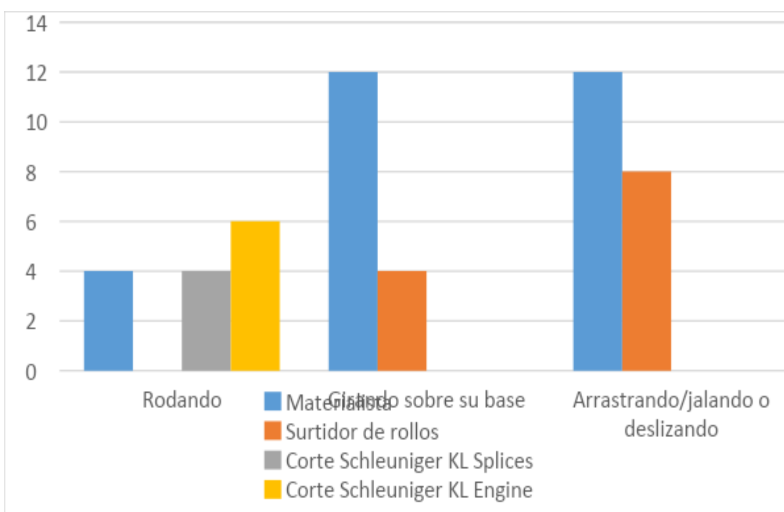



Figure 2. Results of risk levels of activities that involve pushing and pulling or dragging materials without the aid of auxiliary equipment.

After the analysis of these activities, they were detected:

1. 3 low acceptable risk activities
2. 4 Medium-Possible risk activities
3. 0 High-Significant Risk Activity

Figure 3 shows the summary results of activities involving pushing and pulling or dragging materials with the aid of auxiliary equipment.

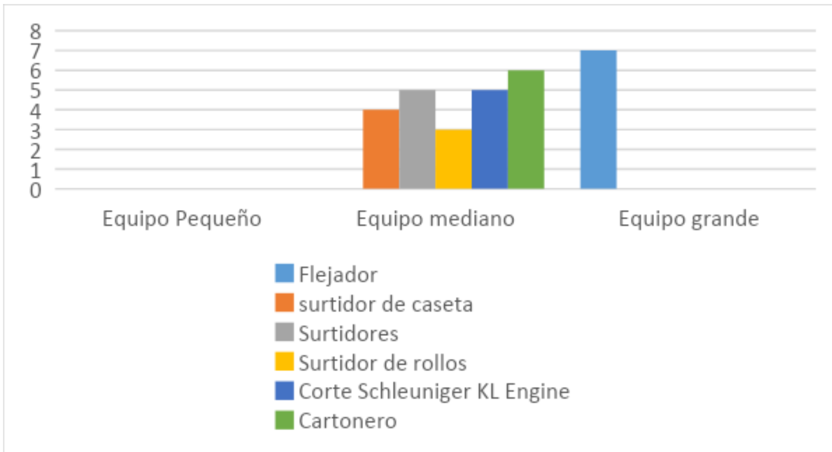



Figure 3. Results of risk levels of activities that involve pushing and pulling or dragging materials with the help of auxiliary equipment

After the analysis of these activities, they were detected:

1. 2 Low-Acceptable Risk activities
2. 4 Medium-Possible risk activities
3. 0 High-Significant Risk Activity

In order to have an overview of all results of the evaluated posts, table 2 is shown below, where you can observe the evaluated post, the area to which it corresponds, what type of manual handling of loads is done in the post and the degree of risk with which such activity is being performed.

***Table 2. General results of the risk levels of the activities.***

| Area | Operation | Manual charging | | | Without the use of auxiliary equipment | | | With the use of auxiliary equipment | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Lift | Transport | TEAM UP | Rolling | Turning on its Base | Dragging or Pulling | Little Team | Medium team | Medium team |
| 1 | Operation1 | Medio Medium | - | - | - | - | - | - | - | - |
| | Operation2 | High | Medium | Medium | Low | Medium | Medium | - | - | - |
| 2 | Operation1 | - | - | - | - | - | - | - | - | Medium |
| 3 | Operation1 | Medium | Low | - | - | - | - | - | Low | - |
| | Operation2 | - | - | - | - | - | - | - | Medium | - |
| 4 | Operation1 | Medium | - | - | - | Low | Medium | - | Low | - |
| 5 | Operation1 | Low | Low | - | Medium | - | - | - | Medium | - |
| 6 | Operation1 | Medium | Low | - | - | - | - | - | - | - |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Operation2 | Medium | - | - | - | - | - | - | - | - |
| 7 | Operation1 | Medium | Low | - | - | - | - | - | - | - |
| | Operation2 | Medium | Low | - | - | - | - | - | - | - |
| | Operation3 | Medium | - | - | - | - | - | - | - | - |
| | Operation4 | Medium | - | - | - | - | - | - | - | - |
| | Operation5 | Medium | Medium | | | | | | | |
| 8 | Operation1 | Low | Low | - | - | - | - | - | - | - |
| 9 | Operation1 | Low | Low | - | Low | - | - | - | - | - |
| 10 | Operation1 | - | - | - | - | - | - | - | Medium | - |

After making the analysis of the total of the activities that imply manual handling of loads, it was concluded that although the company at the present time already applies measures to prevent the risks by manual handling of loads, these continue present in some activities even existing one of high risk.

Some of the recommendations and actions of prevention and/or control that they carried out are:

- Training of correct manual handling techniques for all exposed personnel.
- Use of auxiliary equipment: in the case of the high risk activity of the Materialist's post in the warehouse area, the implementation of auxiliary equipment is proposed to help the operator to lift the loads, since one of the main risks of the activity is the vertical lifting region, simultaneously this would also help to reduce the risk of the operator of the material reception post. An example of the equipment that could be used is the Hydraulic Scissor Lift Skid,
- Station Redesign: It is recommended to decrease the height of the rack to a distance of 1.20 meters, in order to reduce the fatigue in the operator's arms when lifting the harness, since it requires applying force to mold and tape the harness.
- Technical and/or administrative control measures: reinforce the general safety measures that the company currently has, the safety measures indicated in NOM-036-1-STPS-2018 and the recommendations of prevention and/or control actions, as well as follow-up to the proposed ergonomics program.

## 4. CONCLUSIONS

The positions where manual handling of loads is performed were identified and the risk assessment associated with manual handling of loads was carried out, identifying the number of activities that represent risks for workers; based on such information and after its analysis, it was concluded that the company currently does not comply with all the points evaluated by the regulations, however, it is not far from complying with such regulations because it already had a culture of worker care.

In order to comply with the regulations, the ergonomics program for manual handling of loads was developed, in which the correct technique for carrying out the activities of the posts in which there is manual handling of loads is described, as well as the control measures to be adopted and the prevention actions; of which one implies making modifications in the work procedures of two posts and the other implies making a change in one of the instruments used in the post. Therefore, the application of such a program, in addition to complying with the regulations, would benefit 179 out of a total of 2,971 employees. Achieving the prevention of occupational risks, the reduction of physical discomfort to workers, injuries, accidents and diseases, such as tendinitis, back pain, neck and shoulder pain that operators currently present. These could represent costs for the company, for example, spinal surgeries can cost from 113,370 to 533,500 pesos representing only medical expenses. Taking the situation of the company under study, in the case of the high-risk position, which is performed by 26 workers, if they present spinal problems that require surgery, we would be talking about an expense of at least 2,947,620 pesos. In addition, compliance with this regulation would avoid the imposition of fines for non-compliance, which range from 25,670 to 513,400 Mexican pesos, (Secretaría del Trabajo y Previsión Social, 2017).

Working on the care and safety of the worker is not only a matter of business ethics or a legal issue that directly benefits the worker, but knowing how to orient the objectives also represents a competitive application for any organization, obtaining a reduction of expenses in terms of occupational health, increase in productivity, prevention of failures, resolution of operational and efficiency problems, and an improvement in the commitment of the employees to the organization.

**Acknowledgements**

This publication was funded with resources from PROFEXCE2020

## 5. REFERENCES

Creaser, W. (2008). Prevention through Design (PtD) Safe Design from an Australian Perspective. Journal of Safety Research, 39, 131-134.

Gelenk-Klinik.(2019). CLINICA ORTOPEDICA ALEMANA. Obtenido de CLINICA ORTOPEDICA ALEMANA: https://clinica-ortopedica-alemana.com/tratamiento-ortopedico/cirujano-de-columna-especializada/lista-de-precios-de-cirugia-de-espalda-y-co

Ferre, Á. J. (2009). Índices Ergonómicos-Psicosociales en Invernaderos Tipo "Almería". Almería: Universidad de Almería

Howard, J. (2008). Prevention through Design - Introduction. Journal of Safety Research 39, 113.

Manuele, F. A. (2008a). Prevention Through Design. Professional Safety, 53(10), 28.

Manuele, F. A. (2008b). Prevention through Design (PtD): History and Future. Journal of Safety Research, 39, 127–130.

Naoki Kudo, Yoji Yamada, & Daisuke Ito. (2019). Age-related injury risk curves for the lumbar spine for use in low-back-pain prevention in manual handling tasks. ROBOMECH Journal, (1), 1.

NOHSC. (2004). The role of design issues in work-related injuries in Australia 1997-2002 [electronic resource] / National Occupational Health and Safety Commission. Canberra: National Occupational Health and Safety Commission.

Norma Oficial Mexicana NOM-036-1-STPS-2018, Factores de riesgo ergonómico en el Trabajo-Identificación, análisis, prevención y control. Parte 1: Manejo manual de cargas. México: Diario Oficial de la Federación

OIT. 2019. Safety and health at work. URL https://www.ilo.org/global/topics/safety-and-health-at-work/lang--en/index.htm

Schulte, P. A., Rinehart, R., Okun, A., Geraci, C. L., & Heidel, D. S. (2008). National Prevention through Design (PtD) Initiative. Journal of Safety Research, 39(2), 115-121.

Secretaría del Trabajo y Previsión Social. (2017). gob.mx. Obtenido de gob.mx: https://www.gob.mx/stps/prensa/contempla-ley-sanciones-de-377-mil-pesos-por-incumplir-normas-de-seguridad-en-empresas

Sibaja, R. C. (2002). Salud y Seguridad en el Trabajo. Costa Rica: EUNED.

# ERGONOMIC ANALYSIS OF THE MERCHANDISE PALLETIZING PROCESS

**Gabriela Patricia Cruz Pérez, Ana Violeta Montaño Ayala, Victor Manuel Hernandez Pérez, Mario Abel Padilla Navarro, Acela Castillo Barraza**

Departament of Industrial Engineering
Tecnológico Nacional De México/Instituto Tecnológico de Mexicali
Av. Tecnológico S/N, Col. Plutarco Elías Calles
Mexicali Baja California 21376
xnob-755@hotmail.com

**Resumen**: El proceso de cobro mediante el traspaleo de mercancía en empresas de tipo club en venta por mayoreo, es uno de los principales problemas de lesiones de los empleados debido a la mala forma de carga y actividades repetitivas mediante posibles posturas inadecuadas al momento de trasladar las mercancías de un carrito de compras a otro, generando altos costos incapacidades y rotación de personal. Esta investigación persigue mediante el uso de la ergonomía el análisis de la estación de trabajo, utilizando las cartas Antropométricas adecuadas para el trabajador logrando el mejoramiento del proceso y de la estación de trabajo del traspaleo de mercancías a la hora del cobro, mejorando la calidad de vida del empleado y disminuir los costos que pudieran generarse debido a incapacidades, lesiones y rotaciones en la empresa.

**Palabras clave**: Cargar, Postura, MAC

**Relevancia para la ergonomía**: El análisis de información antropométrica y de métodos utilizados, utilizando una pequeña cantidad de mediciones, nos ayuda al uso de todos los datos para rediseñar el carrito para que sea con un enfoque ergonómico.

**Abstract:** The collection process through the transfer of merchandise in club-type companies for wholesale, is one of the main problems of employee injuries due to the poor form of cargo and repetitive activities through possible inappropriate postures at the time of moving the merchandise. from one shopping cart to another, generating high costs, disabilities and staff turnover. This research pursues through the use of ergonomics the analysis of the work station, using the appropriate Anthropometric charts for the worker, achieving the improvement of the process and the work station of the merchandise transfer at the time of collection, to improve the quality life of the employee and reduce the costs that could be generated due to disabilities, injuries and rotations in the company.

**Keywords:** Upload, Posture, MAC

**Relevance for ergonomics:** The analysis of anthropometric information and methods used, using a small amount of measurements, helps us to use all the data to redesign the cart so that it is with an ergonomic approach.

## 1. INTRODUCTION

At a wholesale sales branch there are currently problems with handling and lifting techniques, in which an ergonomic analysis must be carried out to evaluate the work carried out by cashier operators, for which the Mexican Standard was applied, NOM-036-1-STPS-2018, on "Ergonomic Risk Factors at Work-Identification, Analysis, Prevention and Control"

. The work environment must be evaluated, as well as the state of the worker per day to see the operator's physical health results, as well as the way in which he performs constant lifting of the merchandise since its weight varies depending on the wholesale product.

It is necessary to analyze all the possible ergonomic causes to apply the solutions since this work is based on the fact that at the moment the cashier operator receives the customer, he scans the product and loads the merchandise to shovel it to the next cart, and this is done during his work period. In the long term it can cause the operator injuries due to the constant overstrain.

With the present situation of merchandise loads, it is desired to correct the way in which this operation is currently carried out by providing the cashier operator with a table that has the necessary measurements in the form of a slide for the sliding of the merchandise while it is fully scanned, also a pallet type cart that the client uses so that the height where it is most convenient for the cashier operator to take the merchandise and slide it on the table, which will be provided so that he can carry out it, in a comfortable and simple way this operation in a more ergonomic posture that favors you in your state of physical health.

The following measurements of the collection area were taken, thus making the nodes (minimum and maximum value) that will be analyzed of the area

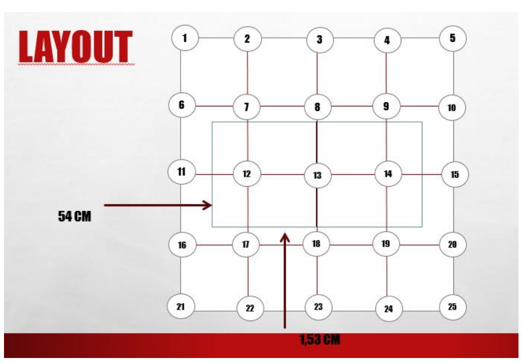



Figure 1. Layout of collection area

## 2. OBJECTIVES

With the present situation of merchandise loads, it is desired to correct the way in which this operation is currently carried out by providing it, Reduce the risk in the handling of loading and unloading of merchandise so that ergonomic evaluations and application of Mexican standards will be carried out so that the operator count on the tools that can carry out their work adequately and safely during their workday.

## 3. METHODOLOGY

Analysis of the merchandise transfer process

1.Application of load lifting methodologies, NOM-036-1-STPS-2018, Ergonomic Risk Factors at Work-Identification, analysis, prevention and control. Manual handling of loads.

Process improvement proposal

Supermarket Cart Design Proposal

Carry out ergonomic evaluations so that the operator has the tools for handling goods loading and unloading so that they can carry out their work adequately and safely during their workday.

2. With the application of the NIOSH methodology to evaluate the tasks performed by the cashier operators by applying the equation of this method to evaluate and avoid risks on the recommended weight.

3. Application of the MAC methodology Through the application of the MAC methodology, it was possible to carry out the analysis of the correct lifting of loads, descent and transport, it is the necessary tool for the manual handling of loads, as well as the manipulation of objects when they are being lifted to prevent physical health problems. from the workers.

4. Analysis of WERA method With the application of the WERA method, the following results were obtained and the analysis was also carried out applying the improvement of the area and the changes that favored the operator to be able to carry out his work in a more ergonomic way.

5. OIT (International Labor Organization)

## 4. RESULTS

**4.1** Mexican Standards

NOM-036-1-STPS-2018, Ergonomic Risk Factors at Work-Identification, analysis, prevention and control. Manual handling of loads.

One of the main analyzes carried out for this project is NOM-036-1-STPS-2018

Labor authority: The competent administrative units of the Ministry of Labor and Social Welfare that carry out inspection and surveillance functions in the field of occupational health and safety, and the corresponding ones of the federal entities, which act in their assistance.

At this point of the standard, we will carry out inspections from time to time in order to observe any anomaly that will eventually result and thus be able to work on it to solve it either totally or reduce its effects on the worker and thus avoid an injury in the short term. or long term.

Pushing, pulling or dragging (pulling) loads: Those activities or tasks in which a load is pushed or dragged, manually, with or without the help of auxiliary equipment, where the direction of the fundamental resulting force is horizontal.

During traction, the force is directed towards the body and in the push, it moves away from the body.

At this point we observe that the cashier constantly makes the movement of loading the merchandise from one cart to another in very long periods of time, taking horizontal movements and due to this at the end of their working day the staff ends up with back discomfort.

Auxiliary equipment: Vehicles with one, two or more wheels, without own locomotion, which are used as support for manual loading in the transport of material in bulk or packaged over relatively short distances, which are partially supported and / or driven by the workers. For the purposes of this Standard, wheelbarrows, devils and skates, among others, are included as such The cashier can use the plates or pallets for the movement of merchandise from one place to another. Stowage: The action of stacking materials or containers on top of each other, in an orderly manner, at floor level, on pallets, structures or platforms. This point of the norm does not apply since the cashier accommodates the merchandise in another cart since it passes through the shocker.

Ergonomic risk factors: Those that may entail over physical effort, repetitive movements or forced postures in the work performed, with the consequent fatigue, errors, accidents and work diseases, derived from the design of the facilities, machinery, equipment, tools or position. of work. The movements that the cashier makes day by day are very repetitive at the time of trapalear the merchandise since the carts that the company uses are very low and the person has to make a lot of effort of load at the moment of passing the material from one cart to another.

Lifting and lowering loads: Those activities or tasks carried out manually, without the help of machinery, that produce a moment-force on the spine, and / or upper and lower extremities, regardless of the direction. In lifting the force is carried out against gravity and, in favor of it, when the load is lowered At the time of loading any merchandise, the cashier may make a wrong movement or a bad posture when doing his job and that may affect his spine or his hip in the long term.

Federal Regulation of Safety and Health at Work

Dangerous Conditions: Those characteristics inherent to the facilities, processes, machinery, equipment, tools and materials, that may put at risk the health, physical integrity or life of the workers, or damage the facilities of the Work Center

The company's trolleys do not have an insurance or brake that makes the trolley stable when the cashier is hauling the merchandise from one trolley to another and this can cause a risk to the worker.

Personal Protective Equipment: The set of elements and devices specifically designed to protect the worker against Work-related Accidents and Diseases
Staff must wear a sash at all times of their day to avoid injury when carrying a very heavy item.

Ergonomic Risk Factors: Those that may entail over physical effort, repetitive movements or forced postures in the work carried out, with the consequent fatigue, errors, Accidents and Work Diseases, derived from the design of the facilities, machinery, equipment, tools or position. of work

The worker may suffer wear and tear at the end of their shift since they work 7 hours in the same posture and with the same movements all day.

**4.2** Risk analysis

**4.2.1** NIOSH Methodology

With the application of the NIOSH methodology to evaluate the tasks performed by the cashier operators by applying the equation of this method to evaluate and avoid risks on the recommended weight which gave us the following results:

Table 1. NIOSH results (own table)

| **Factores** | **Medidas** | **Ecuación** | **Resultados** |
|---|---|---|---|
| **LC** | 25 | 25 | 25 |
| **HM** | 15 Cm | 25/15 | 1.66 |
| **VM** | 60 Cm | 1-0.003*60-75 | 0.955 |
| **DM** | 30 Cm | 0.82+4.5/60 | 0.895 |
| **AM** | 90 Cm | 1-0.0032*90 | 0.712 |
| **FM** | | | 0.81 |
| **CM** | | | 1.00 |

**RWL =** 25*1.66*0.955*0.895*0.712*0.81*1.00 = **20.45 Kg**

Given the results, it was determined that the recommended weight limit for the operator should not exceed 20.45 Kg to avoid risks or injuries, among other ills.

Table 2. Measurements

| **VALOR NODOS** | **LUX** | **RUIDO** | **TEMPERATURA** |
|---|---|---|---|
| **MIN** | 4625 | 60 | 21 |
| **MAX** | 7625 | 73 | 24 |

### **4.2.2** Application of the MAC methodology

Through the application of the MAC methodology, it was possible to carry out the analysis of the correct lifting of loads, descent and transport, it is the necessary tool for the manual handling of loads, as well as the manipulation of objects when they are being lifted to prevent physical health problems. from the workers. During the observation of the work of the cashier operators we can observe the performance of the survey they carry out, as well as the risk to be able to analyze through the MAC evaluation where when analyzing we obtained the following results:

R high risk level 13 to 20 3 Corrective actions are required soon.

Through the application of the MAC methodology, it was possible to carry out the analysis of the correct lifting of loads, descent and transport, it is the necessary tool for the manual handling of loads, as well as the manipulation of objects when they are being lifted to prevent physical health problems. from the workers.

During the observation of the work of the cashier operators we can observe the performance of the survey they carry out, as well as the risk to be able to analyze through the MAC evaluation where when analyzing we obtained the following results:

Table 3. MAC Results (Own Table)

| Factores de Riesgo | | Color | Valor |
|---|---|---|---|
| A | Peso de la carga y frecuencia | M | 10 |
| B | Distancia horizontal de las manos a la región lumbar | R | 6 |
| C | Carga asimétrica sobre la espalda | M | 3 |
| D | Restricciones posturales | V | 1 |
| E | Acoplamiento mano-objeto | N | 1 |
| F | Superficie de transito | N | 1 |
| G | Factores ambientales (aire, temperatura, iluminación) | N | 1 |
| H | Distancia de traslado | R | 2 |
| I | Obstáculos | N | 1 |
| Puntaje Total | | | 26 |

### **4.2.3** WERA method analysis

With the application of the WERA method, the following results were obtained and in the same way the analysis was carried out applying the improvement of the area and the changes that favored the operator to be able to carry out his work in a more ergonomic way

Table 4. WERA results (own table)

| Factor de riesgo ergonómico | Antes de mejora | Después de la mejora | Mejora |
|---|---|---|---|
| 1. Hombro | 4 | 3 | 25% |
| 2. Muñeca | 5 | 3 | 40% |
| 3. Espalda | 5 | 2 | 60% |
| 4. Cuello | 4 | 2 | 50% |
| 5. Piernas | 4 | 2 | 50% |
| 6. Fuerza | 6 | 6 | 0% |
| 7. Vibración | N/A | N/A | N/A |
| 8. Estrés por contacto | N/A | N/A | N/A |
| 9. Duración de tarea | 6 | 6 | 0% |
| Total de puntos | 34 | 24 | |
| Nivel de respuesta | ALTO | MEDIO | PROMEDIO |
| Acción | La tarea es inaceptable, son requeridos cambios de inmediato | La tarea necesita ser más investigada y son requeridos cambios | MEJORA 25% |

**4.3** Improvements

OIT (International Labor Organization)

As a reference point on eliminating tasks that require turning or tilting to solve ergonomic problems that arise when lifting loads when carrying out the goods shoveling operation.

Eliminate jobs or change and improve operator tools to avoid types of movement that require you to have to lean to reach the merchandise to improve the work area and change the conditions that allow you to perform a better posture when the merchandise is being moved.

It also takes into account the options given to perform a more ergonomic job and the facilities of the operator to perform them, such as granting a working condition that meets your needs and specifications of the work you do.

## 5. CONCLUSIONS AND RECOMMENDATIONS

The objective was achieved since the loads with labels that were placed on heavy items were reduced, the cashier stopped shoveling it to the other cart, having a person who is visualizing what is being scanned with the labels.

The modification of the trolley is at the cashier's height so that the personnel no longer have to make more effort to load the other less heavy items so that the post of the cashier operator was more ergonomic based on the measures obtained by applying the posture improvements where the mechanism allows the cashier operator to manipulate the height of the trolley where he feels most comfortable when taking the merchandise to start his process. Similarly, when performing a WERA methodology analysis, we can see that the operator's performance as a posture had an improvement of 25% compared to the method he previously used.

A table was proposed that has the necessary measurements in the form of a slide for the sliding of the merchandise while it is scanned based on OIT, and in this way the operator can perform this operation in a more ergonomic position that favors his health. physical and safe.

## 6. REFERENCES

Chanel Alberto. (2019). Formato y aplicación de método ergonomico WERA para la valoracion postural. De scribd Sitio web: https://es.scribd.com/document/412838172/Metodo-WERA.

Diego-Mas, Jose Antonio. (2015). Evaluación ergonómica del levantamiento de carga mediante la ecuación de Niosh. Ergonautas, Universidad Politécnica de Valencia Sitio web: https://www.ergonautas.upv.es/metodos/niosh/niosh-ayuda.

Mario Andres Arriagada Viveros. (2013). Manual Handling. 2013, de scribd Sitio web: https://es.scribd.com/document/137256537/Metodo-Mac.

Organización internacional del Trabajo. (1996). Ergonomic checkpoints. Ginebra: grafobet.

Secretaria de Trabajo y Previsión social. (2018). NOM-036-1-STPS-2018, Factores de riesgo ergonómico en el Trabajo-Identificación, análisis, prevención y control. Manejo manual de cargas. Noviembre 23, 2018 de Diario Oficial de la Federación Sitio web: https://dof.gob.mx/nota_detalle.php?codigo=5544579&fecha=23/11/2018.

Secretaria de Trabajo y Previsión social. (2001). Norma Oficial Mexicana NOM-011-STPS-2001, Condiciones de seguridad e higiene en los centros de trabajo donde se genere ruido. 2002, de Diario Oficial de la Federación Sitio web: http://asinom.stps.gob.mx:8145/upload/noms/Nom-011.pdf.

Secretaria de Trabajo y Previsión social. (2008). Norma Oficial Mexicana NOM-025-STPS-2008, Condiciones de iluminación en los centros de trabajo. Diciembre 30 2008, de Diario Oficial de la Federacion Sitio web: http://asinom.stps.gob.mx:8145/upload/noms/Nom-025.pdf.

Secretaria de Trabajo y Previsión social. (2001). Norma Oficial Mexicana NOM-015-STPS-2001, Condiciones térmicas elevadas o abatidas-Condiciones de seguridad e higiene. Junio 14, 2002, de Diario Oficial de la Federación Sitio web: http://asinom.stps.gob.mx:8145/upload/noms/Nom-015.pdf.

Secretaria de Trabajo y Previsión social. (2014). Reglamento Federal de Seguridad y Salud en el Trabajo. Noviembre 12 del 2014, de Diario oficial de la Federación Sitio web: http://www.diputados.gob.mx/LeyesBiblio/regla/n152.pdf.

# ERGONOMIC PHYSICAL HAZARD LEVELS IN THE CONSTRUCTION INDUSTRY

**Andrea Angélica Rocha Hernández, Joaquín Vásquez Quiroga, Enrique de la Vega Bustillos, Rafael Hernández León, Jesús Martin Cadena Badilla.**

Universidad de Sonora
Unidad Regional Norte
Caborca, Sonora, México

Corresponding author's e-mail: jovaqui@caborca.uson.mx
[2]Tecnologico Nacional de Mexico/Instituto Tecnológico de Hermosillo
Av. Tecnologico S/N
Hermosillo, Sonora, México

**Abstract** Ergonomics in the construction industry is an issue that has little deepened, but which has a great impact on the appearance of musculoskeletal disorders (MSD) in people involved in this sector. With this problem as the main research point, an emphasis is placed on the importance of the role that ergonomics plays in this area. in general it presents a conceptual vision of ergonomics, its objectives, fields of action and physiological aspects, in addition through the study of people who work in the area and in the city of H. Caborca, Sonora, alternative solutions are provided, and above all it aims to demonstrate the need for the analysis of this area through a methodology, throughout the research and through the application of the manual handling assessment charts (MAC) methodology, which is applied in several countries such as Chile, to diagnose the level of risk existing in the activities of the construction industry, as well as a an interview with a general doctor, showed as a general result that the level of risk that is handled in the professions of this sector is high, and in some occasions very high, so corrective actions must be taken, allowing employees to develop properly, minimizing the possibility of acquiring disorders that affect the health of the worker.

**Keywords**: Ergonomic, Construction industry, MAC.

## 1. INTRODUCTION

The role of ergonomics in the construction industry sector is of great importance, it is therefore essential to analyze the risk factors to which workers in this sector are exposed, as well as the repercussions that these can have on their health. This is considered as extremely important because it can affect a large part of the society dedicated to this work line, for this reason it is necessary to have adequate knowledge on the subject, thus preventing and decreasing injury rates and the level of risk thereof.

Likewise, the research will not only analyze the main risk factor, but seeks to establish the right method for analyzing a worker in this sector, so the analysis will be carried out, trying to give alternatives of methods, tools, etc., that allow the worker to develop in a more comfortable way, thus reducing the risk in their work.
Ergonomics in the construction sector should have great study relevance, taking into account the benefits it could bring to society in terms of health and productivity, this work aims to diagnose in the city of Heroica Caborca, Sonora, Mexico if there is or not a real risk in this area and at what level, by analyzing workers using the method called " Manual Handling Assessment Charts" (MAC), which is used in some countries such as Great Britain and Chile, among others, thus trying to provide working alternatives that reduce this risk.

## 2. METHODOLOGY

In the first instance, an exploratory investigation was carried out to identify whether or not there is a risk in this area, by searching and analyzing data from previous investigations in the construction industry in H. Caborca, Sonora. In addition, an interview was conducted with a doctor in order to corroborate in some way the information obtained. Secondly, videos of the construction processes were taken, applying the MAC method to thirty workers in this sector, allowing to know the existing risk to which they are exposed, through this the importance of the application of an evaluation method was established, thus knowing the areas of opportunity and generating alternatives that allow to reduce the level or degree of risk of the activities to be carried out by the employee.

## 3. ANALYSIS OF RESULTS

The level of risk in the Construction industry in H. Caborca,Sonora is represented in the figure 1.1

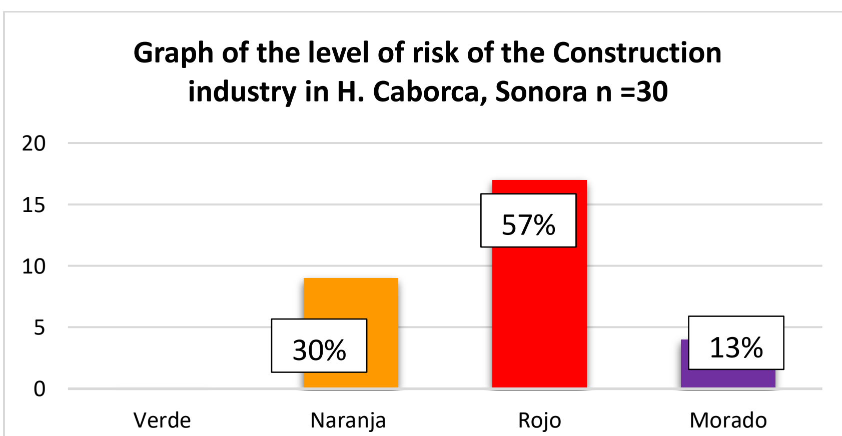



Figure 1. Graph of the level of risk of the Construction industry in H. Caborca, Sonora, n=30.

Where the results obtained were divided by evaluation type, in which six are from transport tasks and 24 for individual lifting and lowering tasks, see figure 1.2.

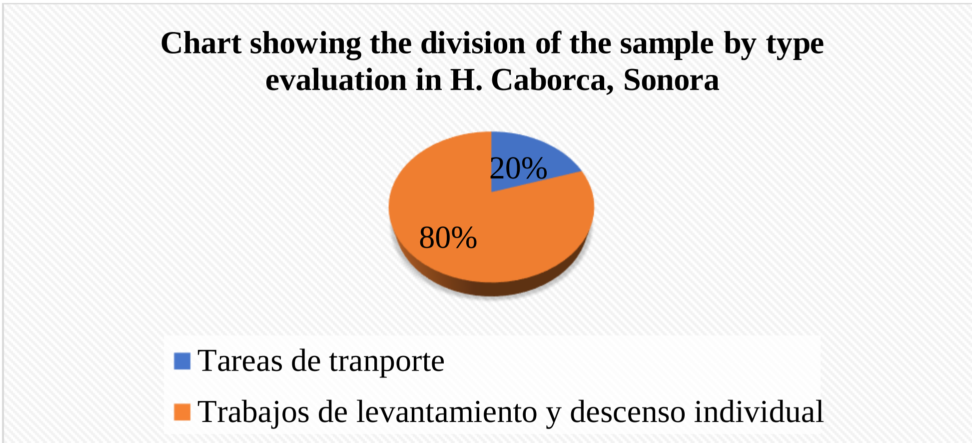
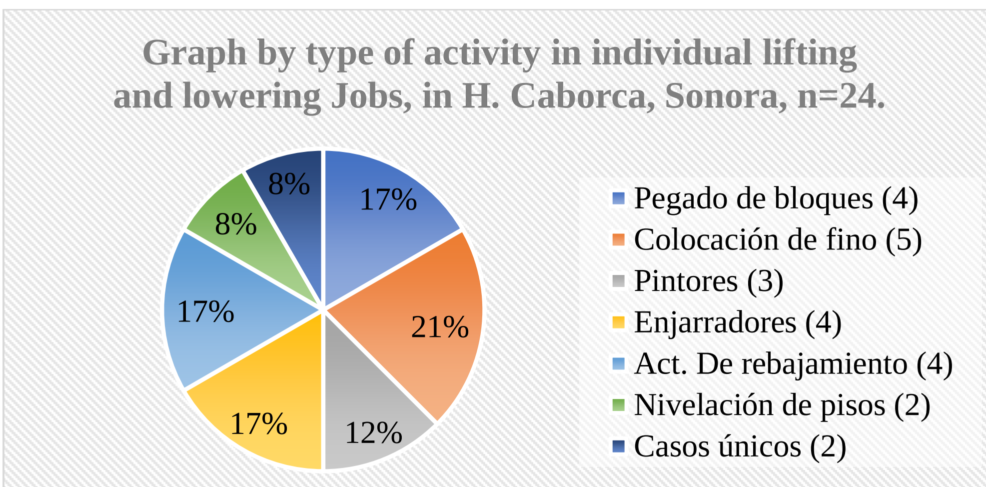



Figure 2. Chart showing the division of the sample by type evaluation in H. Caborca, Sonora.

Lifting and lowering work. At the same time this division had categories relating similar activities, see figure 3




GLUING BLOCKS-FINO- PAINTERS- PASTING-REDUCTION ACTIVITIES-FLOOR LEVELING-UNIQUE CASES

Figure 3. Graph by type of activity in individual lifting and lowering Jobs, in H. Caborca, Sonora, n=24.

Considering the 24 samples corresponding to this area showed the following risks levels see figure 1.4

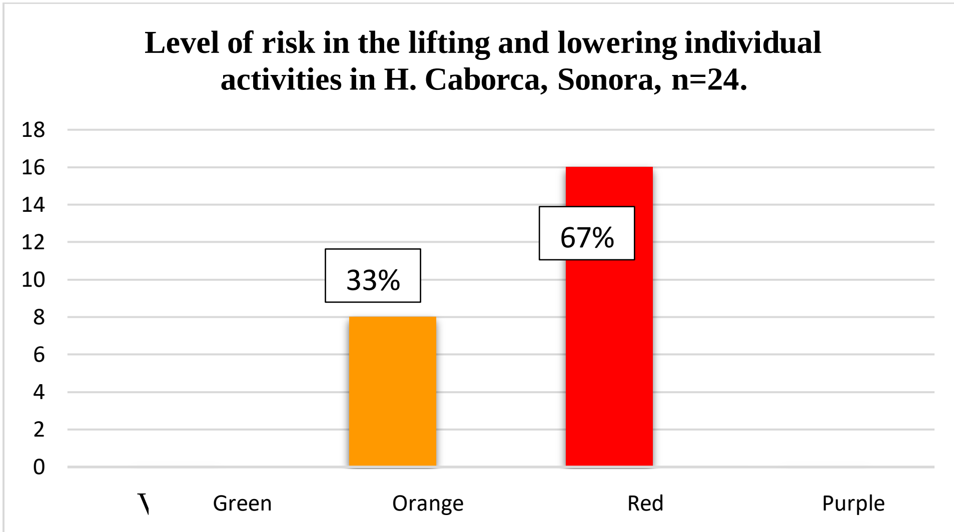



Figure 4: Level of risk in the lifting and lowering individual activities in H. Caborca, Sonora, n=24

Block Gluing. In the gluing activity we could analyze four workers doing this activity in which all of them contained a high risk level (red) in which corrective actions are required soon. The workers are the corresponding to the numbers 18, 22, 27,and 28, see figure 5 and annexes.

Figure 5: Images of the workers 18,22, 27 and 28 evaluated with the MAC methodology in H. Caborca, Sonora.

To plaster with mortar**.** In the placement of the to plaster with mortar risks levels of 60% moderate and 40% high were obtained, see figure 6. In this activity 5 workers were analyzed, being the ones corresponding to the numbers 4,5,6,23,26 see figure 7.

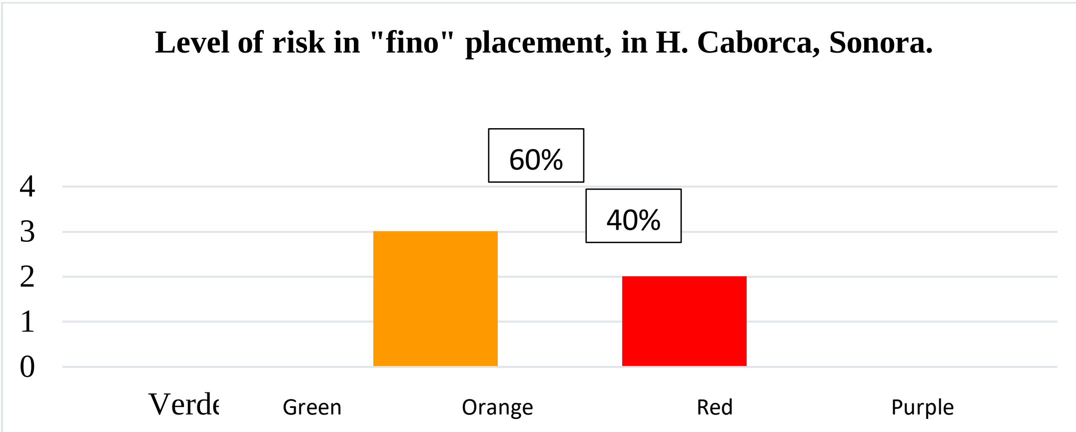



Figure 6: Graph of risk level in to plaster with mortar placement in H. Caborca, Sonora.

Figure 7: Images of the workers 4, 5, 6, 23 and 26, evaluated with the MAC methodology in H. Caborca, Sonora.

Pasting. A high risk level was obtained (RED) in which corrective actions are required son, since the workers analyzed and doing this activity had a high risk level, the workers mentioned are number 12, 14, 15 and 30, see figure 8

Figure 8 Images of the workers 12,14,15 and 30 evaluated with MAC Methodology in Caborca, Sonora.

Transport tasks. 6 workers were analyzed doing activities in which they transported loads using wheelbarrows, others manually, the transport was of blocks, mix and sand. The levels of risk in this activity were warning, see figure 9.These workers correspond to the numbers 7.8.11.16.19 and 29, see figure 10.

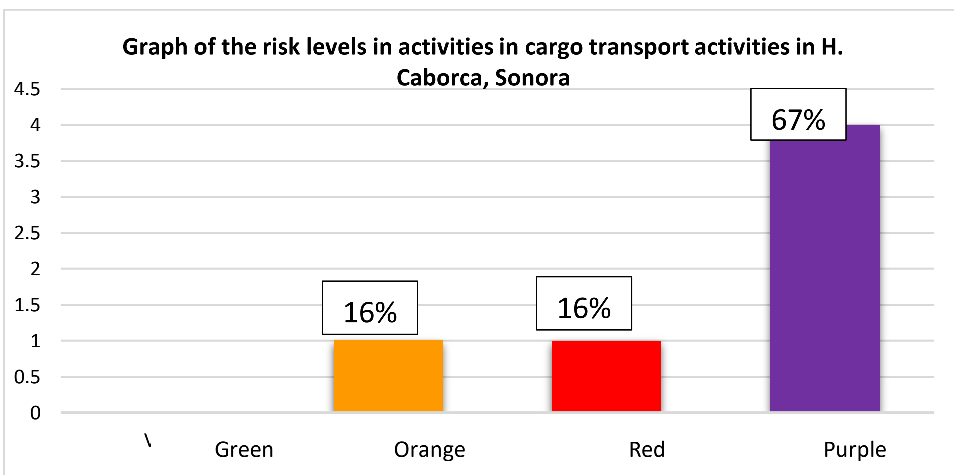



Figure 9. Graph of the risk levels in activities in cargo transport activities in H. Caborca, Sonora

Figure 10: Images of workers 7, 8, 11, 16, 19 and 29, evaluated with the MAC methodology in H. Caborca, Sonora.

## 4. CONCLUSIONS AND RECOMMENDATIONS

Ergonomics in the construction industry is a need to be attacked, this information was obtained through documentary research and the application of the MAC methodology, which is used in Chile to measure the level of latent risk in construction activities, being this very easy to use and interpret, being able to determine that the field of action and opportunity of this area is enormous in that turn. Of the total sample of 30 analyses, 57% have a high risk level, 30% a moderate risk level and finally 13% a very high level of risk, that is, in all samples there was no time when the level of risk was low, making evident the need to measure the levels of risk to which workers in the construction sector are exposed, it is important to note that applying ergonomics the health of workers would improve, minimizing the risk of them acquiring a musculoskeletal disorder, thus avoiding injuries that over the years are usually painful and irreversible.

But this does not stop here, it seeks to make awareness in people of the importance of attending of any discomfort and take this seriously, both on the part of the worker and the boss, because the consequences are really harmful Tools and alternatives must be developed to avoid these damages to health.. It was possible to identify that the main problems are: the weight of the load handled and the very management of it, they constantly take inappropriate postures that can hurt the back, among other things., although it is true that due to the demand of the sector it is very difficult to eradicate the risk, if it is possible to minimize it.

## 5. REFERENCES

Agencia Europea para la Seguridad y Salud en el Trabajo. Observatorio Europeo de Riesgos. Riesgos Nuevos y Emergentes para Seguridad y la Salud en el Trabajo. (2009). Disponible en: http//Europa.eu [acceso en 15.11.2010].

Agencia Europea para la Seguridad y la Salud en el Trabajo. (2015). Lista de control para evitar malas posturas de trabajo. En A. E. Trabajo, Hazards and risks associated with manual handling in the workplace (pág. 1).

Apud, E., y Meyer, F. (2003). La importancia de la ergonomía para los profesionales de la salud. Ciencia y enfermería, 9(1), 15-20.

Armstrong, TJ, P Buckle, L Fine, M Hagberg, B Jonsson, A Kilbom, I Kuorinka, B Silverstein, B Sjøgaard, E Viikari-Juntura. (1993). A conceptual model for work-related neck and upper-limb musculoskeletal disorders. Scand J Work Environ Health 19:73-84.

Barrau, P., Gregori, E., y Mondelo, P. R. (1994). Ergonomía 1 Fundamentos. España: Ediciones de la Universidad Politécnica de Cataluña.

Brinckmann, P. y Pope, M.H. (1990). Effects of repeated loads and vibration. En The Lumbar Spine, dirigido por J Weinstein y SW Weisel. Filadelfia: WB Saunders.

Bruto, Hansen, 1993. Hansen y Jensen, 1993. Enciclopedia de la OIT, Volumen 1, cap. 6, pág. 6.

Caro, E. T. (2014). Factores de riesgo ergonómicos que influyen en la seguridad y salud de los trabajadores mineros. Perú: Ediciones de la Universidad Nacional del Centro de Perú.

Cevallos D. D. L. M. (2015). Evaluación de riesgos ergonómicos biomecánicos en técnicos mecánicos de vehículos pesados, de la agencia Hino en Quito. Propuesta de un programa para disminuir los trastornos musculoesqueléticos. Doctoral dissertation, Universidad Internacional SEK.

Cote, G. C. y Helenice, J. (1999). "The effects of production changes on the musculoskeletal disorders in Brazil and South America". International Journal of Industrial Ergonomics. Vol. 25: 103-104.

Diego-Mas, J.A. a. Evaluación del riesgo por movimientos repetitivos mediante el Check List Ocra. Ergonautas, Universidad Politécnica de Valencia, 2015. [consulta

04-10-2018]. Disponible online: http://www.ergonautas.upv.es/metodos/ocra/ocra-ayuda.php

Diego-Mas, J.A. b. Evaluación de la repetitividad de movimientos mediante el método JSI. Ergonautas, Universidad Politécnica de Valencia, 2015. [consulta

04-10-2018]. Disponible online: http://www.ergonautas.upv.es/metodos/jsi/jsi-ayuda.php

Diego-Mas, J.A. c. Evaluación postural mediante el método RULA. Ergonautas, Universidad Politécnica de Valencia, 2015. [consulta

04-10-2018]. Disponible online: http://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

Diego-Mas, J.A. d. Evaluación postural mediante el método REBA. Ergonautas, Universidad Politécnica de Valencia, 2015. [consulta

04-10-2018]. Disponible online: http://www.ergonautas.upv.es/metodos/reba/reba-ayuda.php

Diego-Mas, J.A. e. Evaluación postural mediante el método OWAS. Ergonautas, Universidad Politécnica de Valencia, 2015. [consulta

04-10-2018]. Disponible online: http://www.ergonautas.upv.es/metodos/owas/owas-ayuda.php

Diego-Mas, J.A. f. Evaluación ergonómica del levantamiento de carga mediante la ecuación de Niosh. Ergonautas, Universidad Politécnica de Valencia, 2015.

Disponible online: https://www.ergonautas.upv.es/metodos/niosh/niosh-ayuda.php

Edwards, R.H.T. (1988). Hypotheses of peripheral and central mechanisms underlying occupational muscle pain and injury. Eur J Appl Physiol 57(3):275-281.

Eransus, J. y Díez, M. (2010). Los trastornos músculo-esqueléticos. Una prioridad en la atención preventiva en la C.A. de Navarra. Revista La mutua, 17(7). Disponible en: http://www.fraternidad.com/es-ES/revista/REVISTA-LA-MUTUANUMERO-17_17.html.

European Agency for Safety and Health at Work OSH in figures (2010). Work-related musculoskeletal disorders in the EU — Facts and figures. Luxembourg: Publications Office of the European Union. Recuperado de: http://europa.eu [acceso en 21.11.2010].

Evaluación De La Manipulación Manual De Cargas Mediante Las Tablas De Snook Y Ciriello. Ergonautas, Universidad Politécnica De Valencia, 2015. Disponible Online: Https://Www.Ergonautas.Upv.Es/Metodos/Snook_y_ciriello/Snook-Ayuda.Php

Eyquem L, Córdova V, Maldonado O. (2007). Usabilidad, confiabilidad y validez de un método para la evaluación de factores de riesgo en el manejo manual de cargas. Ciencia y Trabajo. 9(5):135-142.

Fallentin N, Viikari-Juntura E, Waersted M, Kilbom A. (2001). Evaluation of physical workload standards and guidelines from a Nordic perspective. Scand J Work Environ Health. 27(suppl 2):1-52. Recuperado de: https://www.scielosp.org/scielo.php?pid=S1135572720110004000003&sript=sci_arttext&tlng=en

Fundación Laboral de la Construcción e Instituto Biomecánico de Valencia. (2005). Manual de ergonomía en la construcción. Recuperado de: http://www.acpnavarra.com/Administracion/Archivos/GD/792/FLC-ManualErgonomiaConstruccion-042008.pdf

Fung, Y.B. (1972). Stress-strain history relations of soft tissues in simple elongation. Capítulo 7 en Biomechanics: Its Foundations and Objectives, dirigido por YC Fung, N Perrone y M Anliker. Englewood Cliffs, Nueva Jersey: Prentice Hall.

García, A. M., Gadea, R., Sevilla, M. J., y Ronda, E. (2011). Validación de un cuestionario para identificar daños y exposición a riesgos ergonómicos en el trabajo. Revista española de salud pública, 85, 339-349. Recuperado de: https://www.scielosp.org/scielo.php?pid=S1135-57272011000400003&script=sci_arttext&tlng=en

Goldstein, S.A., Armstrong T.J., Chaffin D.B. y Matthews L.S. (1987). Analysis of cumulative strain in tendons and tendon sheaths. J Biomech 20(1):1-6.

Guillén Fonseca, M. (2006). Ergonomía y la relación con los factores de riesgo en salud ocupacional. Revista cubana de enfermería, 22(4), Recuperado de http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-03192006000400008

Hagberg, M. (1982). Local shoulder muscular strain -symptoms and disorders. J Hum Ergol 11:99-108.

Hamerman, D. (1998). Sistema Musculoesquelético. En Stellman, J. M. (4), OIT: Enciclopedia de Salud y Seguridad en el Trabajo (pp. 6.2 - 6.32). Madrid, Ed: Chantal Dufresne, BA.

Hansen, S.M. y Jensen, P.L. (1993). Arbejdsmiljø Og Samfundsøkonomi -Regneark Og Dataunderlag. Nord: Nordisk Ministerråd. (Nordiske Seminar - og Arbejdsrapporter 1993:556.

IEA. ( 2000). “What is Ergonomics”. IEA Website http://www.iea.cc/whats/index.html

Instituto Nacional de Seguridad e Higiene en el Trabajo. (2011). VLL Encuesta Nacional de Condiciones de Trabajo. Disponible en (17 agosto de 2014): http://www.insht.es/InshtWeb/Contenidos/Documentacion/FICHAS%20DE%20PUBLICACIONES/EN%20CATALOGO/OBSERVATORIO/Informe%20(VII%20ENCT).pdf

Janwantanakul, P., Pensri, P., Jiamjarasrangsi, W. y Sinsongsook, T. (2009). Biopsychosocial factors are associated with high prevalence of self-reported mucculokeletal symptoms in the lower extremities among office workers, Arch Med Res. 40(3):216-222.

Jastrzebowski, W. (1857). Rys ergonomiji czyli Na uki o Pracy, opartej naprawdach poczerpnietych z Nauki Przyrody. Przyoda i Przemysl 29:227-231.

Leadbetter, WB. (1989). Clinical staging concepts in sports trauma. Capítulo 39 en Sports-Induced Inflammation: Clinical and Basic Science Concepts, dirigido por WB Leadbetter, JA Buckwalter y SL Gordon. Park Ridge, Illinois: American Academy of Orthopaedic Surgeons.

Leirós, L. I. (2009). “Historia de la Ergonomía, o de cómo la Ciencia del Trabajo de basa en verdades tomadas de la Psicología”. Revista de historia de la psicología, núm. 30 (4).

Maestre, D. G. (2007). Ergonomía y psicosociología. Madrid, España. FC Editorial.

Magnago, T.S., Lisboall, M.T.L.,Harter, R., Cardosa, L., Camponogara, S., De Quadros, C. y Becker, L. (2010). Condiciones de trabajo, características sociodemográficas y disturbios músculo-esqueléticos en trabajadores de enfermería. Acta paul. Enferm (online) ISSN 0103-2100), vol.23, n.2, pp.187-193.. http://dx.doi.org/10.1590/S0103-21002010000200006.

Marras, W.S. y Hancock, P.A. (2014). Putting mind and body back together: A human-systems approach to the integration of the physical and cognitive dimensions of task design and operations. Appl. Ergon, 45, 55–60.

Martínez, M. M. y Muñoz, R. A. (2017). Validación del Cuestionario Nórdico Estandarizado de Síntomas Musculoesqueléticos para la población trabajadora chilena, adicionando una escala de dolor. Revista de Salud Pública, 21(2), 43-53.

Martínez, S. (2013). Ergonomía en construcción: Su importancia con respecto a la seguridad. Universidad Pública de Navarra, España.

Meyers, F. E. y Stephens, M. P. (2006). R Diseño de instalaciones de manufactura y manejo de materiales, Naucalpan de Juárez, México: Pearson educación.

Ministerio del trabajo y previsión social. (2008). Guía técnica para la evaluación y control de los riesgos asociados al manejo o manipulación manual de carga Santiago, Chile: Subsecretaría de Previsión Social.

Munabi, I.G., Buwembo, W., Kitara, D.L., Ochieng, J. y Mwaka, E.S. (2014). Musculoskeletal disorder risk factors among nursing professionals in low resource settings: A cross-sectional study in Uganda. BMC Nurs.13, 7.

Ortuño, P. (2012). Evaluación ergonómica de los puestos de trabajo en el sector de la conserva: medidas de prevención. Revisión de la literatura. Revista de Ergonomía, 3(6): 12-22.

Podniece, Z. (2007). La ergonomía y la prevención de los trastornos músculo-esqueléticos. Revista La Mutua, 17, 69-82.

Prado, L. y Roselia, L. ( Ed. 1ra). (2003). Factores ergonómicos en las lumbalgias ocupacionales. Un estudio de casos y controles. Guadalajara, México: Universidad de Guadalajara. Colección: Producción académica de los miembros de Sistema nacional de investigadores.

Punnett, L. and Wegman, D.H. (2004). Work-Related Musculoskeletal Disorders: The Epidemiologic Evidence and the Debate. Journal of Electromyography & Kinesiology, 14, 13-23. https://doi.org/10.1016/j.jelekin.2003.09.015

Riihimäki, H. (1998). Sistema Musculoesquelético. En Stellman, J. M. (4), OIT: Enciclopedia de Salud y Seguridad en el Trabajo (pp. 6.2 - 6.32). Madrid, Ed: Chantal Dufresne, BA.

Rodríguez, Y., y Pérez, E. (2014). Procedimiento ergonómico para la prevención de enfermedades en el contexto ocupacional. Revista Cubana de salud pública, 40, 279-285.

Romo, P. y Del Campo, T. (2011). Trastornos musculoesqueléticos en trabajadores sanitarios y su valoración mediante cuestionarios de discapacidad y dolor. Medicina del Trabajo , 20 (1), (27-33).

Sjøgaard, G. (1990). Exercise-induced muscle fatigue: The significance of potassium. Acta Physiol Scand 140 Supl. 593:1-64.

Snook, S.H., 1987. The design of manual handling tasks: revised tables of maximum acceptable weights and forces, Ergonomics, 34, pp. 1197 - 1213.

Urban, JPG y Roberts, S. (1994). Chemistry of the intervertebral disc in relation to functional requirements. En Grieve's Modern Manual Therapy, dirigido por JD Boyling y N Palastanga. Edimburgo: Churchill Livingstone.

Viikari-Juntura, E. (1984). Tenosynovitis, peritendinitis and the tennis elbow syndrome. Scand J Work Environ Health 10:443-449.

World Health Organization (WHO). N◦5 Prevención de Trastornos Musculoesqueléticos en el Lugar de Trabajo. 2004. Available online: http://www.who.int/occupational_health/publications/en/pwh5sp.pdf (accessed on 19 July 2017)

# ERGONOMIC PROCEDURE IN ORDER TO REDUCE MUSCULOSKELETAL DISORDERS IN STOMATOLOGY WORK.

**Lamberto Vázquez, Maricarmen Loya, Ana Suzeth Santiago, Daniel Carrillo, Mario Alberto Sánchez**

Department of Industrial Engineering
Tecnológico Nacional de México, Instituto Tecnológico de Agua Prieta
Ave. Tecnológico and Road to Janos Chihuahua
Agua Prieta, Sonora, 84200
drlamberto@gmail.com

**Resumen:** El trabajo odontológico se caracteriza por un conjunto multifactorial de actividades, con un alto nivel de complejidad, principalmente al mantener diversos factores y circunstancias como: un campo o área de trabajo reducidos, zonas de difícil acceso, precisión en movimientos, alta concentración, posturas forzadas, trabajo altamente diferenciado, estrés por contacto con las herramientas de trabajo, vibración por manejo de instrumentos neumáticos, iluminación específica y no global, estrés psicosocial producto de la ansiedad y dolor del paciente. Todo lo anterior conlleva a un incremento en la posibilidad de generar Desordenes – Músculo – Esqueléticos (DME´s) específicamente referenciados en la columna vertebral, carpo, metacarpo y las falanges. Esta situación problemática afecta de manera directa la seguridad, precisión, eficiencia y desempeño en el trabajo, además de una disminución considerable en la calidad de vida del estomatólogo.

Es por ello que se plantea una investigación dialéctica experimental de tipo mixta que contempla como objetivo el diseño de un procedimiento que contemple las principales directrices ergonómicas establecidas para el trabajo repetitivo y las posturas inadecuadas, además de la aplicación de un conjunto de modernas tecnologías de información y comunicación y las normas DIN 13923 e ISO 4073, que en su convolución dan como resultado una mejora sustancial en la relación sinérgica, estomatólogo – estación de trabajo.

**Palabras clave**: riesgos laborales, ergonomía en odontología

**Relevancia para la ergonomía**: El trabajo de investigación establece una conformación pragmática de: estudios de movimiento, análisis ergonómico del trabajo dental, anatomía y fisiología de posturas repetitivas, procedimiento de medición y cuantificación de riesgos laborales. Con esto, se desarrolló un procedimiento ergonómico para la mejora sustancial de la unidad funcional dental. Esto, se considera una contribución esencial a la ciencia ergonómica.

**Abstract:** The field of dentistry is characterized by a set of multifactorial activities with a high level of complexity, primarily by maintaining various factors and circumstances such as: reduced field or work area, difficult to access zones, precision movements, high concentration, forced postures, a highly diverse work, stress caused by contact with work related tools, vibrations by handling pneumatic instruments, focused illumination and not general, psychosocial stress caused by anxiety and pain from the patient. All of this leads to an increase in the possibility of generating Musculoskeletal Disorders (MSD's) tied to the spine column, carpus, metacarpus and the phalanges. This issue affects directly the security, precision, efficiency and performance at work, in addition to a considerable decrease in the quality of life of the stomatologist.

Therefore, an experimental dialectic investigation of a mixed type arises, which contemplates as an objective the design of a procedure that takes into account the main ergonomic guidelines established for repetitive work and inadequate postures, in addition to the application of a series of modern technologies of information and communication, the standards DIN 13923 and ISO 4073, its integration results in a substantial improvement of the synergetic relationship, stomatologist-workstation.

**Key Words:** Workplace Hazards, Ergonomics in Dentistry

**Relevance to ergonomics**: The research work establishes a pragmatic conformation of: movement studies, ergonomic analysis of dental work, anatomy and physiology of repetitive postures, measurement procedure and quantification of work risks. With this, an ergonomic procedure was developed for the substantial improvement of the dental functional unit. This is seen as an essential contribution to ergonomic science.

## 1. INTRODUCTION

The different professional activities that are developed in modern society carry with them a high value and importance in human and productive interaction. It is therefore the case that strategies, programs and procedures leading to an optimal level of health for each and every worker must maintain a high priority level. Having good physical health is, in most cases, a guarantee of good work performance and a good quality of life.

Dentistry is one of the branches of health science, mainly responsible for studying, diagnosing, preventing and treating diseases or ailments that are present within the stomatognathic system or apparatus. The stomatognathic system is the integrated and coordinated morphofunctional unit, constituted by the set of skeletal, muscular, angiological, nervous, glandular and dental structures, organized around the occipital – atloidea joints – atlo – axoidea, vertebro – cervical vertebrals, temporus – mandibular, dento – dental in occlusion and dento – alveolars, which are linked organically and functionally with the digestive, respiratory, phonological and aesthetic expression systems – facial and with the senses of taste, touch, balance and orientation, to develop the functions of suctioning, oral digestion (comprising chewing, salivation, tasting and initial degradation of carbohydrates); swallowing, verbal communication (integrated, among other actions, by phonological modulation, articulation of sounds, speech, whistling and desire); alternative breathing and life defense, consisting of cough, expectoration, sneezing, yawning, sigh, exhalation and vomiting, essential for the survival of the individual.

In dental practice, stress, tension, poor postures, and segmental (localized) vibration may contribute to problems at the musculoskeletal system level of personnel exercising it. These disorders can differ in severity from mild periodic symptoms to severe chronic debilitating conditions. Dental work is characterized by a series of repetitive movements and a high degree of complexity, as well as a set of forced working postures. Coupled with it, the odontologist has to work constantly with a high degree of concentration, a highly differentiated work, forcing his view through areas of difficult access and a great precision in every movement he performs, not forgetting to mention that you have to live with the psychosocial stress that is generated by the anxiety and pain of the patients. In addition to doing its work in a confined work area with specific lighting, and not general as most workstations; manual handling tools can cause contact stress, as some of these tools produce vibrations as they are pneumatic instruments.

All these factors and circumstances lead to an unavoidable increase in the chances of the dentist developing so called musculoskeletal disorders (MSD’s) specifically located in the lumbar area of the spine, carpus, metacarpus and phalanges; because these are the parts of the body that the dentist uses consistently. With the combination of repetitive movements and forced postures in which the dentist performs his daily activity the appearance of MusculoSkeletal Disorders is eminently feasible, affecting the mobility of the body by causing injuries and damage, this represents a major problem with the health and quality of life of the dentist and in turn causes a decrease in his level of precision, effectiveness and performance.

The problematic situation raised, shows that the movements, factors and circumstances in which the stomatologists are involved can put their quality of life at risk, having a high probability of developing MusculoSkeletal Disorders.

The aim of this research is to study dental workstations and as a main objective, to reduce the chances of stomatologists developing MusculoSkeletal Disorders while doing their work, by implementing a procedure that addresses the main ergonomical guidelines established for repetitive work and inappropriate postures.

To achieve this, a set of investigative procedures is carried out, which contemplate the evaluation in the foreground, by direct observation, of the stomatologist's workstation using the Suzanne Rodgers method, with the idea of obtaining the ergonomic assessment of the current situation, with this we achieve the degree of risk in which the workstation is located. With the collection of this data we start with the design of the procedure and the application of the rules applicable to stomatologist work, as well as information and communication technologies.

Once the ergonomic procedure and workstation design for the stomatologist was completed, the ergonomic assessment was again carried out using the Suzanne Rodgers method, with the aim of comparing the risk associated with the workstation, before and after the application of the ergonomic guidelines. It is important to note that the decrease in risk at the stomatologist's workstation is considerably high, which results in a substantial improvement in the quality of life of the dentist and contributes to the increase in efficiency, effectiveness and service in the work developed.

# 2. OBJECTIVES

## 2.1 General objective

Reduce Musculoskeletal Disorder on Stomatologist's, through the application of a procedure that contemplates the main ergonomic guidelines established for repetitive work and inadequate postures, the standards DIN 13923 and ISO 4073, along with the implementation of a set of modern information and communication technologies.

## 2.2 Specific objectives

1. Develop from a theoretical point of view, the related aspects to the work performed in a clinic and a satisfactory attention to the dental patient.
2. Design a procedure that takes into account the main ergonomic guidelines established for repetitive work and the inadequate postures, the standards DIN 13923 and ISO 4073, along with the implementation of a set of modern information and communication technologies.
3. Validate the decrease of workplace hazards in a stomatologist's work station.

# 3. DELIMITATIONS

1. Its established as a subject of study: the workstations in which its activities include medical practice and a satisfactory attention of the dental patient.

# 4. METHODOLOGY

The pragmatic methodological action of this research is established in three steps that are developed below:

1. The first point that is made is a diagnosis of the current situation that values the development of the activity by the stomatologist and the negative impact on their quality of life. This situation is framed by the application of the Suzanne Rodgers method in order to define the degree of risk in which the workstation is.
2. Once the diagnosis is developed, a process of analysis - synthesis is carried out, which assesses the synergistic relationship between the work station and the stomatologist and establishes the necessary and sufficient conditions to develop the ergonomic adjustment procedure that contemplates: the main guidelines of ergonomics, the standards DIN 13923 and ISO 4073, along with the application of a set of modern information and communication technologies.
3. The third point in developing establishes the application of the procedure designed in dental offices and defining a comparison of the ergonomic evaluations performed with the Suzanne Rodgers' method, before and after the application.

## 4. RESULTS

To carry out the diagnosis on the working conditions in the dental station, it is necessary to perform a direct observation procedure on the workstation, as well as to carry out a set of video recordings that consistently support observations and to be in possibility of making a correct and reliable diagnosis.

Figure 1 shows the stomatologist's station, as well as some of the postures in which the dentist performs his tasks with high repetitiveness, it is worth noting the inadequate posture of the neck, the lifting of the man and the high need for concentration of the view and there are no instruments for applying the visual grade. As a whole, it is observed that the work station contemplates a series of adverse situations to the development of the task, which necessarily implies an increase in the probability of generating a skeletal muscle disorder or injury in the dentist.

In order to carry out a greater depth in the analysis and ergonomic evaluation of the workstation, Suzanne Rodgers´ ergonomic evaluation method was applied, considering that the amount of movements are highly repetitive and concentrated in what is called micro-movements, coupled with it the use of force and finger handling.

Figure 1: Dentistry work station.

The results of the application of Suzanne Rodgers´ ergonomic evaluation method are presented in Figure 2. The qualifications obtained by the evaluation method entail an urgent need to study and modify the workstation immediately.

According to the methodology proposed in the present investigation, the next step is to define the ergonomic principles applicable to the type of workstation in which the study is immersed and proceed to develop the redesign of the workstation. The main focus that is maintained in the redesign process is to reduce the forced postures in which the dentist carries out his activity.

The characteristics of the workstation define the need for the workstation to contemplate work in a sitting position. Therefore, the characteristics and requirements necessary for the adaptation and use of an ergonomic chair are established.

A problem established in the diagnosis was the high visual concentration required by the workstation. For this, the application of information and communication technologies is contemplated, based on the acquisition and adaptation of a microscope in real time.

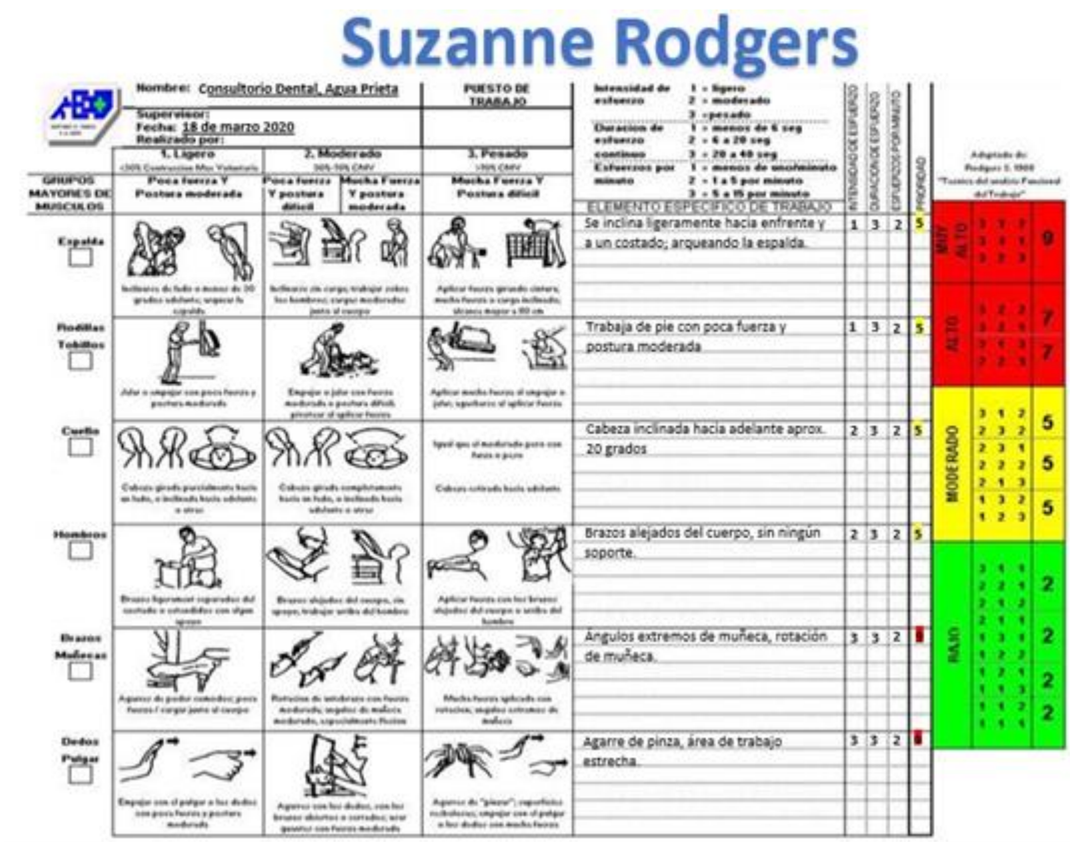



Figure 2: Results of the application of Suzanne Rodgers ergonomic evaluation method in the dental workstation.

Figure 3 shows the real-time microscope applied in the redesign of the workstation. The versatility that this microscope provides to the dentist is the extension of the work object according to its visual acuity.

In addition to the above, the need for the stomatologist's work to include an auxiliary for the optimal performance of the work to be performed is established, this situation allows the dentist to focus his attention on the development of the own activity required by each patient.

For this it is necessary that the proposed ergonomic procedure contemplates the physical distribution of the work equipment, in this case the dental functional unit, where according to the DIN standard, four positions are determined for the dentist's work element and four for the the assistant The pure combinations between both: 1/1, 2/2, 3/3 and 4/4, generate the four basic concepts, BK1, BK2, BK3 and BK4, respectively.

Figure 3: Real-time microscope applied to the redesign of the workstation.

The physical distribution of the possible combinations is presented in Figure 4.

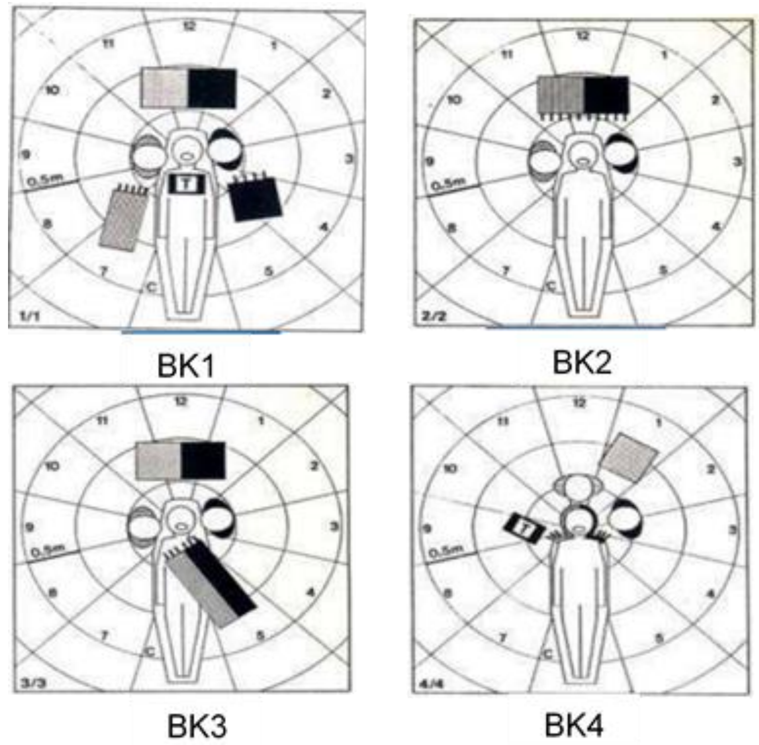



Figure 4: Physical distribution of the dental functional unit

With this, the ergonomic procedure is defined for the redesign of the dental work station and with it the procedure is applied, to compare the station with the Suzanne Rogers method through a new evaluation of the station, if the degree of risk of the dental work station.

The result of the research work was the design of a workstation that contemplated the main guidelines of biomechanics and ergonomics, resulting in a better adaptation of the stomatologist to his workplace.

In the first instance, the need was defined for the work to be carried out in a chair with ergonomic characteristics, which will facilitate the dentist's locomotion and stability when carrying out the great diversity of tasks corresponding to oral health.

The second relevant feature of the new ergonomic design was the incorporation of a microscope that establishes, in real time, all the movements made by the stomatologist in the daily practice of his work. This allows the dentist's field of vision not to be concentrated only in the part of the patient's mouth, but to visualize the work area on the screen that was placed in front of the dentist, allowing them to avoid a forced and uncomfortable posture in the development of the task.

The incorporation of the microscope in real-time and a screen where the work area is reflected, allows the stomatologist to visualize those places where it is extremely complicated to observe the action of the task. This facilitates access to the instruments required to carry out the necessary actions in the dental procedure. All of this without the need for the dentist to adapt a complicated position that is difficult to maintain throughout the consultation. This reduces the possibility of the dentist developing a muscular-skeletal disorder.

Figure 5 shows the image of the redesigned workstation, it establishes how it is necessary that the work is developed in a seated position and how the microscope in real time improves the posture in which the activity is developed.

It is important to point out that sometimes the tasks of the stomatology maintain very high degrees of complexity and the application of great force in the action is made, added to them it is required of greater precision and care, such it is the case of the extractions of the third molar, for example, where the necessary force to carry out the detachment lever is very great, the effectiveness in the application of the force is necessary not to hurt the bordering pieces and the precision in the movements are essential since tissues, tendons, muscles and bones can be hurt. In these cases, it is highly recommended that the work be carried out in a standing position, since this provides greater stability, allowing the action of the force to be directed efficiently and effectively.

It is evident that in the work defined above, the impact of the action of the work on the stomatologist is mostly exhausting and it is possible that in a very short time a muscular-skeletal disorder develops. Therefore, a new line of research is proposed, in the sense of analyzing this type of stomatological tasks in greater depth and proposing ergonomic procedures that manage to reduce the negative impact of the work on the dentist.

Figure 5: Designed stomatologist's work area.

The ergonomic evidence establishes that for a better contribution of the assistant to the dentist it is necessary to make a set of protocols in the handling of the instruments and the activities and actions that must be carried out in support of the work developed.

The study shows that, due to the characteristics of the technologies implemented in the redesigned workstations, an adaptation of the structures proposed in the DIN standard, specifically of the BK1 and BK4, would generate a greater benefit from the ergonomic point of view for the dentists.

It is important to point out that the protocols for instrument operation and the development of task actions and activities that they maintain at the time of task action, both for the dentist and the support assistant, are already clearly defined in the procedures for surgical intervention and dental work. Therefore, in this ergonomic research, only the analysis of the postures in which each one develops his/her activity is considered, and a physical distribution is proposed to facilitate the development of the activity, improving the interaction between the assistant, the dentist and the work station in which both perform. With this, it is possible to improve the efficiency, efficacy and quality of the service provided. In addition, the quality of life of the dentist and his assistant is considerably improved.

It is important to point out that the protocols for instrument operation and the development of task actions and activities that they maintain at the time of task action, both for the dentist and the support assistant, are already clearly defined in the procedures for surgical intervention and dental work. Therefore, in this ergonomic research, only the analysis of the postures in which each one develops his/her activity is considered, and a physical distribution is proposed to facilitate the development of the activity, improving the interaction between the assistant, the dentist, and the work station in which both perform. With this, it is possible to improve the efficiency, efficacy, and quality of the service provided. In addition, the quality of life of the dentist and his assistant is considerably improved.

Figure 6 shows the workplace design that was presented as a result of this research and that results in a decrease in the level of risk associated with the dental workstation.

Figure 6: Ergonomic design for the stomatology work area.

Once the redesign of the dental workstation is completed and the design is applied in a dental office in the city of Agua Prieta, the ergonomic assessment procedure is carried out using the Suzanne Rodgers method, in order to evaluate the impact of the proposals on the work risk associated with these dental workstations.

Figure 7 shows the evaluation obtained by the Suzanne Rodgers ergonomic valuation method and table 1 compares the risks before and after the implemented ergonomic improvements.

Table 1. Risk comparison of the stoma workstation

| Assessment period | Risk level obtained |
|---|---|
| Before the application of ergonomics | 5,5,5,5,9,9 |
| After application of ergonomics | 2,5,2,5,5,5 |

As can be seen in table 1, the ergonomic risk of the dental workstation was considerably reduced.

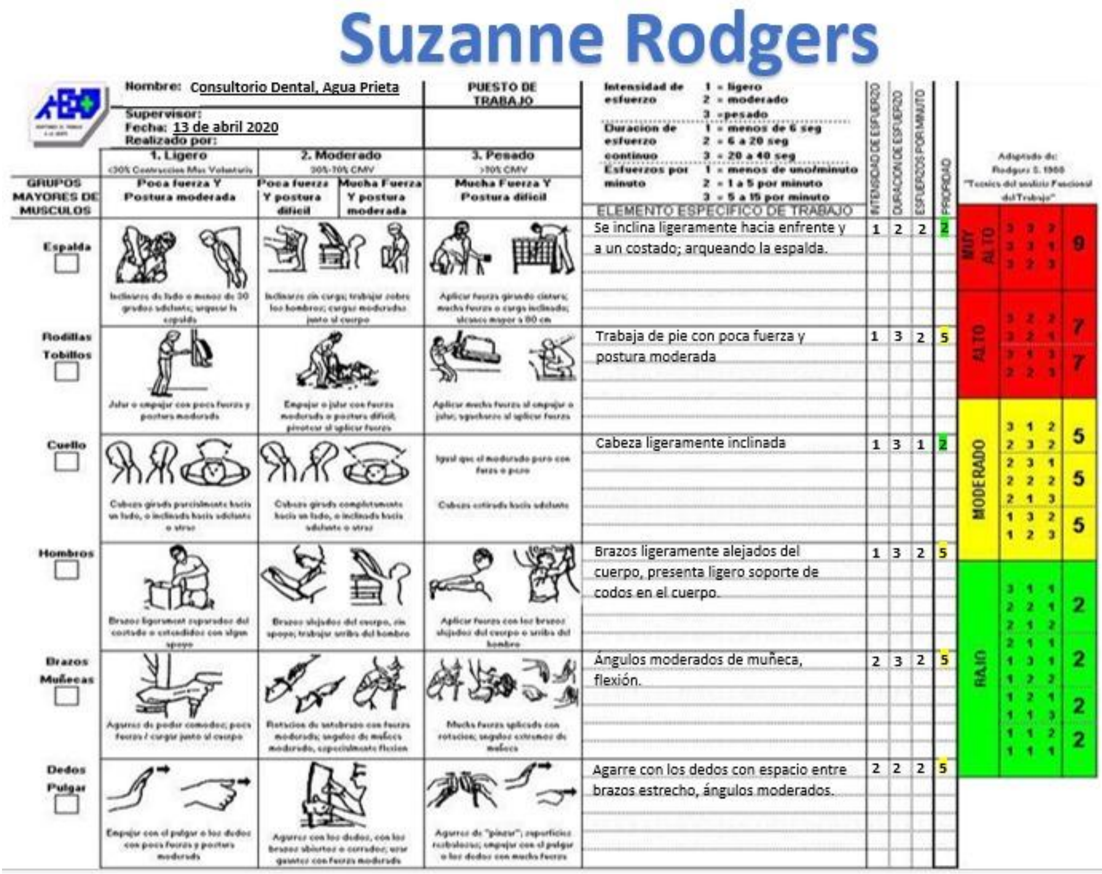



Figure 7: Evaluation obtained with the Suzanne Rodgers method.

The implementation of the ergonomic redesign of the dental workstation presents a number of benefits, both for the operators of the station and for the customers served at the station. The reduction of uncomfortable postures and repetitive movements reduces the possibility of the stomatologist developing a muscular skeletal disorder in a short period of time, which leads to a substantial improvement in professional performance, improves their quality of life and provides better patient service.

## 6. CONCLUSIONS

The application of ergonomic guidelines is of vital importance and an urgent practice to be performed for dental consultation stations. The present investigation contemplates the application of three important changes made to work stations dedicated to oral health, based on ergonomic guidelines. These changes were the adaptation of an ergonomic chair for job performance; the installation of a real-time microscope and the assignment of a physical distribution of the dental functional unit. As a whole, the modifications made to the workstation impacted the reduction of occupational risk.

It is important to emphasize that there are activities typical of stomatology that entail a greater effort, a greater need to apply a great amount of force, and high precision in the movements, such is the case of the extraction of the third molar, for which a new research guideline is recommended focused on this type of task.

## 7. REFERENCES

Barreto JF. (2018). Contenidos mínimos para el Plan de Estudios de Odontología. Comité Nacional de Recursos Humanos. Instituto Colombiano de Fomento de la Educación Superior (ICFES). División de Capacitación de la Dirección de Recursos Humanos. Bogotá; Ministerio de Salud. Federación Odontológica Colombiana (FOC).

Buitrón D. (2015). Estudio ergonómico sobre Trastornos Músculo Esqueléticos por posturas forzadas en odontólogos en el Hospital de Especialidades de las Fuerzas Armadas N°1". Trabajo de grado para obtener el título de Ingeniera en Seguridad y Salud Laboral. Universidad Internacional SEK. Ecuador. 2015.

García-Camba E. (2005). Psicopatología y patología psicosomática. En: El Dentista I Trastornos de ansiedad. Científica Dental. Vol. 2 nº 1.

Goplnadh A., Neellman K., Chiramana S., Manne P., Sampath A. &Suresh M. (2013). Ergonomics and musculoskeletal disorder: as an occupational hazard in dentistry. The Journal of Contemporary Dental Practice. 2013; 14 (2): 299-300.

Guillén, M. and Linares, D (2002). "Bases biológicas y fisiológicas del movimiento humano". Madrid: Médica Panamericana, S.A.

Gupta A., Bhat M., Mohammed T., Bansal N. & Gupta G. (2014). Ergonomics in dentistry.International Scientific Journals from Jaypee. 2014; 7 (1): 30-34. Disponible en: http://www.jaypeejournals.com/eJournals/ShowText.aspx?ID=5933&Type=FREE&TYP= TOP&IN=_eJournals/images/JPLOGO.gif&IID=449&isPDF=NO.

Hokwerda O., Wouters J., de Ruijter R. & Zijlstra-Shaw S. (2007). Ergonomic requirements for dental equipment. Guidelines and recommendations for designing, constructing and selecting dental equipment. 2007. Disponible en:

http://www.meridentoptergo.fi/Liitetiedostot/SCIENTIFIC_ARTICLE_Ergonomic_require ments_for_dental_equipment.pdf.

Pîrvu C., Pătraşcu I., Pîrvu D. & Ionescu C. (2014). The dentist's operating posture – ergonomic aspects. Journal of Medicine and Life. 2014; 7 (2): 177-182. Disponible en: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4151237/pdf/JMedLife-07-177.pdf

UNE 179001. (2007). Calidad en los centros y servicios dentales. Requisitos generales.

Vázquez, L. (2012) "Contribución a la evaluación del desempeño productivo y la salud del trabajador, en el ensamble manual de la industria maquiladora en el Noreste de Sonora, México". Director: José Manuel Pozo. Tesis de doctorado, Universidad de La Habana, Ciudad de La Habana.

# MARITAL STATUS AND BURNOUT IN MIDDLE AND SENIOR MANAGERS OF THE MAQUILADORA INDUSTRY

**Oziely Daniela Armenta-Hernández[1], Aidé Aracely Maldonado-Macias[2*], Manuel Alejandro Barajas-Bustillos[1], Arturo Realyvasquez[3], Yolanda Angelica Báez López[4]**

[1] Department of Electrical Engineering and Computer Sciences
Autonomous University of Ciudad Juarez
Del Charro Ave. 450N
Ciudad Juarez, Chihuahua 32310

[2]Department of Industrial Engineering and Manufacturing
Autonomous University of Ciudad Juarez
Del Charro Ave. 450N
Ciudad Juarez, Chihuahua 32310
Corresponding author's e-mail: amaldona@uacj.mx

[3] Tijuana Institute of Technology.
Calzada Del Tecnológico S/N
Fraccionamiento Tomas Aquino.
Tijuana, Baja California. 22414

[4] Autonomous University of Baja California
Ensenada Campus
. Km 103, carretera Tijuana - Ensenada,
Ensenada, Baja California

**Resumen:** El síndrome de Burnout se ha convertido en uno de los problemas de salud mental más estudiados y está teniendo un interés creciente en el contexto industrial. El presente estudio se está llevando a cabo en la industria maquiladora de Ciudad Juárez, México, donde hay 321 industrias manufactureras de exportación y actualmente emplea a más de 250,000 personas. Entre ellos, los empleados de la gerencia media y superior se consideran de importancia crítica ya que están sujetos a fuertes demandas laborales tanto de sus superiores como de sus subordinados, por lo que su trabajo es clave para el logro de los objetivos de la organización. Esta población es vulnerable al estrés laboral crónico, por lo que este estudio presenta resultados de la presencia de Burnout en una muestra de 932 empleados. Asimismo, se ha reconocido que el estado civil es una variable que puede influir en la presencia del síndrome de Burnout. Por lo tanto, los valores medios se obtuvieron para cada dimensión de Burnout por estado civil y se compararon usando ANOVA y la prueba de Tukey con un nivel de significancia de 0.05. Se compararon cinco estados maritales. Como resultado, se encontró un grado medio de agotamiento de las tres dimensiones para cada estado civil estudiado. Además, se infiere que el estado civil influye en las puntuaciones medias de Burnout ya que ANOVA detecta diferencias significativas entre las medias obtenidas por estado civil en las tres dimensiones. Además, esta misma prueba detecta diferencias significativas entre las puntuaciones medias obtenidas de los gerentes intermedios y superiores que son solteros, casados, en unión libre y divorciados con respecto a las viudas, respectivamente. Es posible concluir que existe evidencia de la presencia de Burnout en todo el estado civil estudiado. Sin embargo, solo la dimensión Agotamiento emocional presenta diferencias en los estados matrimoniales, donde estar casado genera una diferencia estadística entre los otros estados matrimoniales.

**Palabras clave**: Burnout, estado civil, estrés, industria.

**Relevancia para la ergonomía**: A través de este trabajo se podrá tener una idea más clara de cómo el estado civil de los trabajadores está relacionado con el síndrome de burnout.

**Abstract:** Burnout syndrome has become one of the most studied mental health issues and is having a growing interest in the industrial context. The present study is being conducted in the maquiladora industry of Ciudad Juarez Mexico, where there are 321 export-manufacturing industries and currently employs more than 250,000 individuals. Among them, middle and senior management employees are considered of critical importance since they are subjected to strong labor demands from both their superiors and their subordinates, so their work is key to the achievement of organizational goals. This population is vulnerable to chronic labor stress, so this study presents results of Burnout's presence in a sample of 932 employees. Likewise, it has been recognized that marital status is a variable that can influence the presence of Burnout syndrome. Therefore, mean values were obtained for each Burnout dimension by marital status and compared using ANOVA s and the Tukey test with a significance level of 0.05. Five marital status were compared. As a result, a medium degree of Burnout was found for all three dimensions for each marital status studied. Additionally, it is inferred that marital status does influence Burnout's mean scores since ANOVA detects significant differences between the means obtained by marital status in all three dimensions. Additionally, this same test detects significant differences between the mean scores obtained from middle and senior managers who are single, married, in free union and divorced concerning those who are widowed respectively. It is possible to conclude that there is evidence of the presence of Burnout in all the marital status studied. Nevertheless, only the Emotional Exhaustion dimension presents differences in the marital statuses, where being married generates a statistical difference between the other marital statuses.

**Keywords:** Burnout, marital status, stress, industry.

**Relevance to Ergonomics:** Through this work it helps to have a clearer idea of how the marital status of workers is related to the burnout syndrome.

# 1. INTRODUCTION

Several factors can influence the mental health of workers. Stress is one such factor, it is contagious, as seeing or being around someone who is under stress can increase cortisol levels (IMSS, 2018). Workplace stress is one of the health problems that is receiving the most attention. This is mainly because more and more are known about the importance of its consequences. Preventing or treating it will help us to maintain a level of health, both physical and mental. Lately, stress is one of the psychological disorders that most affect health, causing alterations that impact on workers or the company (Aguirre, N.H., Medellín, J., Vázquez, L., Gutiérrez, G. & Fernández, 2014; González, 2019).

Several studies relate Burnout to marital status, one of them is the study of Hernando Ávila Toscano, Tatiana Gómez Hernández Marlen & Margoth Montiel Salgado, (2010)that does not find any statistical difference between them, as well as the study of (Picasso-Pozo et al., 2017) who also found no relationship between marital status and the Burnout. In contrast, in the study of Bautista et al., (2013) it was found that married individuals are more likely to have Burnout; and in the study of Carina R. Peralta Ayala, (2018) it was found that being in free union tends to have greater results of emotional exhaustion.

Stress is defined as a physiological reaction of the organism before a situation that the person perceives like threatening; it is an automatic and necessary answer for survival. When this natural answer appears in excess, an overload of tension is produced that has repercussions in all the organisms and causes the appearance of diseases and alterations of the health that prevent the normal development and operation of the human body (Fátima Izquierdo Botica, 2019). Likewise, work-related stress is described as a series of physical and psychological reactions that occur when workers are faced with occupational demands, which do not correspond to their knowledge, skills or abilities. Worker reactions to stress can include physiological, emotional, cognitive and behavioral responses.

Burnout syndrome, which is a type of job stress, or a state of physical, mental and emotional exhaustion that can affect self-esteem. This syndrome occurs in phases where first there is a slow imbalance between the demand for work and the resources to cope with it. The second stage is an emotional imbalance of the worker and is when there is a change of behavior towards work, doing the minimum necessary, but avoiding danger at work. The Burnout consists of 3 dimensions that are the emotional exhaustion that is when the experience of being emotionally exhausted by the demands of the work is perceived; the cynicism that is when the degree in which each one recognizes attitudes of coldness and distancing; and finally the professional effectiveness that deals with the feelings of self-efficacy and personal fulfillment in the work.

In the model of González Ramírez et al., (2008) the perceived stress would be the result of facing one or several stressors and to value that situation as stressful and overflowing of the resources of the individual in question; the valuation of the resources includes the valuation of the own resources (self-esteem and self-efficacy) and the valuation of the environmental support (social support). Socio-demographic variables. Social conditions (social organization, socio-economic aspects, marital status, work role, gender, etc.) may be involved in both the origin and the consequences of stressful experiences (Sandín, 2003)

### 1.1. Objective

The main objective of this research is to determine the prevalence of Burnout syndrome in a sample of middle and senior managers of Ciudad Juarez, Mexico and the existence of significance differences between marital status and burnout among them.

### 1.2. Delimitation

The present study was conducted in the maquiladora industry of Ciudad Juarez, Mexico from a sample of middle and senior managers.

## 2. METODOLOGY

For gathering data, a questionnaire was applied. The questionnaire consists of 2 sections where the first section measures the Burnout and the second contains a questionnaire of socio-demographic questions to describe the sample.

The questionnaire used to measure the burnout is the Maslach Burnout Inventory in its Spanish version by Moreno (Moreno-Jiménez et al., 2001) this questionnaire consists of 16 questions divided into its 3 dimensions which are emotional exhaustion, cynicism and professional efficiency.

The socio-demographic data section of the questionnaire presents questions about their marital status, seniority in the company, hours worked, and job position among other questions in order to have information to describe the sample.

For the descriptive study of burnout, it is presented in 3 different ways, i.e. by mean scores, degrees, and levels of burnout.

### 2.1 Presence of burnout by mean values

To obtain the midpoints, the SPSS software is used to calculate the variables of each of the dimensions. Then, we analyze each of the dimensions where we extract the mean and the maximum and minimum for each dimension and compare them with the results of other research that has been carried out (Guerrero, E. y Vicente, 2001). To determine if there was a difference between the Burnout and the marital status of the participants, an ANOVA was performed. A significance level of $\alpha = 0.05$ was used in this work.

### 2.2 Obtaining the presence of Burnout by degree

The degree of exhaustion (high, medium and low) is assessed according to whether the average scores are in the upper, middle or lower third of the possible values. This is done by dividing the 3 degrees, low, and medium.

### 2.3 Obtaining the presence of Burnout by Levels

This level shows the level of burnout individuals presenting them in 5 categories. To obtain this point, the data obtained from obtaining degrees were used and with them, the 27 combinations began to be made to obtain the categories.

## 3. RESULTS

The sample for this study included 932 participants. Figure 1 shows the marital status, Figure 2 shows the seniority at work, Figure 3 shows the hours worked, Figure 4 shows the position, and Figure 5 shows the gender.

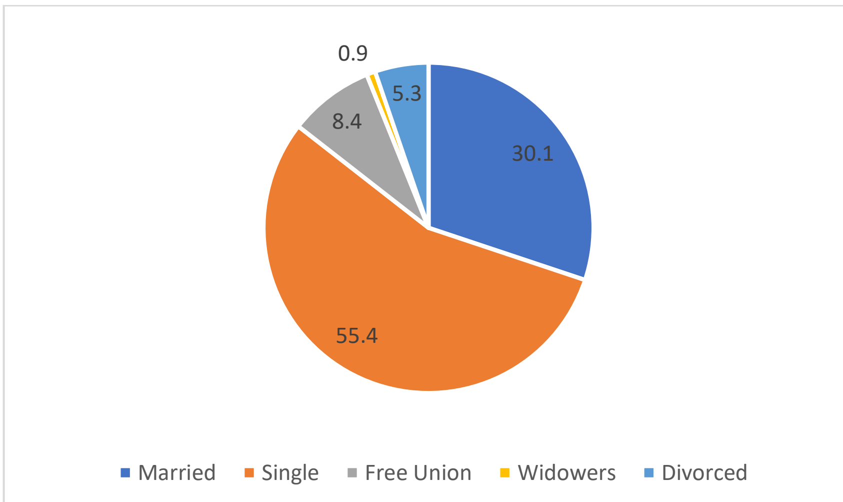



Figure 1. Marital status of the participants (%).

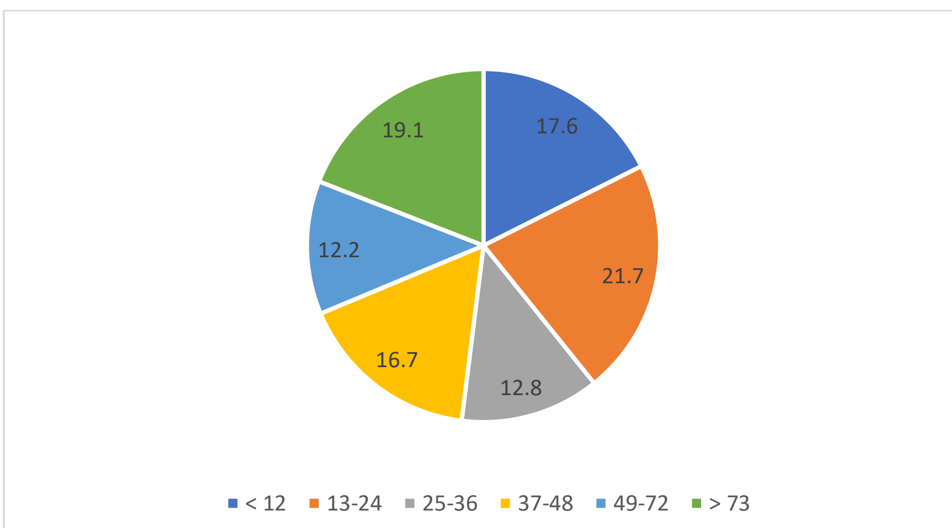



Figure 2. Seniority of the participants, in months.

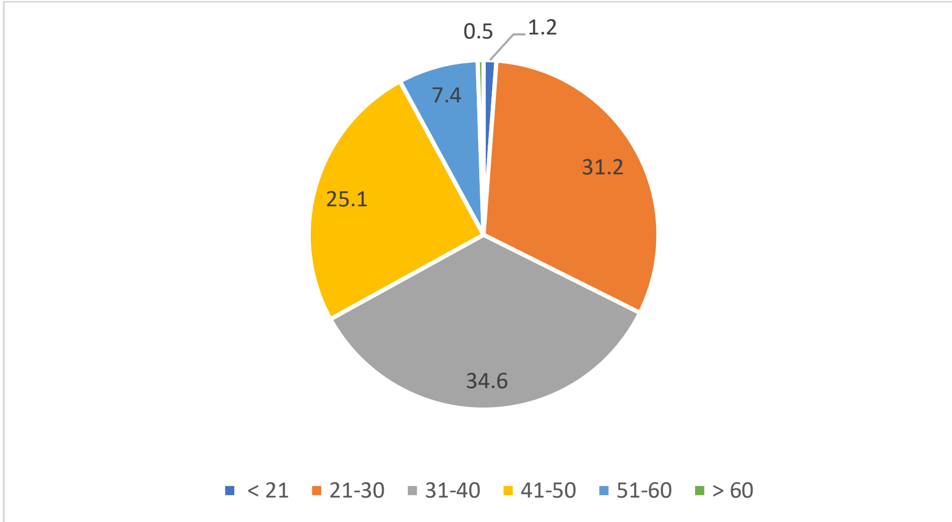



Figure 3. Age of the participants (years).

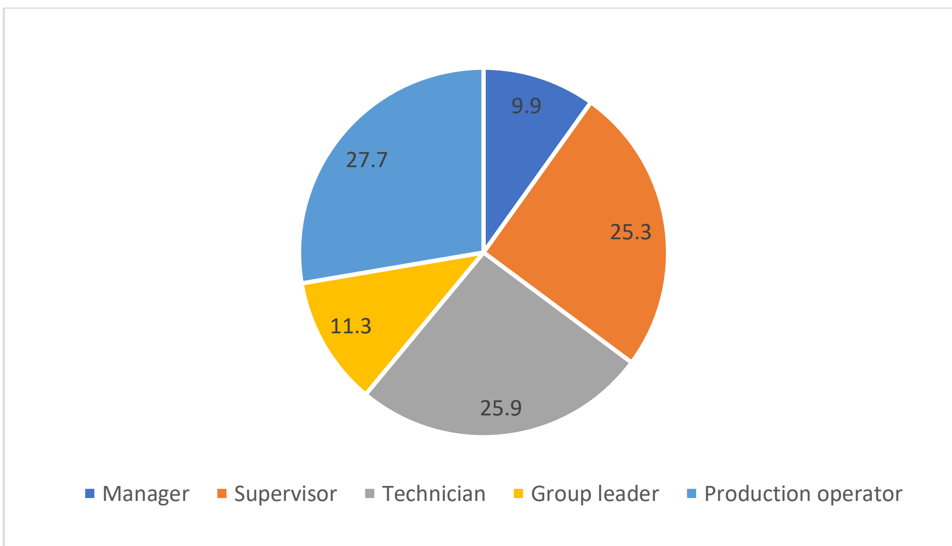



Figure 4. Position of the participants (%).

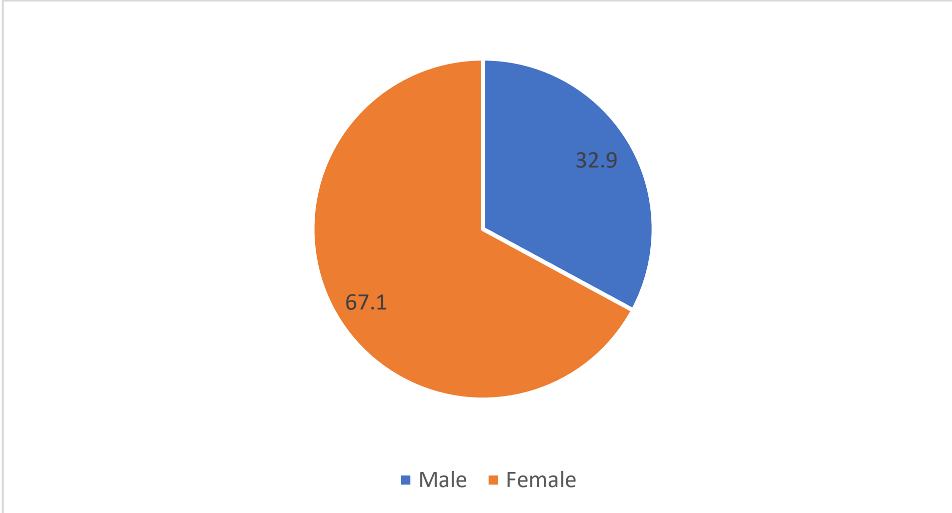



Figure 5. Gender of the participants (%).

### 3.1 Results of mean points of Burnout

The table 1 present the means points of the three dimensions of Burnout.

Table 1. Means points of Burnout

| Dimension | Mean point |
|---|---|
| Emotional exhausted | 7.8574 |
| Cynicism | 7.0214 |
| Professional efficacy | 23.0043 |

### 3.2 Grades of Burnout

The results by grades are presented in the Table 4, using the results by average scores to obtain the grades.

Table 4. Grades of Burnout

| Grade | Emotional exhausted | Cynicism | Professional Efficacy |
|---|---|---|---|
| Low | <=5 | <=4 | >30 |
| Medium | 6-9 (7.85) | 5-9 (7.02) | 19-29 (23.00) |
| High | >10 | >10 | <=18 |

The results show that the three dimensions of the Burnout are located at an average degree.

### 3.3 Levels of Burnout

The result by levels is presented in the Table 5.

Table 5. Levels of Burnout

| Level | Percentage |
|---|---|
| None | 21.97 |
| Low | 22.40 |
| Medium | 20.79 |
| Enough | 17.90 |
| Extreme | 16.93 |

### 3.4 Marital Status and Burnout

To determine if there is a difference in the level of Burnout, an ANOVA was conducted. The results are shown in Table 2, where p-values < 0.05, so it can be concluded that there is a difference between the levels of Burnout depending on the marital status of the participant.

Table 2. ANOVA test whit α = 0.05

| | | Sum of Squares | Degrees of Freedom | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Emotional Exhaustion | Between Groups | 11.99 | 4 | 2.998 | 4.161 | 0.002 |
| | Within Groups | 668.505 | 928 | 0.72 | | |
| | Total | 680.495 | 932 | | | |
| Cynicism | Between Groups | 7.06 | 4 | 1.765 | 2.673 | 0.031 |
| | Within Groups | 612.837 | 928 | 0.66 | | |
| | Total | 619.897 | 932 | | | |
| Professional Efficacy | Between Groups | 12.122 | 4 | 3.03 | 4.69 | 0.001 |
| | Within Groups | 599.668 | 928 | 0.646 | | |
| | Total | 611.79 | 932 | | | |

To get a clearer picture, this study ran the Tukey's test, the results of which are shown in Table 3. Accordingly some results are:

- Emotional Exhausted: There is a difference in the perceived level between single and married participants, as well as between single and free-living participants.
- Cynicism: There is no significant difference.

- Professional Efficacy: There is a difference between single and married participants, between widowers and singles and between widowers and married participants.

Table 3. Tukey´s test.

| Dependent Variable | | | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Emotional Exhausted | Single | Married | .212* | 0.063 | 0.007 | 0.04 | 0.38 |
| | | Free Union | 0.020 | 0.109 | 1.000 | -0.28 | 0.32 |
| | | Widower | 0.007 | 0.304 | 1.000 | -0.82 | 0.84 |
| | | Divorced | -0.115 | 0.131 | 0.905 | -0.47 | 0.24 |
| | Free Union | Single | -.212* | 0.063 | 0.007 | -0.38 | -0.04 |
| | | Free Union | -0.192 | 0.103 | 0.337 | -0.47 | 0.09 |
| | | Widower | -0.205 | 0.302 | 0.961 | -1.03 | 0.62 |
| | | Divorced | -0.327 | 0.127 | 0.075 | -0.67 | 0.02 |
| | Widower | Single | -0.020 | 0.109 | 1.000 | -0.32 | 0.28 |
| | | Married | 0.192 | 0.103 | 0.337 | -0.09 | 0.47 |
| | | Widower | -0.013 | 0.315 | 1.000 | -0.87 | 0.85 |
| | | Divorced | -0.135 | 0.155 | 0.906 | -0.56 | 0.29 |
| | Divorced | Single | -0.007 | 0.304 | 1.000 | -0.84 | 0.82 |
| | | Married | 0.205 | 0.302 | 0.961 | -0.62 | 1.03 |
| | | Free Union | 0.013 | 0.315 | 1.000 | -0.85 | 0.87 |
| | | Divorced | -0.122 | 0.324 | 0.996 | -1.01 | 0.76 |
| | Married | Single | 0.115 | 0.131 | 0.905 | -0.24 | 0.47 |
| | | Married | 0.327 | 0.127 | 0.075 | -0.02 | 0.67 |
| | | Free Union | 0.135 | 0.155 | 0.906 | -0.29 | 0.56 |
| | | Widower | 0.122 | 0.324 | 0.996 | -0.76 | 1.01 |
| Cynicism | Single | Married | 0.103 | 0.060 | 0.432 | -0.06 | 0.27 |
| | | Free Union | 0.252 | 0.104 | 0.110 | -0.03 | 0.54 |
| | | Widower | 0.521 | 0.291 | 0.380 | -0.28 | 1.32 |
| | | Divorced | 0.246 | 0.126 | 0.290 | -0.10 | 0.59 |
| | Free Union | Single | -0.103 | 0.060 | 0.432 | -0.27 | 0.06 |
| | | Free Union | 0.150 | 0.099 | 0.553 | -0.12 | 0.42 |
| | | Widower | 0.419 | 0.290 | 0.598 | -0.37 | 1.21 |
| | | Divorced | 0.143 | 0.121 | 0.763 | -0.19 | 0.48 |
| | Widower | Single | -0.252 | 0.104 | 0.110 | -0.54 | 0.03 |
| | | Married | -0.150 | 0.099 | 0.553 | -0.42 | 0.12 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Widower | 0.269 | 0.302 | 0.900 | -0.56 | 1.09 |
| | | Divorced | -0.006 | 0.148 | 1.000 | -0.41 | 0.40 |
| | Divorced | Single | -0.521 | 0.291 | 0.380 | -1.32 | 0.28 |
| | | Married | -0.419 | 0.290 | 0.598 | -1.21 | 0.37 |
| | | Free Union | -0.269 | 0.302 | 0.900 | -1.09 | 0.56 |
| | | Divorced | -0.276 | 0.310 | 0.901 | -1.12 | 0.57 |
| | Married | Single | -0.246 | 0.126 | 0.290 | -0.59 | 0.10 |
| | | Married | -0.143 | 0.121 | 0.763 | -0.48 | 0.19 |
| | | Free Union | 0.006 | 0.148 | 1.000 | -0.40 | 0.41 |
| | | Widower | 0.276 | 0.310 | 0.901 | -0.57 | 1.12 |
| Professional Efficacy | Single | Married | 0.001 | 0.060 | 1.000 | -0.16 | 0.16 |
| | | Free Union | -.355* | 0.103 | 0.005 | -0.64 | -0.07 |
| | | Widower | -0.310 | 0.288 | 0.818 | -1.10 | 0.48 |
| | | Divorced | -0.265 | 0.124 | 0.210 | -0.60 | 0.08 |
| | Free Union | Single | -0.001 | 0.060 | 1.000 | -0.16 | 0.16 |
| | | Free Union | -.357* | 0.098 | 0.003 | -0.62 | -0.09 |
| | | Widower | -0.312 | 0.286 | 0.812 | -1.09 | 0.47 |
| | | Divorced | -0.266 | 0.120 | 0.175 | -0.59 | 0.06 |
| | Widower | Single | .355* | 0.103 | 0.005 | 0.07 | 0.64 |
| | | Married | .357* | 0.098 | 0.003 | 0.09 | 0.62 |
| | | Widower | 0.045 | 0.298 | 1.000 | -0.77 | 0.86 |
| | | Divorced | 0.091 | 0.147 | 0.972 | -0.31 | 0.49 |
| | Divorced | Single | 0.310 | 0.288 | 0.818 | -0.48 | 1.10 |
| | | Married | 0.312 | 0.286 | 0.812 | -0.47 | 1.09 |
| | | Free Union | -0.045 | 0.298 | 1.000 | -0.86 | 0.77 |
| | | Divorced | 0.046 | 0.307 | 1.000 | -0.79 | 0.88 |
| | Married | Single | 0.265 | 0.124 | 0.210 | -0.08 | 0.60 |
| | | Married | 0.266 | 0.120 | 0.175 | -0.06 | 0.59 |
| | | Free Union | -0.091 | 0.147 | 0.972 | -0.49 | 0.31 |
| | | Widower | -0.046 | 0.307 | 1.000 | -0.88 | 0.79 |
| *. The mean difference is significant at the 0.05 level. | | | | | | | |

## 5. CONCLUSIONS

It can be concluded that the prevalence of Burnout in the sample presents a Medium degree of Burnout all dimensions, and in reference of the Burnout by levels it is concluded that 75% of the sample presents some level of Burnout, where more than 30% is found in the higher levels.

It is possible to conclude that there is evidence of the presence of Burnout in all the studied marital statuses; however, the statistical tests showed that the sole dimension of Burnout where a statistical difference was found is emotional exhaustion and that the marital state that causes this difference is being married where the significant values were encountered.

The results obtained in this investigation differ partially with some studies found, such the one by Facal-Fondo, (2012) that found non-significant relationships between marital status and the Burnout. In the other hand, the study of Ramírez, (2017) presents similarities with our findings by highlighting that the marital status is directly related with Burnout.

## ACKNOWLEDGEMENT

The authors thank the participating companies for their invaluable contributions and participation. Similarly, we thank the Autonomous University of Ciudad Juárez (UACJ) and the National Institute of Science and Technology (CONACYT) for the financial support granted through project CONACYT-INS (FRONTERAS CIENCIA) 2016-01-2433.

## REFERENCES

Aguirre, N.H., Medellín, J., Vázquez, L., Gutiérrez, G. & Fernández, M. C. (2014). Síndrome de quemarse por el trabajo y su relación con el puesto de trabajo en empleados de la industria maquiladora. Revista PsicologiaCientifica.com, 16.

Bautista, O., Tombé, P., & Victoria, M. (2013). Síndrome de Burnout y su relación con el Estado de Salud Mental en un Grupo de Trabajadores de Seguridad Privada. Revista Colombiana de Salud Ocupacional, 3(4), 20–24.

Carina R. Peralta Ayala, T. J. M. S. (2018). Síndrome de Burnout en estudiantes de Odontología—Dialnet. https://dialnet.unirioja.es/servlet/articulo?codigo=5802896

Facal-Fondo, T. (2012). Prevalencia del Síndrome de Burnout en trabajadores sociales de los servicios sociales comunitarios [Prevalence of Burnout in Social Workers in Community Social Services]. Portularia, 12(1), 59–69. https://doi.org/10.5218/prts.2012.0034

Fátima Izquierdo Botica. (2019). Estrés laboral: No dejes que entre en tu vida—Fundación Española del Corazón. https://fundaciondelcorazon.com/corazon-facil/blog-impulso-vital/2499-estres-laboral-no-dejes-que-entre-vida.html

González, A. & D. (2019). Estrés laboral, ladrón de la salud y la productividad empresarial. http://lanotaeconomica.com.co/pildoras-ejecutivas/estres-laboral-ladron-de-la-salud-y-la-productividad-empresarial.html

Guerrero, E. y Vicente, F. (2001). Síndrome de burnout o desgaste profesional y estrés en el profesorado. Servicio de publicaciones de la Universidad de Extremadura (en prensa).

Hernando Ávila Toscano, J., & Tatiana Gómez Hernández Marlen Margoth Montiel Salgado, L. (2010). Características demográficas y laborales asociadas al Síndrome de Burnout en profesionales de la salud1 (Vol. 8, Número 15).

IMSS. (2018). Estrés Laboral. http://www.imss.gob.mx/salud-en-linea/estres-laboral

Moreno-Jiménez, B., Rodríguez-Carvajal, R., & Escobar Redonda, E. (2001). La evaluación del burnout profesional. Facotrialización del MBI-GS. Un análisis preliminar. Ansiedad y Estrés, 7(1), 69–78.

Picasso-Pozo, M., Huillca-Castillo, N., Ávalos-Marquez, J., Omori-Mitumori, E., Gallardo-Schultz, A., Salas-Chavez, M., Ángel Picasso Pozo Dirección, M., Badajoz, C., & Luis Lima, S. (2017). Artículo Original BURNOUT'S SYNDROME IN DENTAL STUDENTS OF A PERUVIAN UNIVERSITY. Kiru, 9(1), 2012.

Quezada Berumen, L. Carmen., & Gonzales Ramirez, M. Teresa. (2018). El papel de los estresores y las condiciones de estado civil para explicar la depresión y el estrés en adolescentes gestantes. https://www.redalyc.org/articulo.oa?id=21323171003&idp=1&cid=32156

Ramírez, M. R. (2017). Prevalencia del síndrome de burnout y la asociación con variables sociodemográficas y laborales en una provincia de Ecuador. International Journal of Developmental and Educational Psychology. Revista INFAD de Psicología., 4(1), 241. https://doi.org/10.17060/ijodaep.2017.n1.v4.1053

Sandín, B. (2003). El estrés: Un análisis basado en el papel de los factores sociales—Dialnet. https://dialnet.unirioja.es/servlet/articulo?codigo=325942

Teresa González Ramírez, M., Landero Hernández, R., & De Citar, F. (2008). Confirmación de un modelo explicativo del estrés y de los síntomas psicosomáticos mediante ecuaciones estructurales. En Rev Panam Salud Publica/Pan Am J Public Health (Vol. 23, Número 1).

# PSYCHOSOCIAL RISK FACTORS AT WORK. COMPARATIVE ANALYSIS BETWEEN DOMAINS USING REFERENCE GUIDE II OF NOM-STPS-035-2018 IN WORKERS RELATED TO THE SALE, DISTRIBUTION AND STORAGE OF CONSTRUCTION MATERIALS.

**José Ignacio Aguilar Carrasco, Johana Jakelin Murillo Higuera, Sandy Orantes Higuera, Ramón Geovanny García Solorio and Germán Gerardo Higuera.**

División de Ingeniería Industrial
Instituto Tecnológico Superior de Cd. Constitución
Constitución, Marcelo Rubio Ruiz s/n
Colonia cuatro de Marzo
Cd. Constitución, Baja California Sur 23641

Jose.ac@cdconstitucion.tecnm.mx, L173110099@cdconstitucion.tecnm.mx, L173110131@cdconstitucion.tecnm.mx, L173110119@cdconstitucion.tecnm.mx and L173110148@cdconstitucion.tecnm.mx.

**Resumen**: En Octubre del 2019 en México entra en vigor la NOM-035-STPS-2018 cuyo objetivo es identificar identificar, analizar y prevenir los factores de riesgo psicosociales a los cuales están expuestos los trabajadores en su entorno laboral empleando diversos cuestionarios incluidos en la norma. En la presente investigacion se encuestó a un grupo de trabajadores de una empresa del sector servicios para identificar los niveles de factores de riesgo psicosocial utilizando la guía de referencia II incluida en en los anexos de la mencionada norma, ademas con los resultados obtenidos se realizó un análisis descriptivo clasificando los ítems por dominio y a través de un análisis de varianza unifactorial se determinó si existe diferencia significativa entre las puntuaciones medias obtenidas de los dominios. De esta manera se pretende demostrar que el análisis de los factores de riesgo psicosociales puede servir como herramienta para mantener las buenas prácticas de convivencia y salud en el trabajo promoviendo la aplicancion de la NOM-035-STPS-2018.

**Palabras clave**: Riesgos psicosociales, análisis de varianza, salud en el trabajo y NOM-035-STPS-2018.

**Relevancia para la ergonomía**: A partir de octubre del año 2019 entró en vigor la NOM-035-STPS-2018 en la cual se establecen los mecanismos para la identificación, control y seguimiento de factores de riesgo psicosocial, es por ello que, gracias a la reciente incorporación de la mencionada norma, el análisis de riesgos psicosociales forma parte importante en las actividades de los encargados de la salud y seguridad ocupacional.

Como se demostró en la presente investigación, se puede identificar cuáles son los factores que riesgo que afectan en mayor nivel a un grupo de trabajadores, a pesar de que la aparición de estos puede presentarse en niveles insignificantes, es importante iniciar con un análisis que permita establecer medidas preventivas considerando los resultados obtenidos.

**Abstract:** October 2019 in Mexico the NOM-035-STPS-2018 enters into force whose objective is to identify, analyze and prevent psychosocial risk factors to which workers are exposed in their work environment using various questionnaires included in the NOM. In this research, a group of workers from a service sector company was surveyed to identify the levels of psychosocial risk factors using reference guide II included in the annexes of the aforementioned standard, in addition to the results obtained, a descriptive analysis classifying the items by domain and through a unifactorial analysis of variance it was determined if there is a significant difference between the mean scores obtained from the domains. In this way, it is intended to demonstrate that the analysis of psychosocial risk factors can serve as a tool to maintain good coexistence and health practices at work by promoting the application of NOM-035-STPS-2018.

**Keywords**. Psychosocial risks, analysis of variance and health at work and NOM-035-STPS-2018.

**Relevance to Ergonomics**: As of October 2019, the NOM-035-STPS-2018 came into force, which establishes the mechanisms for the identification, control and monitoring of psychosocial risk factors, which is why to the recent incorporation of the mentioned standard, the analysis of psychosocial risks is an important part of the activities of those in charge of occupational health and safety.

As demonstrated in this research, it is possible to identify which are the risk factors that affect a group of workers at a higher level, despite the fact that the appearance of these can occur at insignificant levels, it is important to start with an analysis that allows establish preventive measures considering the results obtained.

## 1. INTRODUCTION

Currently there is a diversity of work activities in which the mexican worker operates, that is why the identification, control and prevention of risks in the workplace is a fundamental activity to keep health at work in optimal conditions. In this sense, psychosocial risks can be considered as a factor that affect health at work, this concept originates during the last quarter of the last century, Moreno (2011) defines it as being work situations that have a high probability of damaging seriously the health of workers, physically, socially or mentally. The importance of the investigation of this type of risks is that psychological harassment and intimidation at work are frequent causes of work-related stress, therefore they can cause health effects in workers such as low self-esteem, harmful alcohol consumption, drugs or any type of substance that affects the good performance of productive activities during the journal work.

In Mexico as of October 2019, the NOM-035-STPS-2018 enters into force through the Secretaria del Trabajo y Previsión Social, which is called “Psychosocial Risk Factors at Work-Identification, Analysis and Prevention”. This rule aims to identify, analyze and prevent the psychosocial risk factors to which workers are exposed in their work environment through the application of various questionnaires depending on the number of workers that the company has.

In this sense, reference guide II of the aforementioned NOM was applied to identify psychosocial risk factors in a company dedicated to the storage, logistics and commercialization of construction products in Ciudad Constitución Baja California Sur. In addition, a descriptive analysis was carried out with the results obtained by classifying the items by domain, in the same way, through an ANOVA analysis, it was determined whether there is a significant difference between the average scores obtained from the domains. In this way it is intended to demonstrate that the analysis of psychosocial risk factors can serve as a tool to maintain good practices of coexistence and health at work.

## 2. OBJECTIVES

Identify the psychosocial risk factors in the company “ELÉCTRICA Y PLOMERÍA DE SUDCALIFORNIA S DE RL DE CV” through a descriptive analysis of the results obtained from the reference guide II, extracted from NOM-035-STPS-2018.

Specific objectives:

- Analyze the psychosocial risk factors grouped by domains to make a comparison of means and identify which of the domains is presented with the highest score.
- Establish the levels of risk found in participants based on NOM-035-STPS-2018.

## 3. METHODOLOGY

It is important to mention that in the present study the application of NOM-035-STPS-2018 was not carried out, only the questionnaire called reference guide II was considered, which is used for workplaces that have up to 50 workers and is aimed at the identification of psychosocial risk factors.

After conducting a thorough analysis of the 46 items of the questionnaire, the following was carried out:

- The generalities of the aforementioned NOM were visited and explained to the managers of the company, this to explain the context of the investigation.
- Once the methodology for the application of the questionnaire was organized, it was applied in paper format, giving the participants the appropriate conditions in time and form for its correct filling.
- By management provisions 15 surveys were applied that at the end of its filling it was verified that they were answered correctly, resulting in 15 questionnaires filled correctly by workers who perform various activities such

as secretarial activities, loading and unloading of material, warehouse work and work of personnel supervision. The filling of the questionnaires was done anonymously.

Once the research work in the workplace was completed, the responses were processed, for which Table 1 was consulted, which shows the values for the weighting of the questionnaire items:

Table 1. Value of response options. Source: NOM-035-STPS-2018

| **Items** | **Rating of response options** | | | | |
|---|---|---|---|---|---|
| | **Always** | **Almost always** | **Sometimes** | **Almost never** | **Never** |
| 18,19,20,21,22,23,24, 25,26,27,28,29,30,31, 32,33 | 0 | 1 | 2 | 3 | 4 |
| 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,34,35,36,37,38,39,40,41,42,43,44,45,46 | 4 | 3 | 2 | 1 | 0 |

.

To obtain the total grade, the ranges shown in table 2 should be considered:

Table 2. Ranges of scores obtained for the total qualification of the questionnaire. Source: NOM-035-STPS-2018.

| **Questionnaire result** | **Null** | **Low** | **Medium** | **High** | **Very high** |
|---|---|---|---|---|---|
| final qualification of the questionnaire Cfinal | Cfinal < 20 | 20≤ Cfinal< 45 | 45≤ Cfinal < 70 | 70≤ Cfinal < 90 | Cfinal ≥90 |

To obtain the domain rating, the score of each of the items that make up the domain is added and the following ranges shown in table 3 are considered:

Table 3. Ranges for domain qualification. Source: NOM-035-STPS-2018

| **Domain** | **Null** | **Low** | **Medium** | **High** | **Very high** |
|---|---|---|---|---|---|
| conditions of work environment | Cdom < 3 | 3≤ Cdom< 5 | 5≤ Cdom< 7 | 7≤ Cdom < 9 | Cdom≥9 |
| workload | Cdom < 12 | 12≤ Cdom< 16 | 16≤ Cdom< 20 | 20≤ Cdom < 24 | Cdom≥24 |
| lack of control over work | Cdom < 5 | 5≤ Cdom< 8 | 8≤ Cdom< 11 | 11≤ Cdom < 14 | Cdom≥14 |
| workday | Cdom < 1 | 1≤ Cdom< 2 | 2≤ Cdom< 4 | 4≤ Cdom < 6 | Cdom≥6 |
| interference in the work- | Cdom < 1 | 1≤ Cdom< 2 | 2≤ Cdom< 4 | 4≤ Cdom < 6 | Cdom≥6 |

| | | | | | |
|---|---|---|---|---|---|
| family relationship | | | | | |
| leadership | Cdom < 3 | 3≤ Cdom< 5 | 5≤ Cdom< 8 | 8≤ Cdom < 11 | Cdom≥11 |
| work relationships | Cdom < 5 | 5≤ Cdom< 8 | 8≤ Cdom < 11 | 11≤ Cdom < 14 | Cdom≥14 |
| violence | Cdom < 7 | 7≤ Cdom< 10 | 10≤ Cdom < 13 | 13≤ Cdom < 16 | Cdom≥16 |

.

To concentrate the questionnaire responses, a concentrator format was designed in Excel software where the scores obtained by domain of each participant were emptied as shown in table 4:

Table 4. Results concentrator format per domain

| **Participante 1** | | | | | |
|---|---|---|---|---|---|
| **Resultado del dominio** | **Null** | **Low** | **Medium** | **High** | **Very high** |
| conditions of work environment | | | 5 | | |
| workload | | | 18 | | |
| lack of control over work | | 7 | | | |
| workday | 0 | | | | |
| interference in the work-family relationship | | 1 | | | |
| leadership | 2 | | | | |
| work relationships | 3 | | | | |
| violence | 4 | | | | |

| **CALIF.FINAL** | **RANGE** |
|---|---|
| 40 | LOW |

.

A coding was established to determine the degree of affectation for each domain, in this way a numerical value was assigned to each level, resulting in the following: null = 0, low = 1, medium = 2, high = 3, very high = 4.

For the interpretation of the results of the average scores obtained by domain, the following ranges were considered (Table 5):

Table 5. Ranks for domain scores

| Null level | Low level | Medium level | High level | Very high level |
|---|---|---|---|---|
| score< 1 | 1≤ score< 2 | 2≤ score < 3 | 3≤ socre < 4 | score ≥4 |

.

Through SPSS software, the analysis of variance was used to know the descriptive statistics and identify the significant difference between the result of the average scores obtained by each domain among the participants.

## 4. RESULTS

To obtain the average score of the first domain “Conditions in the work environment”, the average of the 15 participants considering the coding, so if the number participant was at an average level in this domain, the result was 2 , this methodology was applied for each and for each domain resulting in the following descriptive statistics (table 6):

Table 6. Descriptive statistics of the domains

| Domain | N | average | Level | typical deviation | Error típico | Intervalo de confianza para la media al 95% | | Mín. | Máx. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Límite inferior | Límite superior | | |
| conditions of work environment | 15 | 0.6000 | Null | .73679 | .19024 | .1920 | 1.0080 | .00 | 2.00 |
| workload | 15 | 1.8667 | Low | 1.12546 | .29059 | 1.2434 | 2.4899 | .00 | 4.00 |
| lack of control over work | 15 | 2.0000 | Medium | 1.25357 | .32367 | 1.3058 | 2.6942 | .00 | 4.00 |
| workday | 15 | 0.1333 | Null | .35187 | .09085 | -.0615 | .3282 | .00 | 1.00 |
| interference in the work-family relationship | 15 | 1.0667 | Low | .88372 | .22817 | .5773 | 1.5561 | .00 | 2.00 |
| leadership | 15 | 0.9333 | Null | 1.27988 | .33046 | .2246 | 1.6421 | .00 | 4.00 |
| work relationships | 15 | 0.4000 | Null | .63246 | .16330 | .0498 | .7502 | .00 | 2.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| violence | 15 | 0.1333 | Null | .35187 | .09085 | -.0615 | .3282 | .00 | 1.00 |
| Total | 120 | 0.8917 | Null | 1.10610 | .10097 | .6917 | 1.0916 | .00 | 4.00 |

As shown in the previous table, it is possible to identify that the domain with the highest average score is the lack of control over the work, being located at a medium level = 2. In addition, as it can see, most of the domains are located at a null level. or low, so there is no need to investigate in depth about the causes that give rise to high levels of risk levels in these domains. Table 7 shows the results of the analysis of variance, a significance of 0.05 was used to determine if there is a significant difference between the results of the domains in at least one of them:

Table 7. ANOVA results

| | **Suma de cuadrados** | **gl** | **Media cuadrática** | **F** | **Sig.** |
|---|---|---|---|---|---|
| Inter-grupos | 55.325 | 7 | 7.904 | 9.806 | .000 |
| Intra-grupos | 90.267 | 112 | .806 | | |
| Total | 145.592 | 119 | | | |

.

Considering that the significance obtained was 0.000 and that it is less than 0.05, it can be concluded that if there is a difference between at least one average score of any of the domains, to identify it, Tukey's multiple comparisons test was used, which shows that the domain "lack of control over work" is the one that presents the greatest difference between the rest as shown in table 8:

Table 8. The difference in means is significant at the .05 level.

| **(I) Dominio** | **(J) Dominio** | **Diferencia de medias (I-J)** | **Error típico** | **Sig.** | **Intervalo de confianza al 95%** | |
|---|---|---|---|---|---|---|
| | | **Límite inferior** | **Límite superior** | **Límite inferior** | **Límite superior** | **Límite inferior** |
| lack of control over work | conditions of work environment | 1.40000(*) | .32781 | .001 | .3874 | 2.4126 |
| | workload | .13333 | .32781 | 1.000 | -.8793 | 1.1460 |
| | workday | 1.86667(*) | .32781 | .000 | .8540 | 2.8793 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | interference in the work-family relationship | .93333 | .32781 | .094 | -.0793 | 1.9460 |
| | leadership | 1.06667(*) | .32781 | .031 | .0540 | 2.0793 |
| | work relationships | 1.60000(*) | .32781 | .000 | .5874 | 2.6126 |
| | violence | 1.86667(*) | .32781 | .000 | .8540 | 2.8793 |

Finally, in the image one shows a variation of the average scores, the domain "lack of control over work" is clearly identified as the one of greatest interest since its level is above the others.

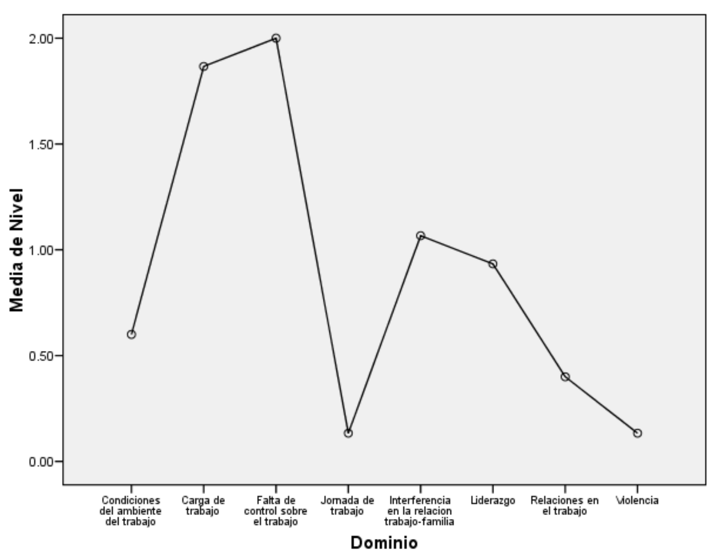
## 5. CONCLUSIONS

As demonstrated above, the domain "lack of control over work" turned out to have the highest average score, this situation refers to the participants feeling identified with the following set of related situations in their workplace:

- Lack of control and autonomy over work.
- Limited or no possibility of development.
- Limited or nonexistent training.

Although the level of this domain is located in the middle, it is important that the company carries out preventive actions to avoid the appearance of high levels of psychosocial risks, these actions may include the design of a risk prevention policy and promotion programs to preserve the organizational environment in favorable conditions, in addition to establishing the mechanisms so that employees feel better prepared through training programs in the activities they perform, in this way the level found for this domain can be reduced.

Figure 1 Graph of means.



## 6. REFERENCES

Moreno, B. (2011). Factores y riesgos laborales psicosociales: conceptualización, historia y cambios actuales. *Medicina y seguridad del trabajo*, 1: 1-262. Recuperado de http://scielo.isciii.es/pdf/mesetra/v57s1/especial.pdf

NOM-035-STPS-2018. Recuperado de https://www.dof.gob.mx/nota_detalle.php?codigo=5541828&fecha=23/10/2018

# IDENTIFICATION OF ERGONOMIC AND PSYCHOSOCIAL RISK FACTORS IN NURSING PROFESSIONALS IN THE SONORA HOSPITAL

**Edith Montoya Enriquez, Francisco Octavio López Millán, Enrique Javier de la Vega Bustillos, Martha Estela Diaz Muro**

Divisón de Estudios de Posgrado e Investigación
Tecnológico Nacional de México/Instituto Tecnológico de Hermosillo
Av. Tecnológico S/N, Col. Sahuaro
Hermosillo, Sonora, México
edithmontoyae@gmail.com, lopezoctavio@yahoo.com.mx

**Resumen**. En la actualidad, la seguridad y salud son dos factores de gran importancia en todos los ámbitos. El departamento de Seguridad y Salud en el trabajo en México, destaca la elevada proporción del personal Sanitario con problemas Musculo Esqueléticos, específicamente las lesiones en espalda, encontrando una relación significativa con altos niveles de estrés derivados al tipo de trabajo que desempeñan (secretaria del Trabajo y Previsión Social, 2017).
El objetivo de este proyecto es identificar y establecer la asociación entre factores de riesgo por exposición física y psicosocial intralaboral con la presencia de síntomas de dolor por región corporal en trabajadores del sector sanitario. La metodología se integró en tres fases; 1) evaluación del riesgo ergonómico 2) evaluación del riesgo psicosocial 3) análisis de los resultados. El tipo de estudio descriptivo, exploratorio de corte transversal a 50 profesionales de enfermería en el área de medicina interna y cirugía. Se recolectaron datos sociodemográficos, laborales y extralaborales.

**Palabras clave**: Riesgo Ergonómico, Riesgo Psicosocial, Trastorno Musculo Esquelético, Personal Sanitario.

**Relevancia para la ergonomía**: Identificación de los factores de riesgo ergonómico y psicosocial asociados con sintomatología de trastornos musculoesqueléticos. Analisis de causalidad de los datos a través de técnicas multivariantes para posibles estudios posteriores.

**Abstract:** Nowadays, health and safety are two factors of great importance in all areas. The Department of Safety and Health at work in Mexico highlights the high proportion of health personnel with musculoskeletal problems, specifically back injuries, finding a significant relationship with high levels of stress derived from the type of work they perform (Secretary of Labor and Social Security, 2017).

The objective of this project is to identify and establish the association between risk factors due to physical and psychosocial intra-occupational exposure with the presence of pain symptoms by body region in health sector workers. The methodology was integrated into three phases; 1) ergonomic risk assessment 2) psychosocial risk assessment 3) analysis of the results. The type of descriptive, exploratory cross-sectional study of 50 nursing professionals. Sociodemographic, work, and non-work data were collected.

**Keywords:** Ergonomic Risk, Psychosocial Risk, Skeletal Muscle Disorder, Health Personnel.

**Relevance to Ergonomics:** Identification of ergonomic and psychosocial risk factors associated with the symptoms of musculoskeletal disorders. Data causality analysis through multivariate techniques for possible subsequent studies.

## 1. INTRODUCTION

One of the main factors that interfere in the presence of occupational risk in health personnel is the overload of work. The nurse-patient relationship is the coefficient that determines the workload of nursing work. When the nurse-patient relationship is high, due to the lack of personnel, it is when both physical and mental consequences occur in the nurse (Andrea et al., 2015).

According to data from the Organization for Economic Cooperation and Development (OECD, 2018), Mexico has 2.8 nurses per 1,000 inhabitants, a value considerably lower than the figure established at least by the WHO (23 nurses per 1,000 inhabitants). In the state of Sonora, the indicator is below the average with 3.0 nurses per 1,000 inhabitants, 70% are women in the ranges of 41 to 50 years in their majority (Ministry of Health, 2018).

Musculoskeletal injuries in nursing professionals are due in large part to overexertion associated with patient transfer and repositioning, among the most common high-risk patient management tasks include transferring the patient from toilet to chair, transferring from chair to bed, transfer from a bathtub to chair, reposition from side to side in bed, lift the patient from the bed, reposition the patient in the chair, and change the bedclothes with a patient in it (US Department of Labor, 2018).

Another important aspect is related to long hours of work, which generates fatigue in health personnel, inadequate recovery, lack of sleep are strongly associated with cognitive, psychomotor, and behavioral deterioration. Documented incidents include slower reaction times, inattention to critical details, errors of omission, reduced motivation to complete required tasks (Goel, Rao, Durmer, & Dinges, 2009).

This research work develops a multivariate correlation between the Ergonomic and Piscosocial Risk factors associated with musculoskeletal disorders, through the ergonomic evaluation methods REBA and ART tool, the Nordic Kourinka questionnaire, psychosocial evaluation applying the Reference Guide III questionnaire, proposed in NOM-035-STPS-2018; identification of psychosocial risk factors and favorable organizational environment.

## 2. OBJECTIVES

There are three main goals in this research:

I.- Identify the exposure to ergonomic and psychosocial risks derived from nursing interventions in the area of surgery and internal medicine.
II.- Analyze multiple relationships of demographic, socio-occupational, ergonomic, psychosocial variables with musculoskeletal pain symptoms.
III.- Determine if there are conditions adjacent to work and modifications of life cycles.

## 3. METHODOLOGY

The methodological design of this research is descriptive, exploratory with a cross-sectional cohort. This research began exploratory and ended as a descriptive correlational. A non-probabilistic sample was taken, sample selection for convenience. The exclusion criteria considered candidates with a chronic disease that justifies a musculoskeletal disorder.

### 3.1 INSTRUMENT

The following instruments were used to carry out the research:

A) REBA Method Worksheet; Assessment instrument for Physical Risk factors by Posture.
B) ART Tool Method Worksheet; Assessment instrument for Physical Risk factors for repetitive tasks.
C) Nordic Kourinka Questionnaire; Assessment instrument for determining Pain Symptoms by Body Region.
D) Reference Guide Questionnaire III of NOM-035-STPS-2018; Assessment instrument for the determination of Psychosocial Risk and evaluation of the Organizational Environment.

### 3.2 ANALYSIS OF DATA

Data were collected in parallel and separately from quantitative and qualitative data. The results of both types of analysis were not consolidated in the interpretation phase of each method until both sets of data were collected and analyzed separately. After the collection and interpretation of results, qualitative and quantitative inferences were established. Statistical analysis was performed using the IBM SPSS ® V25.0 software.

The Factorial analysis was modeled under the Structural Equations system (SEM), the IBM SPSS AMOS Software was used, allowing a multivariate analysis, including the analysis of factors and correlation.

## 4. RESULTS

The results obtained based on the demographic characterization, a global mean age of 31.54 years was obtained with a range of values between 24 and 50 years. Of the study subjects, 80% were female and 20% were male. The mean age for females is 32.13 ± 2.5 years (95% CI 34.62 - 29.63), men 29.20 ± 3.45 years (95% CI 32.65 - 25.75).

The distribution of the sample according to marital status; Most of the individuals in the study, specifically 60% (n = 30) affirm that their current status is single; 30% are married; 10% are in free union.

The level of studies presented by the analyzed population offers the following distribution; 8% (n = 4) of the subjects have a technical level; 12% (n = 6) have a bachelor's level; 78% (n = 39) have a specialty and 2% (n = 1) have a master's degree.

The mean BMI obtained was 28.03 (Overweight), with a range of values between 18 and 40 (Malnutrition - Obesity II). The mean BMI corresponding to the female sex is 28.02 ± 1.69 (95% CI 29.71 - 26.33), being 28.05 ± 2.73 (95% CI 30.78 - 25.32) in the case of men. The seniority was measured in years, the mean obtained was 8.20 ± 1.9 years.

Pain symptoms by anatomical region before the appearance of a declared disease, based on the results of the application of the Pain Symptom Questionnaire, it was determined that the anatomical region with the greatest presence of pain in health personnel is the Region Lumbar (86%), followed by symptoms of pain in Shoulders 74%, Arm and Forearm 66%, (table 1 and 2).

Table 1. Pain symptoms by body region

| **Anatomical region** | **Pain, discomfort, or discomfort in the past 12 months** | | **Interference with work tasks due to pain** | | **Pain Rating** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **1= not present** | | **2= low level** | | **3= medium level** | | **4= high level** | |
| | **n** | **%** | **n** | **%** | **n** | **%** | **n** | **%** | **n** | **%** | **n** | **%** |
| Neck | 22 | 44 | | | 28 | 56 | 9 | 18 | 13 | 26 | | |
| Dorsal region | 32 | 64 | | | 18 | 36 | 19 | 38 | 13 | 26 | | |
| Lumbar region | 47 | 94 | 3 | 6.3 | 3 | 6 | 4 | 8 | 43 | 86 | | |
| Shoulders | 46 | 92 | | | 4 | 8 | 9 | 18 | 37 | 74 | | |
| Arm / Forearm | 39 | 78 | | | 11 | 22 | 6 | 12 | 33 | 66 | | |
| Hand / wrist | 11 | 22 | 1 | 9.09 | 39 | 78 | 2 | 4 | 9 | 18 | | |
| Feet | 50 | 100 | | | | | 44 | 88 | 1 | 2 | 5 | 10 |

The results obtained in the evaluation of the risk factors for physical load and posture through the REBA method; resulted in a 39% moderate risk level, in the interventions classified as patient cleaning tasks, a very high and high-risk level index in 61% of the tasks classified as mobilization of the patient in bed and transfer of the patient, significantly affecting the load/force factor. The tasks with the greatest exposure to the risk of presenting an MSD by posture were; raising the patient to walk, assisted ambulation, postural watch, and mobilization of the patient in bed (Table 2).

Through the ergonomic evaluation method ART tool, exposure to risk from repetitive tasks presented a medium risk level in 66% of the interventions where the task needs to be closely examined, 22% of the interventions presented a level of high risk; where immediate actions are needed and 11% of the interventions with a low-risk level (Table 2).

Table 2. Risk Rating REBA and ART TOOL Method

| ***Job task*** | ***REBA Risk Level*** | ***Risk Level ART tool*** |
|---|---|---|
| 1A 0221 - Passive Exercises | Moderate | Moderate |
| 1A 0221 - Raise patient to walk | Very high | N / A |
| 1A 0221- Assisted Ambulation | Very high | N / A |
| 1B 0580 - Foley Catheter Placement | Moderate | Moderate |
| 1B 0580 - Foley Probe Water Control | High | Low |
| 1B 0580 - Foley Catheter Cleaning | High | N / A |
| 1B 1804 - Genital Grooming | Moderate | Moderate |
| 1C 0840 - Postural clock change | Very high | N / A |
| 1C 0846 - Patient Mobilization in Bed | Very high | N / A |
| 1D 1200 - Administer Patient Nutrition | Moderate | Moderate |
| 1F 1610 - Chair bath | Very high | Low |
| 1F 1610 - Change of Clothes | Moderate | N / A |
| 1F 1801 - Bed Bath | High | |
| 1F 1803 - Oral Cavity Cleaning | High | Moderate |
| 1F 1804 - Diaper Change | High | N / A |
| 1F 1804 - Placement Protector on Bed | High | N / A |
| 2G 2130 - Capillary Glycemia | Low | N / A |
| 2G 4232 - Take blood sample | Moderate | N / A |
| 2H 2240 - Chemotherapy Administration | Moderate | High |
| 2H 2300 - Drug Preparation | Null | High |
| 2H 2300 - Ventilation equipment purge | Low | Moderate |
| 2H 2314 - Forearm venous cannulation | Moderate | Moderate |
| 2H 2314 - Diverting | Moderate | Low |
| 2H 2314 - Intravenous drug supply | Moderate | N / A |
| 2H 2314 - Verification of solutions | Moderate | N / A |
| 2H 2314- medication placement | Low | N / A |
| 2I 3660 - Healing in patient | Low | Moderate |
| 2J2930 - Compressive Stockings Application | Moderate | N / A |

| | | |
|---|---|---|
| 2K 3160 - Suction of secretions | Low | Low |
| 2K 3230 - Respiratory Physiotherapy | Very high | High |
| 2M 3740 - Cold Development Application | Null | N / A |
| 2N 4030 - Transfusion (Blood, Plasma) | Moderate | N / A |
| 4V 6680 - Taking Vital Signs | Low | N / A |

In the results obtained about the levels of psychosocial risk, it was identified that 26% of the professionals presented a very high level of risk; highlighting the Work Environment category (48%) and factors specific to the activity (62%). Corresponding to the high level of psychosocial risk, the factors present were; the organizational environment (36%) and the organization of work time (28%). In the medium-risk classification; the Leadership and Labor Relations factors (42%), as shown in Table 3. The level of psychosocial risk in health personnel was very high.

Table 3. Risk Rating Method NOM-035-STPS-2018

| ***CATEGORY*** | ***RISK LEVEL*** |
|---|---|
| Work environment | Very high |
| Factors of Activity | Very high |
| Work Time Organization | High |
| Leadership And Relationships At Work | Moderate |
| Organizational Environment | High |

**Causal analysis results - Structural Equations.**

The initial model is presented in Figure 1, in which the causal analysis of the variables defined by the Ergonomic Risk factor, Psychosocial Risk, and Symptomatology by Body Region in nursing professionals begins.

In Figure 1 the two integral parts of the structural equation models can be differentiated: the measurement submodel and the structural submodel. The first of them is composed of the latent variables: (F1) Individual Factors, (F2) Intra-work Factors, (F3) Extra-Work Factors, (F4) Symptoms, (F5) Psychosocial Factors, which function as latent exogenous variables.

**Reliability Analysis**

For this study, the reliability was verified through Cronbach's Alpha, describing the average of the correlations between the variables that are part of the instruments. Based on the Geroge and Mallery (2013) scale, recommendations are suggested for the estimation of the Reliability analysis through Cronbach's Alpha.

The initial model starts from a Cronbach's Alpha 0.713, with good fit values. Based on the SPSS reliability analysis, it shows us the behavior of Cronbach's Alpha value in the initial model (Table 4).

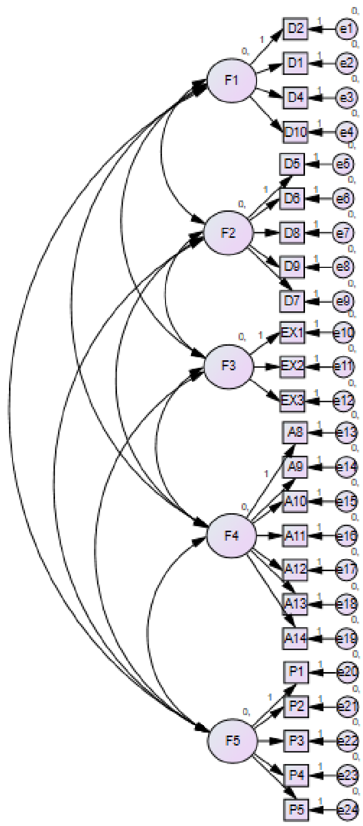



Figure 1. Initial Structural Equations Model

## Factorial analysis

Factor analysis applied to risk factors yielded the following KMO values, Barlett's sphericity test, in addition to Chi-square and degrees of freedom (Table 5). The interpretation of the results determines that the model is valid since it shows KMO values greater than 0.70, according to the classification of George and Mallery (2003) and its significance is less than 0.05.

Table 4. Cronbach's Alpha Initial Model Results

| Initial Model | Mean scale if item has been deleted | Scale variance if an item has | Corrected total item correlation | Cronbach's alpha if the item has been deleted |
|---|---|---|---|---|

| | been suppressed | | | |
|---|---|---|---|---|
| **D1** | 0.2893598 | 82.180 | 0.441 | 0.691 |
| **D2** | 0.2955719 | 78.013 | 0.682 | 0.672 |
| **D4** | 0.3099837 | 87.551 | 0.146 | 0.712 |
| **D5** | 0.3099837 | 80.147 | 0.568 | 0.682 |
| **D6** | 0.2978204 | 82.758 | 0.406 | 0.693 |
| **D7** | 0.2948115 | 80.638 | 0.532 | 0.684 |
| **D8** | 0.3031091 | 80.260 | 0.558 | 0.682 |
| **D9** | 0.2681493 | 79.784 | 0.591 | 0.680 |
| **D10** | 0.2798543 | 92.705 | -0.123 | 0.730 |
| **EX1** | 0.2839728 | 89.309 | 0.052 | 0.718 |
| **EX2** | 0.3065932 | 78.418 | 0.659 | 0.674 |
| **EX3** | 0.3039645 | 98.541 | -0.407 | 0.749 |
| **A8** | 0.3244668 | 85.843 | 0.246 | 0.705 |
| **A9** | 0.2888587 | 87.515 | 0.149 | 0.712 |
| **A10** | 0.3099837 | 87.178 | 0.169 | 0.710 |
| **A11** | 0.2993391 | 91.493 | -0.061 | 0.726 |
| **A12** | 0.2631843 | 87.405 | 0.160 | 0.711 |
| **A13** | 0.2886834 | 81.894 | 0.457 | 0.690 |
| **A14** | 0.2950974 | 85.715 | 0.243 | 0.705 |
| **P1** | 0.3128629 | 79.906 | 0.579 | 0.681 |
| **P2** | 0.3318899 | 82.876 | 0.402 | 0.694 |
| **P3** | 0.3279858 | 82.655 | 0.413 | 0.693 |
| **P4** | 0.3099837 | 80.870 | 0.513 | 0.685 |
| **P5** | 0.2703540 | 88.609 | 0.091 | 0.716 |

Table 5. KMO and Barlett test

| ***Prueba de KMO y Bartlett*** | | |
|---|---|---|
| **Medida Kaiser-Meyer-Olkin de adecuación de muestreo** | | 0.806 |
| **Prueba de esfericidad de Bartlett** | Aprox. Chi-cuadrado | 926.638 |
| | gl | 153 |
| | Sig. | 0.000 |

The table of total variance explained (Table 6) shows that of the 24 components, 3 show self-evaluations greater than “1” and that if these factors were taken, 70.861% of the variance of the system would accumulate.

Finally, the model was configured by assigning the components to each of the 4 components chosen according to the values in Table 7, from the component matrix, which will be the matrix that establishes the definitive assignment of the observed variables. This table details the weight of each variable in each main component, determining the assignment of the variables to each of the 3 components "Pain symptoms", "Psychosocial Risk Factors" and "Extra work activities".

Table 6. Total variance explained

| Componente | Autovalores iniciales | | | Sumas de cargas al cuadrado de la extracción | | | Sumas de cargas al cuadrado de la rotación |
|---|---|---|---|---|---|---|---|
| | Total | % de varianza | % acumulado | Total | % de varianza | % acumulado | Total |
| 1 | 6.134 | 43.817 | 43.817 | 6.134 | 43.817 | 43.817 | 5.492 |
| 2 | 2.580 | 18.429 | 62.245 | 2.580 | 18.429 | 62.245 | 2.975 |
| 3 | 1.206 | 8.616 | 70.861 | 1.206 | 8.616 | 70.861 | 3.877 |
| 4 | 0.940 | 7.427 | 78.288 | | | | |
| 5 | 0.924 | 6.599 | 84.887 | | | | |
| 6 | 0.778 | 5.560 | 90.447 | | | | |
| 7 | 0.427 | 3.051 | 93.498 | | | | |
| 8 | 0.260 | 1.854 | 95.352 | | | | |
| 9 | 0.218 | 1.555 | 96.907 | | | | |
| 10 | 0.157 | 1.118 | 98.025 | | | | |
| 11 | 0.111 | 0.791 | 98.817 | | | | |
| 12 | 0.080 | 0.572 | 99.388 | | | | |
| 13 | 0.048 | 0.340 | 99.728 | | | | |
| 14 | 0.038 | 0.272 | 100.000 | | | | |

* Extraction method: principal component analysis.

Finally, the model was configured by assigning the components to each of the 4 components chosen according to the values in Table 7, from the component matrix, which will be the matrix that establishes the definitive assignment of the observed variables. This table details the weight of each variable in each main component, determining the assignment of the variables to each of the 3 components "Pain symptoms", "Psychosocial Risk Factors" and "Extra work activities".

Tabla 7. Pattern matrix

| | | Component | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| P4 | Labor Relations | 0.887 | | |
| EX2 | Additional Work Frequency | 0.875 | | |

| | | | | |
|---|---|---|---|---|
| P2 | Own Factors Activity | 0.849 | | |
| P3 | Organization Time | 0.821 | | |
| P1 | Work Environment | 0.795 | | |
| A13 | Hand / Wrist Pain Rating | 0.652 | | |
| A10 | Lower Back Pain Rating | | 0.810 | |
| A11 | Shoulder Pain Rating | | 0.807 | |
| A12 | Arm Pain Rating | | 0.748 | |
| A14 | Foot Pain Rating | | | 0.627 |
| EX3 | Hours of sleep | | | 0.587 |
| EX1 | Frequency Sport | | | 0.580 |
| P5 | Organizational Environment | | | -0.548 |

Extraction method: principal component analysis.
components extracted

Psychosocial Risk Factors in health workers influence pain Symptoms or pain symptoms influence Psychosocial Risk factors. Similarly, extra-work activities influence psychosocial risk factors or psychosocial risk factors are related to extra-work activities. In a positive sense of correlation between both variables, (if one increases, the other also) or in the other negative sense (if one increases, the other decreases). These assumptions that were developed in the models reached values included within the limits of good fit.

The comparison of the results of the weight indices of the relationships between the latent variables and between the observable variables with their corresponding latent.

Table 8. Initial - definitive comparative model

| | ***Modelo Inicial*** | ***Modelo Definitivo*** |
|---|---|---|
| **No. Elemento** | 324 | 29 |
| **Alfa Cronbach** | 0.708 | 0.806 |
| **Probilit Level** | 0.000 | 0.000 |
| **Chi-square** | 541.386 | 137.833 |
| **Degrees of freedom** | 242 | 62 |
| **0≤X2/df≤2** | 2.23 | 1.56 |
| **0,97≤CFI≤1,00** | 0.592 | 0.997 |
| **0,95≤NFI≤1,00** | 0.476 | 0.957 |
| **0,95≤TLI≤1,00** | 0.494 | 1.013 |
| **0,00≤RMSEA≤0,05** | 0.223 | 0.000 |

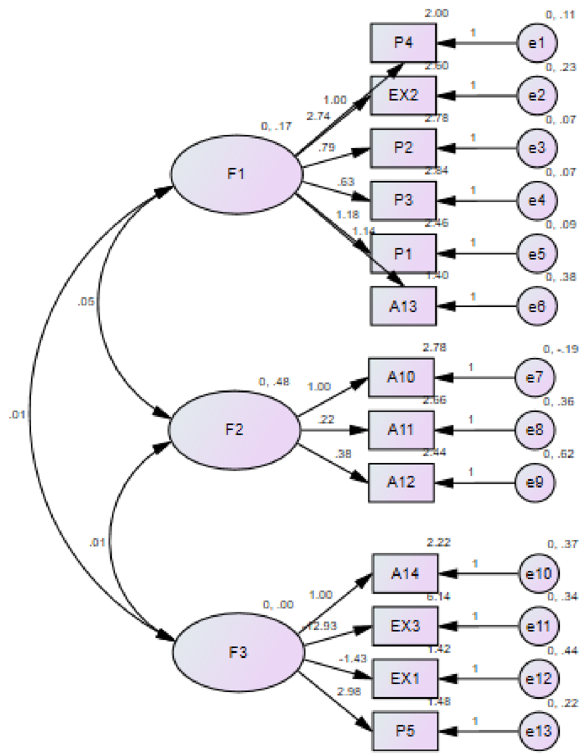



Figure 2. Definitive Structural Equations Model.

## 5. CONCLUSION

The model allowed us to know the effect that certain issues have on risks, which can be considered as a reference and a guide on which to base for future intervention designs and good practice guides in the workplace. From this framework and according to the results, it can be verified that there is a relationship between ergonomic (physical) and psychosocial factors, in comparison with the symptoms of pain present in health workers.

In summary, the findings that were reached in this work can be summarized as:

I.- The levels of Exposure to ergonomic risks of presenting a TME is statistically High, which is derived from the interventions of the work process.

II.- Multiple analysis of the relationships between demographic, work, ergonomic and psychosocial variables, if they present a statistically significant correlation with pain symptoms.

III.- It was possible to examine that, if there are conditions adjacent to work and that present modifications in the workers' lifestyles, such as alterations in sleep cycles, anxiety problems, as well as physical symptoms of stress such as; constant headaches, fatigue, heartburn, among others.

## 6. REFERENCIAS

*California occupational safety and health administration*. (2017). 1973. Retrieved from https://www.osha.gov/

Carayon, P., Kianfar, S., Li, Y., Xie, A., Alyousef, B., & Wooldridge, A. (2015). A systematic review of mixed methods research on human factors and ergonomics in health care. *Applied Ergonomics*, *51*, 291–321. https://doi.org/10.1016/J.APERGO.2015.06.001

Carayon, P., Xie, A., & Kianfar, S. (2014). Human factors and ergonomics as a patient safety practice. *BMJ Quality & Safety*, *23*(3), 196–205. https://doi.org/10.1136/bmjqs-2013-001812

DOF. (2018). Norma Oficial Mexicana 035-STPS-2018. Retrieved from Factores de riesgo psicosocial en el trabajo-Identificación, análisis y prevención. website: https://www.dof.gob.mx/nota_detalle.php?codigo=5541828&fecha=23/10/2018

Ejecutivo, P. (1992). Diario oficial de la federacion. *Director*, *11 Tomo CD*, 4–14. Retrieved from http://www.dof.gob.mx/index.php?year=1992&month=05&day=19%5Cnhttp://www.sep.gob.mx/work/models/sep1/Resource/b490561c-5c33-4254-ad1c-aad33765928a/07104.pdf

Eslamian, J., Taheri, F., Bahrami, M., & Mojdeh, S. (2010). Assessing the nursing error rate and related factors from the view of nursing staff. *Iranian Journal of Nursing and Midwifery Research*, *15*(Suppl 1), 272–277. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22069399

Freitag, S. (2009). *Ergonomisches Patientenhandling - Aktueller Stand und Perspektiven aus europäischer Sicht*.

Guizado Ramos, M., & Zamora Cordova, K. (2016). Riesgos ergonómicos relacionados a la lumbalgia ocupacional en enfermeras que laboran en Centro Quirúrgico del Hospital Daniel Alcides Carrión, 2014. *Ágora Revista Científica*, *3*(1), 337. https://doi.org/10.21679/arc.v3i1.61

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (2010). *Análisis Multivariante* (Quinta ed.; Á. Otero, Ed.). Retrieved from https://www.pearson.com/us/higher-education/program/Hair-Multivariate-Data-Analysis-7th-Edition/PGM263675.html#resources

Hignett, S., & McAtamney, L. (2000). Rapid Entire Body Assessment (REBA). *Applied Ergonomics*, *31*(2), 201–205. https://doi.org/10.1016/S0003-6870(99)00039-3

HSE Books. (2010). *Health and Safety Executive Assessment of repetitive tasks of the upper limbs (the ART tool) Health and Safety Executive Assessment guide Completing the task description form*. 16. Retrieved from http://www.hse.gov.uk/pubns/indg438.pdf

IEA. (2019). *Definicion y dominios de la Ergonomia* (p. 1). p. 1. Retrieved from https://www.iea.cc/whats/index.html

IMSS. (2017). Hombres, los más afectados por dolor en espalda baja | Sitio Web "Acercando el IMSS al Ciudadano" Retrieved August 9, 2019, from 389/2017 website: http://www.imss.gob.mx/conoce-al-imss/memoria-estadistica-2018

Llaneza, F. Javier. (2007). *Ergonomía y psicosociología aplicada : manual para la formación del especialista*. Lex Nova.

Mark, G., & Smith, A. P. (2012). Occupational stress, job characteristics, coping, and the mental health of nurses. *British Journal of Health Psychology*, *17*(3), 505–521. https://doi.org/10.1111/j.2044-8287.2011.02051.x

Martínez, M. M., & Alvarado Muñoz, R. (2017). Validación del Cuestionario Nórdico Estandarizado de Síntomas Musculoesqueléticos para la población trabajadora chilena, adicionando una escala de dolor. *Revista de Salud Pública*, *21*(2), 43. https://doi.org/10.31052/1853.1180.v21.n2.16889

OPS/OMS. (2017). Retrieved August 9, 2019, from Salud de los Trabajadores: Recursos website: https://www.paho.org/hq/index.php?option=com_content&view=article&id=1527:workers-health-resources&Itemid=1349&limitstart=2&lang=es

OSHA. (2017). Healthcare. Retrieved from Safe Patient Handling website: https://www.osha.gov/SLTC/healthcarefacilities/safepatienthandling.html

Suzuki, K., Ohida, T., Kaneita, Y., Yokoyama, E., Miyake, T., Harano, S., … Uchiyama, M. (2004). Mental health status, shift work, and occupational accidents among hospital nurses in Japan. *Journal of Occupational Health*, *46*(6), 448–454. https://doi.org/10.1539/joh.46.448

Yang, S., Lu, J., Zeng, J., Wang, L., & Li, Y. (2019). Prevalence and Risk Factors of Work-Related Musculoskeletal Disorders Among Intensive Care Unit Nurses in China. *Workplace Health and Safety*, *67*(6), 275–287. https://doi.org/10.1177/2165079918809107

# ERGONOMIC ANALYSIS IN THE HARVEST AND POST-HARVEST PROCESSES OF BLUEBERRIES CULTIVATION IN AN AGRICULTURAL COMPANY.

**María Alejandra Camacho Durán, Alejandra Inzunza Castro, Alba Berenice Ornelas Acosta, Briceyda Marialy Bojórquez Peña, Misael Robles Pimienta**.

Department of Industrial Engineering
Instituto Tecnológico Superior de Guasave
Carretera a Brecha S/N, Ej. Burrioncito
Guasave, Sinaloa, CP. 81149
maleduran1901@gmail.com, bereornelas21@gmail.com

**Resumen:** Berries y más es una empresa la cual se encarga del cultivo, cosecha y exportación de arándanos azules a los países de Japón y Estados Unidos. Actualmente, cuentan con dos variedades principales de arándano azul, los cuales son klester y rocío. Se realizó un análisis del proceso de cultivo de estos frutos y de las condiciones físicas en las que se encuentran las personas que laboran, y se determinó que es necesario hacer un análisis ergonómico para determinar posibles DTA en los trabajadores que se encargan de la cosecha y post cosecha del fruto, en una jornada laboral de 8 horas diarias por 6 días a la semana. Se identificaron diferentes áreas de oportunidad, como el método de trabajo para la recolección es inadecuado, ya que el proceso requiere se realice de manera manual en condiciones de temperatura elevadas, y a su vez sobre pasando los límites permisibles de carga. Debido a esto y a las especificaciones de este tipo de fruto hay un gran porcentaje de pérdida de producto por defectos de calidad en su recolección.

**Palabras Clave:** Ergonomía, Ergonomía Ocupacional, Método RULA, Principios Ergonómicos, Análisis Postural, DTA**.**

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

**Abstract** Berries y más is a company that is responsible for the cultivation, harvest and export of blueberries to the countries of Japan and the United States. Currently, they have two main varieties of blueberry, which are klester and rocío. An analysis of the cultivation process of these fruits and of the physical conditions in which the people who work are found was carried out, and it was determined that it is necessary to carry out an ergonomic analysis to determine possible DTA in the workers who are in charge of the harvest and post-harvest of the fruit, in a working day of 8 hours a day for 6 days a week. Different areas of opportunity were identified, such as the work method for the collection is inadequate, since the process requires it to be carried out manually in high temperature conditions, and in turn exceeding

the permissible load limits. Due to this and the specifications of this type of fruit there is a large percentage of product loss due to quality defects in its collection.

**Key Words:** Ergonomics, Occupational Ergonomics, RULA Method, Ergonomic Principles, Postural Analysis, DTA.

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

## 1. INTRODUCTION

Ergonomics in human factors is the scientific discipline related to the knowledge of the interaction between the human being and other elements of a system, and the profession that applies the theory, principles, data and methods to design seeking to optimize human well-being and the execution of the Global System. This science has the objective of adapting equipment, tasks and tools to the needs and capacities of human beings, improving their efficiency, safety and well-being according to the official definition adopted by the Society of Ergonomists of Mexico A.C (SEMAC, 2020).

According to the WHO (2019) International Classification of Diseases, musculoskeletal disorders encompass more than 150 diagnoses of the locomotor system. That is, they affect muscles, bones, joints and associated tissues such as tendons and ligaments. They can range from sudden and short-term trauma, such as fractures, sprains and strains, or chronic illnesses that cause permanent pain and disability. Musculoskeletal disorders are the leading cause of disability and low back pain is the most common cause of disability in the world.

Musculoskeletal diseases represent 38 percent of diseases in our country and of the total costs that are generated by occupational diseases, 40 percent correspond to the care of musculoskeletal disorders, according to data from the International Labor Organization (ILO) . The cost for companies is considered one of the highest, due to medical care, recovery and rehabilitation, decrease in productivity and quality, frequent absenteeism, among others (Katedra, 2017).

Mexico is the fifth largest producer of berries in the world, the value of exports of berries from Mexico has increased at an average annual rate of 17 percent during the period 2008-2015, which has caused the trade balance to continue increasing its positive gap During the last years. (FIRA, 2016).

Berries y más is a company located in the La Brecha community in the Guasave municipality of the state of Sinaloa, which is responsible for the cultivation, harvesting and export of blueberries to the countries of Japan, the United States, Canada and soon China. Currently, they have 9 hectares of crops which are divided into sectors and 5 varieties of blueberry within them, among these types we find; Prelude, Stellar, Kestrel, Day-Break and Rocío. Within the organization, an analysis of the harvest and post-harvest process of these fruits was carried out, in addition to the physical conditions in which the people who work there are found using the tools that Ergonomics gives us, it was also necessary to do an analysis ergonomic to determine possible DTA in the workers who are in charge of the harvest and post harvest of the fruit.

In Mexico, for 2016, the IMSS registered 12,622 cases of occupational diseases, of which 4,683 (37.1%) were skeletal muscle, placing them among the groups of occupational diseases with the highest incidence rate. This is equivalent to the fact that 2 out of 5 cases of occupational diseases are related to this type of illness (Social, 2017).

Evaluating the blueberry harvesting process by applying ergonomics helps to propose improvements for the harvesting of blueberries and to prevent musculoskeletal injuries due to bad posture, making the work less tiring and improving their productivity.

## 2. OBJECTIVES

Analyze the blueberry growing process at Berries y Más to determine DTA in the workers in charge of harvesting and post-harvesting the fruit.

- Make a current diagnosis of the blueberry growing process.
- Determine DTA in workers using the RULA method.
- Determination of ergonomic principles that do not comply within the company

## 3. DELIMITATION

The analysis refers to the ergonomic conditions in which the operators of the blueberry agro-export company, located in the community of La Brecha in the municipality of Guasave in the state of Sinaloa, find themselves. Evaluating the workers and activities that are carried out with the RULA method in a working day of 8 hours a day for 6 days a week.

## 4. METHODOLOGY

1. Visit to the company Berries and more, in order to analyze in detail the process and each of the corresponding areas.
2. Carrying out a diagnosis of the company through the routes, identifying the characteristics of the workers, work stations, work tools and the situation in which the company finds itself.
3. Analysis of workstations for a certain time, in this way activities that present risk factors for the operator in this case in the blueberry harvest area were identified, showing DTA in the organization's workers.

4. Application of the RULA method (Employee Assessment Worksheet), with which the risk that the worker runs in his / her work area is evaluated.
5. Determination of Ergonomic Principles that are not met within the Berries company in the process.

## 4. RESULTS

The RULA (Employee Assessment Worksheet) method was applied, with which the risk that the worker runs in their work area is evaluated. This gave us a result of 5 which means that a redesign of the task that is being done is needed. It is important to make the relevant changes, because the posture in the worker develops cumulative trauma disorders.

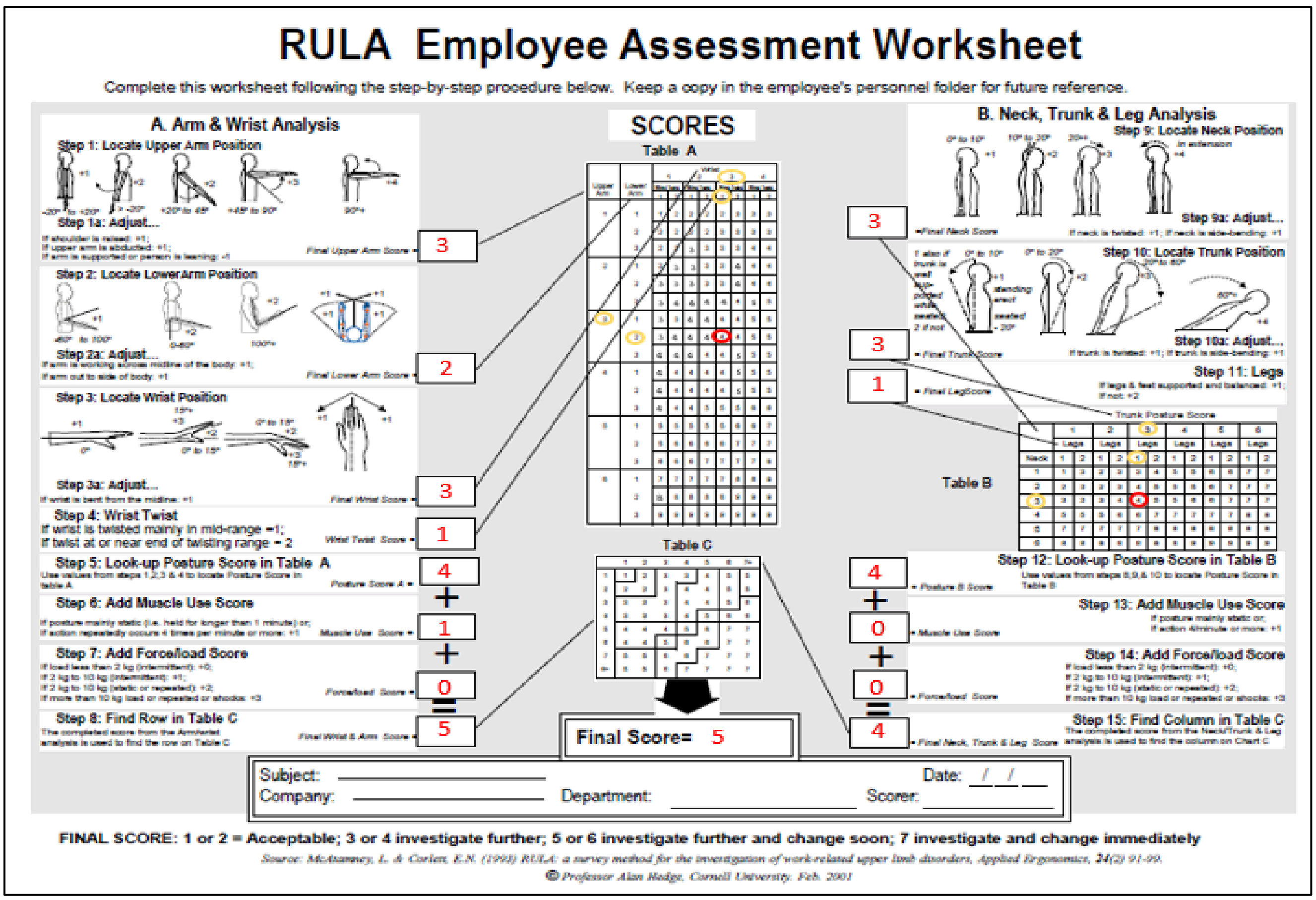



Figure 1: RULA evaluation method

Table 1. Evaluation of Ergonomic Principles

| Ergonomic Principle | if complies / does not comply | Justification |
|---|---|---|
| **1. Use elbow height as a reference** | does not comply | In the blueberry harvesting process, the operator in order to reach the fruit makes more effort on his elbows, exceeding the limits, on repeated occasions he requires obtaining the fruit from very low, that is why he does not comply with the ergonomic principle. |
| **2. Reduce excessive repetitions** | does not comply | The entire blueberry harvesting process requires the same movements of the operators for long working hours. |
| **3. Adjustment and change of posture** | does not comply | Since no adjustments are made to the harvesting process, no correct posture changes are made to reduce injuries or fatigue in workers. |
| **4. Arrange spaces and Access** | does not comply | The accesses where the blueberry harvest is held are usually very narrow and do not allow a good flow of operators |

As a result, a proposal for a prototype of an ergonomic belt is presented (Figure 1) which is designed in SolidWorks software. This consists of a girdle that aims to reduce and eliminate the possibility of injuries in the lumbar area, mainly in workers in the harvest area. On the other hand, it consists of a belt that adjusts to the physical characteristics of each of the workers, helping the collection method to be more efficient. In this way, worker productivity is increased.

Figure 2. SolidWorks® Prototype Designs

It is a prototype that helps to take care of the required quality of the fruit, while the workers are more productive and also causing a lower risk to their health, it was identified after the end of the working day that they had back pain and hips.

## 5. DISCUSSION/CONCLUSIONS

The process of growing blueberries is very delicate and in which you cannot use machinery or equipment to do it, the whole process is done in the most traditional way possible. Harvesting blueberries requires that it be done manually and in a specific way so that the properties that the fruit has are not lost, since in bloom, which is the white protective layer that covers the fruit and is with which you have the first contact, is where all the nutrients are found, the main one being the antioxidants. Studies by the Human Nutrition Research Institute of the United States Department of Agriculture (USDA) ranked blueberries in the highest antioxidant level, compared to 24 other fruits and vegetables.

Since the process requires a lot of use of the human factor, the opportunity was seen to implement different ergonomic methods to carry out an analysis to the workers of the harvest area.

One of the methods used was the RULA method (Rapid Upper Limb Assessment) which helped us to evaluate the exposure of workers to risk factors that cause a high postural load and that can cause disorders in the upper limbs of the body. (Diego-Mas, 2015) This gave us a result of 5 which means that a redesign of the task that is being carried out is needed.

Ergonomic principles were another of the methods used for the analysis, resulting in the use of elbow height as a reference, reducing excessive repetitions, adjusting and changing posture, and the arrangement of spaces and accesses are among the principles with which the company does not comply.

Having said the above, it was necessary to focus on the cutting area as an area of opportunity, to find a way to make the harvesting process more efficient and, at the same time, more ergonomic, thus benefiting the company and the workers of she.

After conducting an analysis in the blueberry harvesting process, a proposal for a prototype was presented that helps to take care of the required quality of the fruit, while the workers are more productive and also causing less risk to their health. , since they mentioned that after the end of the working day they presented back and hip pain. Also having two 30-minute breaks between the day to reduce the risk of heat stroke or dehydration.

Finally, efficient training is proposed for new workers and those who already work in the company to reduce errors in the fruit harvest process.

## 6. REFERENCES

Diego-Mas, J. (2015). *Evaluación postural mediante el método RULA*. Obtenido de Ergonautas: https://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

FIRA. (2016). *www.gob.mx.* Obtenido de www.gob.mx: https://www.gob.mx/cms/uploads/attachment/file/200633/Panorama_Agroalimentario_Berries_2016.pdf

Katedra, G. d. (16 de Junio de 2017). *Saludiario.com*. Obtenido de Saludiario.com: https://www.saludiario.com/mexico

OMS. (09 de Agosto de 2019). *who.int*. Obtenido de who.int: https://www.who.int/es/news-room/fact-sheets/detail/musculoskeletal-conditions

SEMAC. (16 de Marzo de 2020). *www.semac.org.m*. Recuperado el 26 de Marzo de 2020, de www.semac.org.m: http://www.semac.org.mx/index.php/component/content/article/98-introduccion.html

Social, S. d. (Octubre de 2017). *www.gob.mx.* Obtenido de www.gob.mx: https://www.gob.mx/cms/uploads/attachment/file/279153/Libro-Seguridad_y_salud_en_el_trabajo_en_Me_xico-Avances__retos_y_desafios__Digital_.pdf

# ERGONOMIC RISK ASSESSMENT IN VEGETABLE HARVESTING

**Indeliza Armenta Acosta, Karina Luna Soto, Alberto Ramirez Leyva, Everardo Cervantes Acosta, Juan Francisco Mercado Arenivas**

Industrial Engineering Department
Tecnologico Nacional de México/Instituto Tecnológico de Los Mochis
Juan de Dios Bátiz Blvd. and 20 de Noviembre
Los Mochis, Sinaloa 81259
indel5@hotmail.com, karinaluna1@yahoo.com,
Alberto_ramirez_leyva@yahoo.com, juan.mercado608@gmail.com,
Everardo.cervantes_@hotmail.com

**Resumen:**

El trabajo de recolección de hortalizas tiene un gran riesgo, pues con este se pueden llegar a presentar graves riesgos de posturas que pueden afectar gravemente al trabajador con el paso del tiempo, por lo cual la realización de esta investigación busca demostrar cuales posturas son las más graves para este y sobre todo con qué frecuencia y ángulos las llega a realizar, se llevó a cabo el método OWAS (Ovako Working Posture Analysing System), el cual se basa en la observación para después clasificar las posturas. En este caso se observó a un jornalero el cual recolecta distintas hortalizas en una hectárea, esto con el fin de tener diferentes cultivos durante la mayoría del año. Todas las hortalizas se recolectan de forma muy similar, donde el jornalero se agacha para poder seleccionar la hortaliza, y la saca o corta desde el suelo, para posteriormente juntar una cierta cantidad y llevarlo al lugar correspondiente donde se apilan. Estas actividades se repiten a lo largo de la jornada, por lo tanto, se busca encontrar que posturas son las más perjudiciales para realizar los cambios necesarios para la salud del trabajador.

**Palabras clave:** Carga postural, OWAS, riesgo.

**Aportación a la ergonomía:** El estudio de las cargas postulares es un punto muy importante, pues se dan a conocer los riesgos ergonómicos a los que se exponen los trabajadores, en este caso al recolectar hortalizas, pues esto puede tener una gran repercusión en la salud del trabajador; con el presente estudio se puede detectar los riesgos posturales, con lo cual se puede proponer acciones de mejora en el procedimiento de corte y recolección de hortalizas con el fin de evitar o disminuir los riesgos por causa de la carga postural.

**Abstract:**

The work of harvesting vegetables has a great risk, because with it can be presented serious risks of positions that can seriously affect the worker over time, so the realization of this research seeks to demonstrate which positions are the most serious for this and especially how often and angles come to perform, in order to carry out the method OWAS (Ovako Working Posture Analysing System), which is

based on observation and then classify the positions. In this case a day laborer was observed who harvests different vegetables on one hectare, this in order to have different crops during most of the year. All the vegetables are harvested in a very similar way, where the day laborer of the crouch to be able to select the vegetable, and takes it out or cuts it from the ground, to later gather a certain amount and take it to the corresponding place where it is piled up. These activities are repeated throughout the day, so the aim is to find out which postures are the most harmful for making the necessary changes to the worker's health.

**Keywords:** Postural load, OWAS, risk.

**Contribution to ergonomics:** The study of the postural loads is a very important point, since the ergonomic risks to which the workers are exposed are made known, in this case when harvesting vegetables, since this can have a great repercussion on the worker's health; with this study the postural risks can be detected, with which actions of improvement in the procedure of cutting and harvesting vegetables can be proposed in order to avoid or diminish the risks due to the postural load.

## 1. INTRODUCTION

The postural load has affected a large number of workers over time, because field workers are generally not trained in the correct postures to perform their activities, and in Mexico it is not very common to conduct studies and/or apply methods to evaluate workers and make corrections in their postures, Therefore, in this document the OWAS method will be applied, which assigns a score to each section of the body (back, legs and arms) and then assigns a risk classification. This will show us if the postures that the worker performs during his workday are correct or not, and also to what extent it will be necessary to apply the changes in the job if necessary.

An important point to consider is the resistance to change that workers can present, because it is very common that they do not agree with the changes, because this can affect their usual way of carrying out the activities of their work, because many times they are so used to perform bad postures that their body does not suffer immediately, but this causes more serious injuries but in a longer period of time, so it is important to train workers from the beginning, with the correct postures, this applies to all types of jobs, and for any number of workers.

In this case the investigation will be made to a worker whose daily work is the collection of vegetables, in this case he is responsible for straightening different types, in which are the radish, zucchini, cilantro, etc. This in one hectare, because when sowing different types of vegetables, we look to have different crops throughout the year.

The workers are not only in charge of harvesting the vegetables, but also of planting and caring for them, from putting the seed one by one along the whole hectare, taking care that it grows in a correct way (cleaning the weeds), fumigating them, collecting them and packing them in mallets to later sell them, all this process is carried out every day, so the postural load that the workers can present can be extremely high. By obtaining the results of the posture evaluation of the OWAS method, it will be possible to determine what changes or suggestions are necessary to avoid or reduce health problems caused by incorrect posture or an environment that is not favorable to the worker.

## 1.1 JUSTIFICATION

Injuries and postural loads are present in most jobs if they are not designed correctly or are not carried out with the correct movements. Therefore, the design and development of different methods and tools has been fundamental over the years, since most of these were designed in the 80's and 90's, since with more companies that focused on mass production, more workers presented symptoms of discomfort or even injuries due to work.

Ergonomic methods and tools for health care in different parts of the body emerged out of necessity, and are used today, because despite the passage of time, the culture of people at the time of work has not changed, because they still present resistance to change when they are given training, or when they are told that they are doing certain tasks incorrectly, so the use of these tools will be indispensable in the coming years, and most likely new ones will emerge and others will be updated, because with technological advances new jobs arise and new methods will be needed to evaluate them.

The reason for this research is to know the risks that people who work in the agricultural sector may suffer, since this sector is one where the supervision of postures or the weight that the workers carry is less performed. Unfortunately, in Mexico the people who work in this sector are people of low resources, who earn the minimum wage for a working day subjected to excessive weight loads and bad postures, It is therefore complicated to put order in or for the authorities or employers to do their respective work when taking care of the health of the workers, since this work is handled for minimum wage or for the buckets that they can fill during the day. This puts more pressure on the workers, since the more vegetables they can pick, the more money they can earn, which results in an increase in bad posture in a shorter time.

In this case we will talk specifically about workers who are dedicated to the harvesting of vegetables, since being almost all the working day bent over or in incorrect positions can cause serious damage to different parts of the body.

This is not only influenced by the posture factor, but also by the different environments to which they are submitted, since they begin to work very early in the morning, where they can be exposed to low temperatures during the winter season, as well as by wetting their clothes when they bend over because the canals have just been watered. On the other hand, there is the summer factor, where workers work in high temperatures from morning to afternoon, in many cases without access to shade, and can suffer dehydration.

## 2. OBJECTIVE

Assess the worker's acquired postures during vegetable harvesting, to determine if there is excessive postural load or risks that may affect the musculoskeletal system.

### 2.1 DELIMITATION

In this case, the analysis of a position of a male or female worker, in an age range of 15 to 60 years, which focuses on the collection of vegetables in the city of Los Mochis, Sinaloa, Mexico.

## 3. METHODOLOGY

To carry out the study, a field investigation was conducted to collect data by taking photographs and video, this in order to publicize the discomfort or difficulties that a worker may have in the work of cutting and collecting vegetables, as this activity can involve DTA'S (Cumulative Trauma Disorder), by the time and the repetitiveness of the activity being performed.

The objective of this research is to carry out the OWAS method (Ovako Working Posture Analysing System) which consists of assigning scores to different areas of the body used during work activities which are assigned according to the position and angles that workers adopt when performing the activity, the body parts which are observed are the arms, back and legs, in order to avoid finding future problems such as back problems, epicondylitis in elbow and forearm, carpal tunnel syndrome, etc.

The method is an ergonomic evaluation tool that identifies and classifies work postures and their respective combinations, in four levels of action that are determined based on specialized calculations of the musculoskeletal load caused by work postures

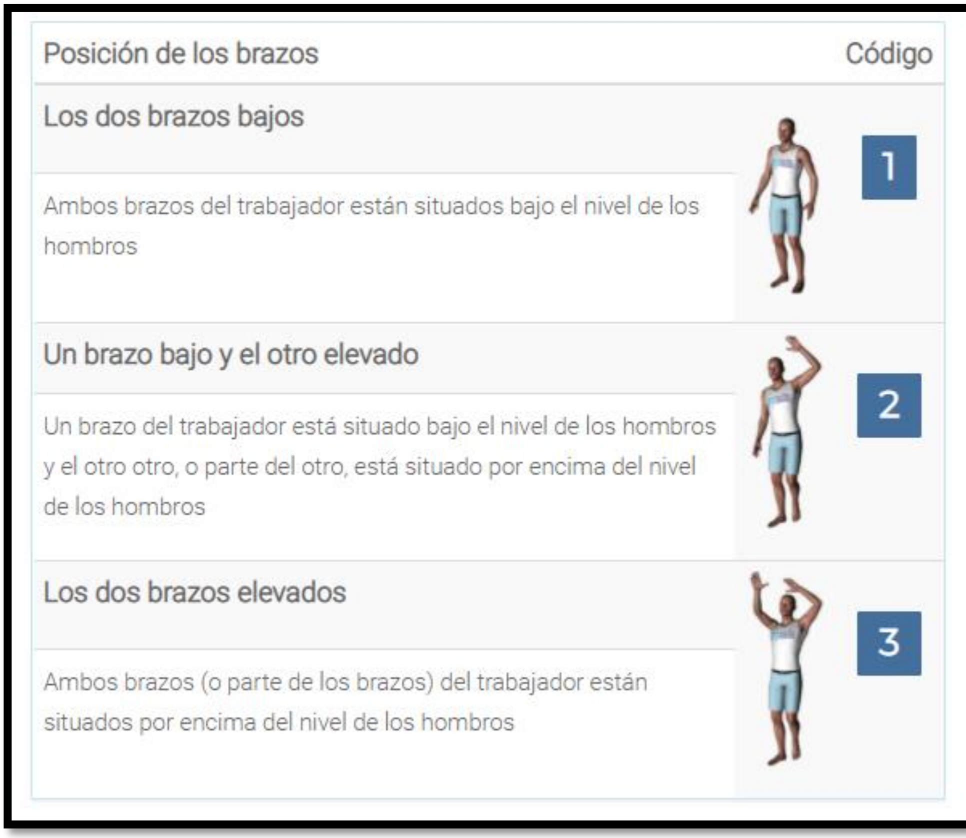
For develop the method, we used the Ergonauts' table to code the positions of the back, so that we could base ourselves on the score that we had to place according to the posture that the worker was taking while picking vegetables.

This method has tables that must be taken into account in order to correctly calculate the level of risk that the worker runs due to incorrect postures taken at the time of work. The other three tables that will be presented will be of the arms, legs and the weight he carries depending on the action he performs.

| Posición de la espalda | Código |
|---|---|
| Espalda derecha<br>El eje del tronco del trabajador está alineado con el eje caderas-piernas | 1 |
| Espalda doblada<br>Puede considerarse que ocurre para inclinaciones mayores de 20º (Mattila et al., 1999) | 2 |
| Espalda con giro<br>Existe torsión del tronco o inclinación lateral superior a 20º | 3 |
| Espalda doblada con giro<br>Existe flexión del tronco y giro (o inclinación) de forma simultánea | 4 |

***Figure 1- Coding of back positions with the OWAS method***

**Source*: Ergonautas***



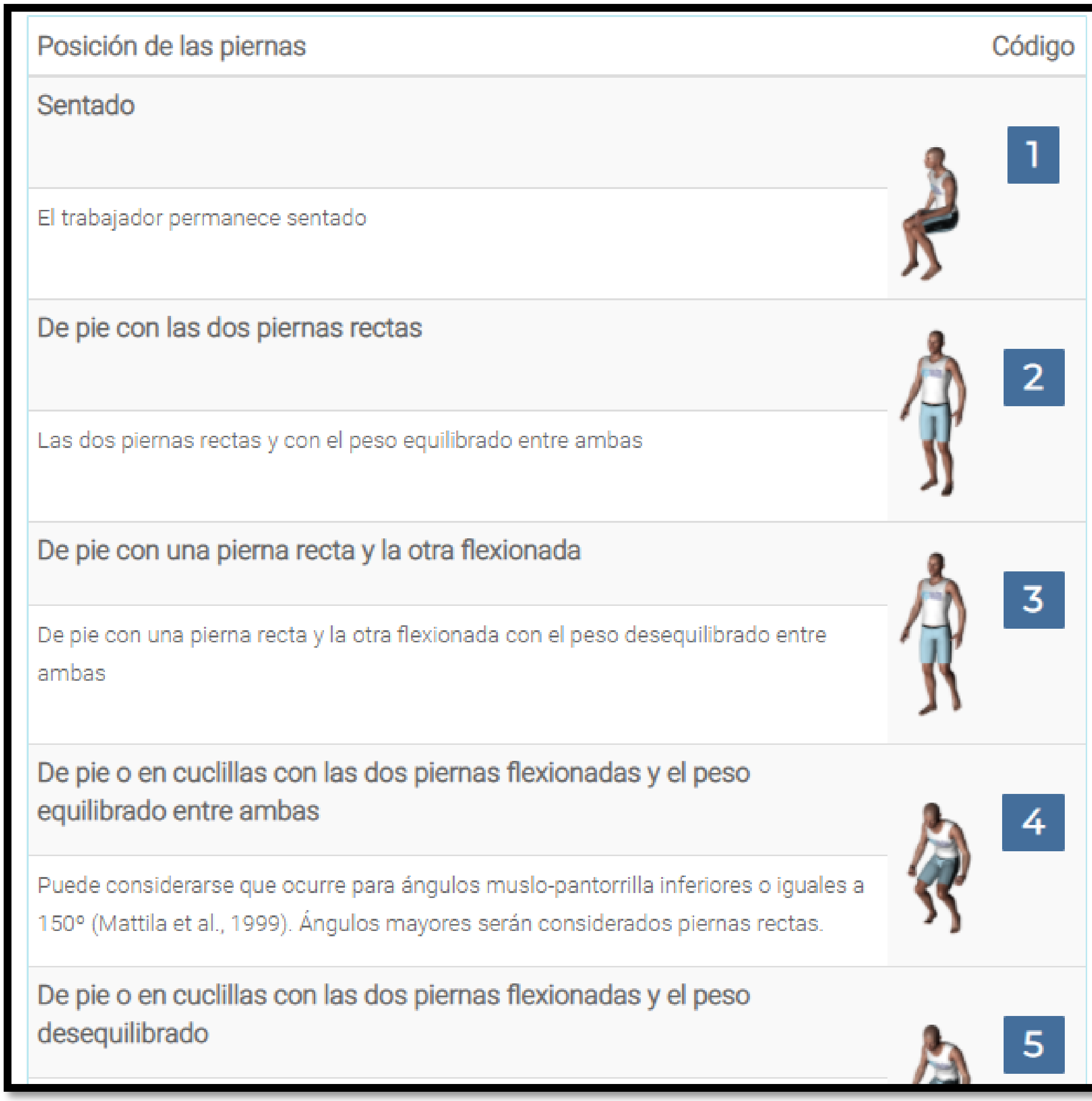
| Posición de los brazos | Código |
| --- | --- |
| **Los dos brazos bajos**<br>Ambos brazos del trabajador están situados bajo el nivel de los hombros | 1 |
| **Un brazo bajo y el otro elevado**<br>Un brazo del trabajador está situado bajo el nivel de los hombros y el otro otro, o parte del otro, está situado por encima del nivel de los hombros | 2 |
| **Los dos brazos elevados**<br>Ambos brazos (o parte de los brazos) del trabajador están situados por encima del nivel de los hombros | 3 |

***Figure 2- Coding of arm positions with the OWAS method***

***Source: Ergonautas***

The second table is useful to evaluate the posture of the arms, in this case it is of great importance because when picking the vegetables from the ground, some workers adopt an incorrect posture thanks to the weight they lift.

The third table is for the codification of the positions of the legs, this is a very important point to consider, because the workers can take very bad positions of legs due to the land in which they work, because the great majority has to walk by means of furrows, which make difficult to raise weight, to bend down and even to walk between the same ones, reason why this incites the worker to take a bad position at the moment of having to raise the bucket with weight from the ground and to have damages in a long term, reason why to take this position in account is of extreme importance by the effort that the worker makes.



| Posición de las piernas | Código |
|---|---|
| Sentado<br>El trabajador permanece sentado | 1 |
| De pie con las dos piernas rectas<br>Las dos piernas rectas y con el peso equilibrado entre ambas | 2 |
| De pie con una pierna recta y la otra flexionada<br>De pie con una pierna recta y la otra flexionada con el peso desequilibrado entre ambas | 3 |
| De pie o en cuclillas con las dos piernas flexionadas y el peso equilibrado entre ambas<br>Puede considerarse que ocurre para ángulos muslo-pantorrilla inferiores o iguales a 150° (Mattila et al., 1999). Ángulos mayores serán considerados piernas rectas. | 4 |
| De pie o en cuclillas con las dos piernas flexionadas y el peso desequilibrado | 5 |

***Figure 3 - Coding of leg positions with the OWAS method***

***Source: Ergonautas***


***Figure 4 - Coding of the load and forces supported with the OWAS method***

***Source: Ergonautas***

The fourth table helps us with the classification of the load and the force supported, in this case the workers must carry up to a weight between 10 and 20 kilos per bucket, which is an important factor to consider, this weight must be moved for long periods and distances of at least 100 meters, so this helps us to verify the damage that this type of work can cause.

Also an application was used as a measurement tool, the name of this is Angulus and is free for Android and IOS, this application allows us to measure angles in images and videos, the application has been developed by physiotherapists and is special for joint measurement.

To apply the OWAS method we studied a worker who collects vegetables in the field, for this we took into account the positions that performed more frequently, in this case make two positions, one where the worker bends to make the cut of the vegetable, where it uses a knife and cut from the stem, or takes it out of the ground, depending on the case.

The other most frequent posture is when the worker gets up and starts to tie up a certain amount of vegetables; this posture is frequently performed in practically all cuts made during the whole working day. So these two postures were the ideal ones to carry out the study, in this case the worker was observed for a period of 40 minutes while performing his activities to make sure that there was a pattern in the postures and which were the most common ones.

These postures, which include fixed or restricted positions, are common in jobs where the person must remain in one position, for long periods, or must adopt a variety of extensions, flexions and/or rotations of one or more regions of his body. The procedure that a worker carries out during his daily workday was followed, with the intention of observing and filming his postural loads and movements.

To obtain information about their work, a conversation was held with 4 permanent day laborers, most of whom have been working in the field for most of their lives. These day laborers range in age from 15 to 60 years old and work 6 days a week for an 8-hour day. To carry out the OWAS method, the following steps were taken, observing a worker, who performs 2 different postures for the collection of vegetables:

1.- To observe the workers in their working day in a discreet way so that they carry out their activities in a natural way and do not get nervous, so that the data are as real as possible.

2.- Photograph and videotape how they perform these activities to document and have evidence, also verify them in more detail for the implementation of angles.

3.- Proceed to implement the OWAS method in the two evaluated positions that the workers of the cut and harvest of vegetables carry out3.

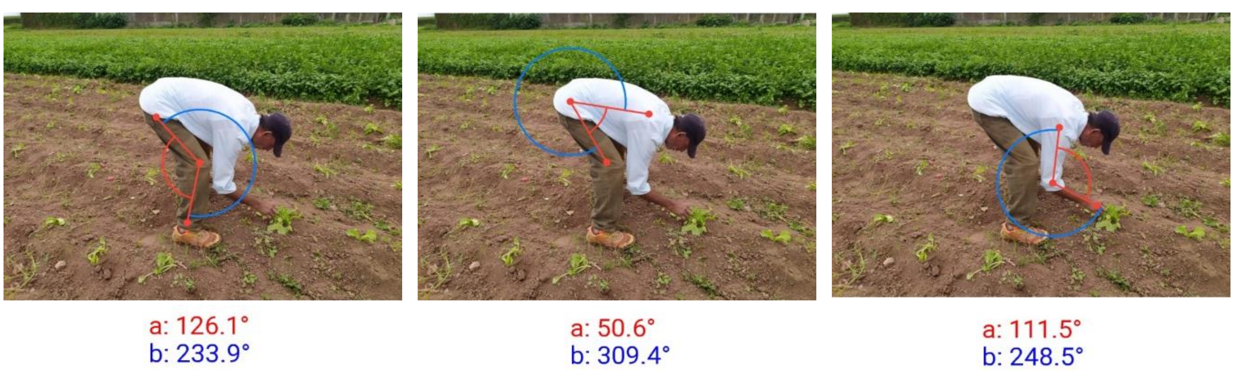



***Figure 5 - Evaluation of a field worker's posture and angle***

***Source: Own elaboration***

Figure 5 shows the positions and angles used for cutting vegetables (radish, beet and chard), this figure is assigned as posture 1 of which the worker performs a torsion of the trunk or lateral tilt (back) above 20 º which is assigned the number

3, in addition to squat with both legs bent and unbalanced weight assigning the number 5 and with both arms located below the level of men with a weight less than 10 kilograms placing the number 1 in the position of arms and weight used.


***Figure 6 - Evaluation of a field worker's posture and angle***

***Source: Own elaboration***

Figure 6 shows another of the positions commonly used by the same workers, this figure is called posture 2 and shows the following angles, which are torsion of the trunk or lateral tilt (back) over 20 ° where it is assigned the number 3, squatting position with both legs bent and weight balanced between them with both arms located below the level of men with a weight of less than 10 kilograms the latter two with assignment of the numbers 4 and 1 and number 1 for the weight used.

Table 1 and 2 show the scheme of which scores were assigned to each part of the body evaluated in posture 1, besides showing the number and color of said posture.

**Table 1.- Sample of the posture scheme 1**

| **Legs** | | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Load** | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| **Back** | **Arms** | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 |
| 2 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 4 | 4 | 3 | 4 | 3 | 3 | 3 | 4 | 2 | 3 | 4 |
| | 3 | 3 | 3 | 4 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 1 | 1 | 1 |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 1 | 1 |
| 4 | 1 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| | 2 | 3 | 3 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| | 3 | 4 | 4 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |

**Table 2.- Sample score with numbering and color to indicate the result of the posture 1 method**

| Legs | | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Load | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Back | Arms | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 |
| 2 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 4 | 4 | 3 | 4 | 3 | 3 | 3 | 4 | 2 | 3 | 4 |
| | 3 | 3 | 3 | 4 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 1 | 1 | 1 |
| | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 1 | 1 |
| 4 | 1 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| | 2 | 3 | 3 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| | 3 | 4 | 4 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |

Table 3 and 4 show the scheme of which scores were assigned to each part of the body evaluated in posture 2, besides showing the number and color of said posture

**Table 3.- Sample of the posture scheme 2**

| Legs | | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Load | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Back | Arms | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 |
| 2 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 4 | 4 | 3 | 4 | 3 | 3 | 3 | 4 | 2 | 3 | 4 |
| | 3 | 3 | 3 | 4 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 1 | 1 | 1 |
| | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 1 | 1 |
| 4 | 1 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 3 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| | 3 | 4 | 4 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |

**Table 4.- Sample score with numbering and color to indicate the result of the posture 2 method**

| Legs | | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Load | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Back | Arms | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 |
| 2 | 1 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 4 | 4 | 3 | 4 | 3 | 3 | 3 | 4 | 2 | 3 | 4 |
| | 3 | 3 | 3 | 4 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 1 | 1 | 1 |
| | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 1 | 1 |
| 4 | 1 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| | 2 | 3 | 3 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| | 3 | 4 | 4 | 4 | 2 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |

## 4. RESULTS

**Table 5.- Risk categories according to the positions evaluated by the OWAS method**

| Risk Category | Effect of posture | Action required |
|---|---|---|
| **1** | Normal and natural posture without harmful effects on the skeletal muscle system | No action required |
| **2** | Posture with the possibility of causing damage to the skeletal muscle system | Corrective actions are required in the near future |
| **3** | Posture with harmful effects on the skeletal muscle system | Corrective action is required as soon as possible |
| **4** | The load caused by this posture has extremely harmful effects on the skeletal muscle system | Corrective action is required immediately |

With the data obtained with the OWAS method in postures 1 and 2, two different results are obtained according to the postures used, which posture 1 was evaluated in category 4 which says that it has extremely harmful effects on the musculoskeletal system and requires immediate corrective action.

While in posture 2 there was a category 3 assessment that causes damage to the musculoskeletal system, so corrective action is required as soon as possible.

## 5. CONCLUSIONS

According to the results obtained with the OWAS method, the conversations with the workers, the observations made and above all the physical health of the worker, it was determined that the postures adopted by the worker for cutting vegetables cause muscular-skeletal damage which is felt by the worker at the end of his work day or many times before the time of completion, this due to the repetitiveness with which the work is done, the frequency with which it is done and above all because of the effort that these loads are made.

The two postures that the worker adopts at the moment of picking the vegetables turn out to be too harmful to his health, since the method recommends immediate changes, this because of the bad postures, these two postures are performed by a great number of people who are dedicated to that turn, they can be simple and inoffensive, But if you perform them for a long period of time your health may be at risk, so it has been decided to give recommendations of different positions more comfortable for the body, bending correctly and lifting the weight with the back straight, this can help you considerably improve your posture and later stop the fatigue in the back, arms and legs.

Because of this, one of the possible improvements and proposals for the reduction of damage is to avoid the postures adopted and to return to postures that make the body feel better and do not cause any damage or effort. Another option is a small and simple training on how to perform this type of work in which the body feels comfortable and does not generate any type of damage or risk to the health of the worker.

## 6. BIBLIOGRAPHY

Diego-Mas, Jose Antonio. Evaluación Postural Mediante El Método OWAS. Ergonautas, Universidad Politécnica de Valencia, 2015. Disponible online: https://www.ergonautas.upv.es/metodos/owas/owas-ayuda.php

Diego-Mas, J.A., Poveda-Bautista, R. Y Garzon-Leal, D.C., 2015. Influences on the use of observational methods by practitioners when identifying risk factors in physical work. Ergonomics, 58(10), pp. 1660-70.

Sánchez José & Ordaz Carlos. (2013). Análisis de posturas por el método OWAS incorporando una plataforma virtual para auxiliar el estudio ergonómico. 03/02/2020, de Universidad Tecnológica de Tecamachalco, Avenida Universidad Tecnológica 1 Sitio web: http://www.ecorfan.org/handbooks/Ciencias%20de%20la%20Ingenieria%20y%20Tecnologia%20T-I/Ciencias_Ingenier%C3%ADa_Tecnolog%C3%ADa_Handbook_T-I_5.pdf

# IMPLEMENTATION OF ENGINEERING METHODS FOR THE IMPROVEMENT OF OPERATIONS IN AN AUDIO EQUIPMENT MANUFACTURING COMPANY.

**Emilia Estéfana Sauceda López, Rafael Arturo Valenzuela López**

Department of Industrial Engineering
Instituto Tecnológico Superior de Guasave
Carretera a Brecha S/N, Ej. Burrioncito
Guasave, Sinaloa, CP. 81149
saucedaemilia@gmail.com

**Resumen** En la actualidad las empresas buscan constantemente mejorar sus métodos de trabajo en busca del aprovechamiento máximo de sus recursos y disminución de sus costos de manufactura para hacer frente a la competitividad del mercado global. El presente trabajo fue desarrollado en una empresa de manufactura de equipos de audio con presencia a nivel mundial cuyo compromiso es ofrecer a sus clientes productos de la mejor calidad. El objetivo fue mejorar las operaciones adicionales en las líneas de ensamble en un área denominada como montaje superficial para reducir costos de mano de obra en función de la disminución de la carga de trabajo, contribuyendo a la reducir el tiempo de la operación. Se utilizó la metodología de ingeniería de métodos desde la selección del proyecto y el establecimiento del diagnóstico de la ejecución de las operaciones y los indicadores de productividad hasta la evaluación de la ejecución de las actividades propuestas, esto como parte de los trabajos de ergonomía temporal empleados en la organización. Se realizó a través del análisis de la secuencia del proceso de ensamble utilizando diagramas de proceso, estudio de tiempos y análisis de operaciones. La implementación de las propuestas representó una disminución del 87% del tiempo de la operación y favoreció la mejora de un 57% en costos de mano de obra para las actividades analizadas.

**Palabras clave** : Ingeniería de métodos, estudio de tiempos, ensambles, economía de movimientos.

**Relevance for the ergonomics**: En términos de ergonomía temporal, la reducción de la carga de trabajo contribuye a disminuir la fatiga laboral y mejorar la salud ocupacional. El presente trabajo muestra el análisis e implementación de mejoras en un proceso, con el cual se logró una reducción significativa de la carga laboral, lo que representa un área de oportunidad para la mejora de la productividad y satisfacción de los trabajadores de la línea.

**Abstract** Today, companies are constantly seeking to improve their working methods in order to make the most of their resources and reduce their manufacturing costs to meet the competitiveness of the global market. The present work was developed in an audio equipment manufacturing company with worldwide presence whose commitment is to offer its customers the best quality products. The objective was to improve the additional operations in the assembly lines in an area called surface assembly to reduce labor costs as a function of the decrease in workload, contributing to the reduction of operation time. The methodology of engineering methods was used from the selection of the project and the establishment of the diagnosis of the execution of the operations and the productivity indicators to the evaluation of the execution of the proposed activities, this as part of the temporary ergonomic works used in the organization. It was done through the analysis of the assembly process sequence using process diagrams, time study and operations analysis. The implementation of the proposals represented a reduction of 87% of the operation time and favored the improvement of 57% in labor costs for the analyzed activities.

**Keywords**. Engineering of methods, times study, assemblies, economy of movements.

**Relevance to Ergonomics**: In terms of temporary ergonomics, the reduction of workload contributes to decrease work fatigue and improve occupational health. The present work shows the analysis and implementation of improvements in a process, with which a significant reduction of the workload was achieved, which represents an area of opportunity for the improvement of the productivity and satisfaction of the workers of the line.

## 1. INTRODUCTION

The ergonomic principle of work organization studies the risk factors that must be verified according to the way the work is organized, workload, high work rates, type of day, night, rotation and its effects on health.

Methods engineering seeks through the analysis of operations the reduction of workloads with the objective of improving the productivity of the area in which it is being applied and, therefore, of the organization in general. It involves the analysis in two different times during the history of a product. First, the methods engineer is responsible for the design and development of several work centers where the product will be manufactured. Second, the engineer must continuously study these workplaces in order to find a better way to manufacture the product and/or improve its quality. In either case, it is necessary for the methods engineer to incorporate the principles of work design into every new method, so that it is not only more productive but also safer and risk-free for the operator (Niebel & Freivalds, 2012)

Heizer and Render (2014) establish that method analysis is a system that involves the development of safe work procedures and that produces quality items efficiently. The study of times has two main objectives, minimize the time required for the execution of work and conserve resources by minimizing costs, to reach its development must run a prior analysis of operations. (Fred E, 2000)

The problem addressed consists of the analysis of the operations of an assembly line in which additional operations are performed on an electronic card that is part of a horn. The card originally, before being inserted, goes through a series of operations for its requirement, which do not add value to the product, but at the same time consume considerable time in its execution.

In the literature we found several investigations that are developed in productive systems scenarios such as the work done by Alzate Guzman Y Sánchez Castaño, (2013) who sought to increase the productivity of the labor force of the productive system of shoe boxes of the company "Industrias Art Print" through the application of method engineering. The study allowed to improve the plasticizing processes, which improved the productivity of the productive system's labor force by 19% with respect to the initial situation. Castillo Jaurégui, (2016) carried out a proposal for the implementation of the methodology of the continuous improvement with the purpose of increasing the effectiveness of the area of operations of the company Transportes Sakura S.A. Wilches Arango, (2013) presented a result of an applied investigation, the analysis and improvement of the chain of value is shown a line of production of chairs for office.

## 2. OBJECTIVES

Decrease the workload time of the additional operations line of the surface assembly area of an audio equipment company by implementing method engineering.

- Establish the diagnosis of the execution of the operations.
- Analyze the data and information of the line to be evaluated
- Propose improvement operations for each activity.
- To implement the improvements in the work method.
- To evaluate the execution of the proposed activities.

## 3. METHODOLOGY

### 3.1 Analysis of the problem to be studied

The cause-effect diagram was used as an exploratory tool to establish a diagnosis of the problem to be studied, the different causes were analyzed in the four main factors and it was identified that the development of the method was the main cause of the additional operations in the line when using pallets.

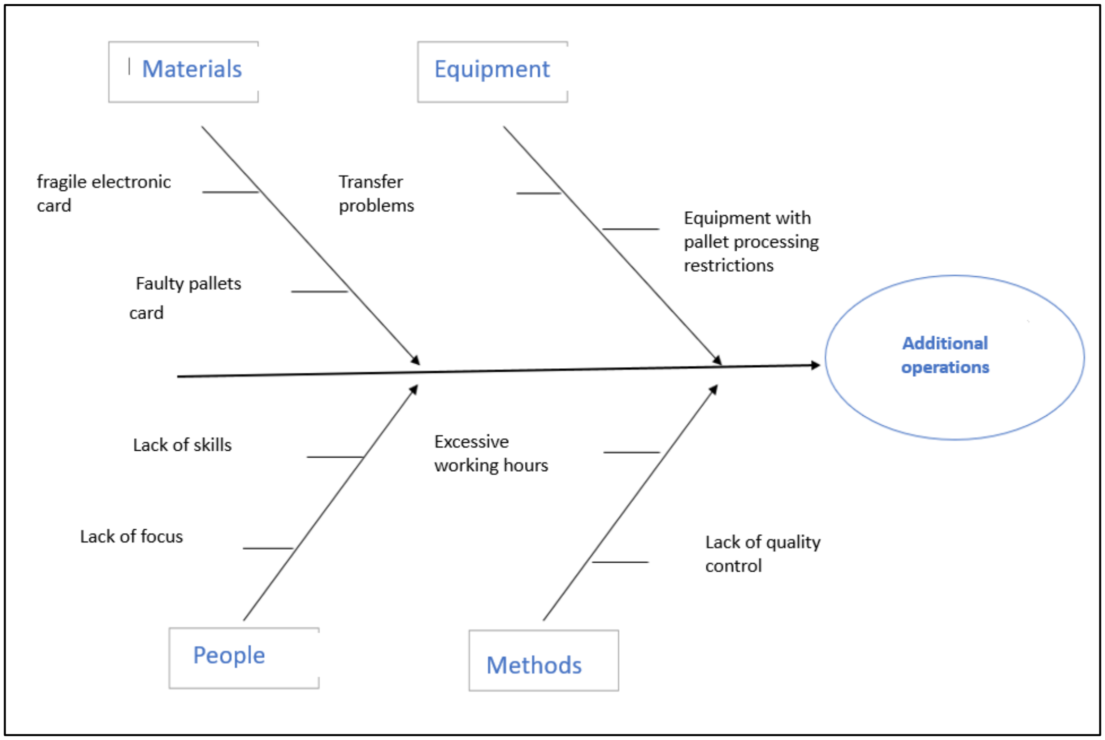



Figure 1. Cause-effect diagram of consequences of additional operations with the use of pallets.

## 3.2 Data analysis

To define this project, research was carried out on two families of models in which there were additional operations, these were the Carrier Bss model and the Bss Module. It can be seen in the flow chart of the process for obtaining data in figure 2.

As can be seen in the flow chart, for the Carrier family models, it starts when the operator makes a request for 150 pallets to the fixture center so that the technician in charge of the fixture area can approve the request. Once the production line has started, the operator must be at the end of the line to take the pallets with the finished electronic cards and remove a surplus (rib) from a component called shied. Then, the finished electronic card is removed from the pallet so that it is available to start the process again.

## 3.3 Process time determination

Based on the stages of the process, a time study was carried out to determine the duration of each one of them. As you can see in the diagram of times in figure 3 this process takes the operator 78 minutes to make the Setup of the model so that the production line is ready to start

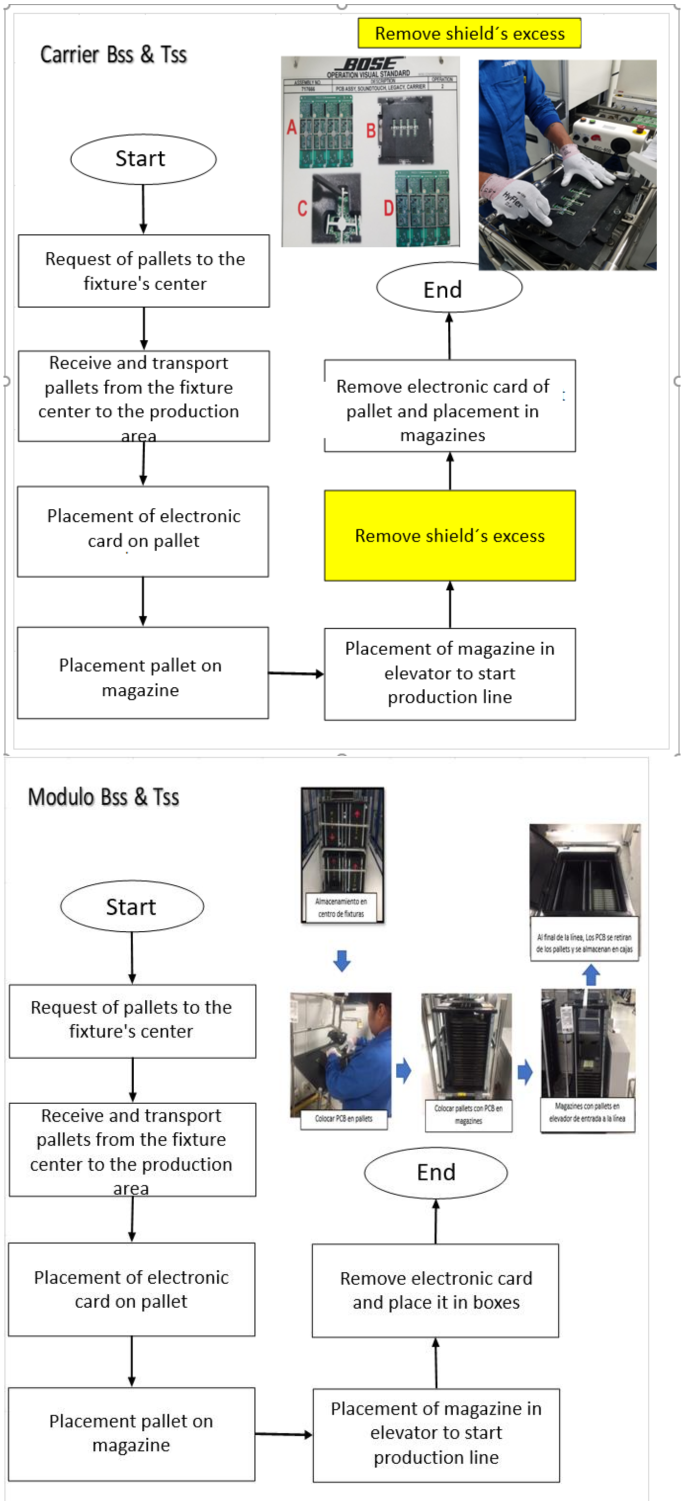



Figure 2. Process flow diagram of the Carrier Bss model and Module Bss model.

### 3.4 Calculation of personnel requirements

Analyzing the time required, the operators needed to carry out the process of both models are calculated, resulting in 17 operators per shift, in four shifts, for a total of 68 hours per week. the results are shown in the table 1.

### 3.5 Implementing improvements

Carrying out the first analysis of operations that consists of determining the purpose of the operation, unnecessary movements were identified that were carried out with the use of the pallets, therefore it was decided to eliminate this operation, that had as consequence the reduction to one the number of operations of the process with respect to the seven operations that originally were developed.

Table 1. Calculation of personnel requirements

| Timing diagram (Set up line) Pallet use | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | OPERACIONES | Time (minutes) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Total |
| | | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 | |
| 1 | Request of pallets to the fixture's center | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 10 |
| 2 | Waiting for pallet preparation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 14 |
| 3 | Receive and transport pallets from the fixture center to the production area | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6 |
| 4 | Placement of electronic card on pallet | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 20 |
| 5 | Placement pallet on magazine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 18 |
| 6 | Placement of magazine in elevator to start production line | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 10 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 78 min |

| Required people per shift with pallet use | | | | | | |
|---|---|---|---|---|---|---|
| Model (producto) | Process | Shift A | Shift B | Shift C | Shift D | |
| Modulo | Bss | 4.5 | 4.5 | 4.5 | 4.5 | |
| | Tss | 4.5 | 4.5 | 4.5 | 4.5 | |
| Carrier | Bss | 4.5 | 4.5 | 4.5 | 4.5 | |
| | Tss | 3.5 | 3.5 | 3.5 | 3.5 | |
| Total operators per working day | | 17 | 17 | 17 | 17 | 68 |

Figure 3. Process time diagram.

## 4. RESULTS

### 4.1 Reduction in the number of operations in the process

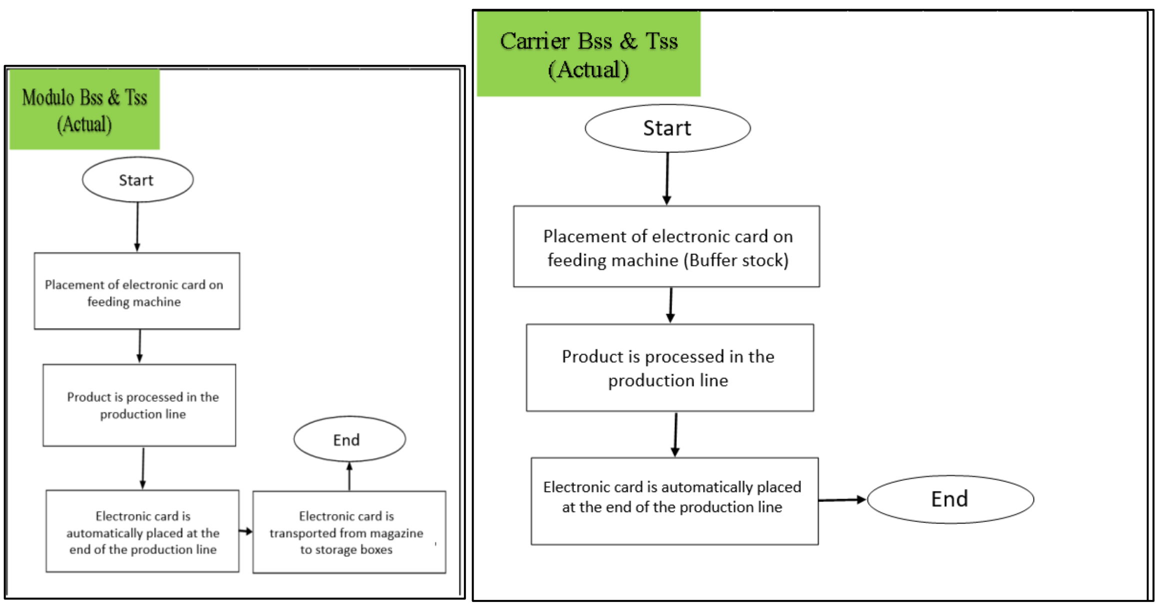



Figure 4. Proposed flowchart for the Module Bss process model Carrier Bss process model

## 4.2 Reduction of the total time of the process.

With the elimination of the additional operations a reduction of time to 10 minutes was obtened

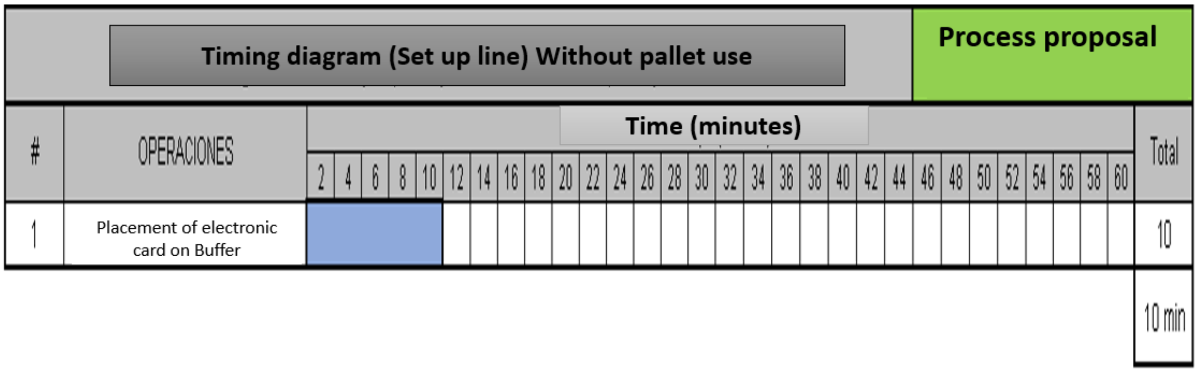



Figure 5. Proposal process time diagram.

## 4.3 Reduction of personnel requirements.

Table 2. Variation in the operator's number in Module Bss process model and Carrier Bss process model.

| MODULO BSS | | IMPROVE | |
|---|---|---|---|
| **Activity** | **Operation** | **Before** | **After** |
| | | **# Operators** | **# Operators** |
| *1 | Request of pallets and placement of electronic card on pallet. | 0.5 | - |
| *2 | Machine operator on line SMT | 2 | 1 |
| *3 | Inspector en AOI | 1 | 0.5 |
| *4 | Remove electronic card and placement on magazines | 0.5 | - |
| 5 | Electronic card repair | 0.5 | 0.5 |
| | **Total** | **4.5** | **2** |

Results 2.5 operators

| CARRIER TSS | | IMPROVE | |
|---|---|---|---|
| Activity | Operation | Before | After |
| | | # Operators | # Operators |
| *1 | Request of pallets and placement of electronic card on pallet. | 0.5 | - |
| *2 | Machine operator on line SMT | 1 | 1 |
| *3 | Remove shield´s excess | 0.5 | - |
| *4 | Inspector en AOI | 0.5 | 0.5 |
| 5 | Remove electronic card and placement on magazines | 0.5 | - |
| 6 | Electronic card repair | 0.5 | 0.5 |
| | Total | 3.5 | 2 |

Results 1.5 operators

## 4.4 Decrease in direct labor costs

| | Costo Actual de DL y Mantenimiento de pallets (Jornada) | | | | |
|---|---|---|---|---|---|
| Familia y Proceso | Qty de DL | Costo DL x Jornada | Costo DL por Modelo (turno) | Costo DL por Modelo (Jornada) | Costo de mantenimiento de pallets por jornada |
| Modulo Bss | 4.5 | $168.48 dlls | $758.16 dlls | $3,032.64 dlls | $860.16 |
| Modulo Tss | 4.5 | | $758.16 dlls | $3,032.64 dlls | |
| Carrier Bss | 4.5 | | $758.16 dlls | $3,032.64 dlls | |
| Carrier tss | 3.5 | | $589.68 dlls | $2,358.72 dlls | |
| Total: | 17 | | $ 2,864.16 dlls | $11,456.64 | $860.16 |
| | | | | $12,316.80 dlls | |

| | Costo Propuesto de DL y Mantenimiento de pallets (Jornada) | | | | |
|---|---|---|---|---|---|
| Familia y Proceso | Qty de DL | Costo DL x Jornada | Costo DL por Modelo (turno) | Costo DL por Modelo (Jornada) | **Costo de mantenimiento de pallets por jornada** |
| Modulo Bss | 2 | $168.48 dlls | $336.96 dlls | $1,347.84 dlls | **$0 dlls** |
| Modulo Tss | 2 | | $336.96 dlls | $1,347.84 dlls | |
| Carrier Bss | 2 | | $336.96 dlls | $1,347.84 dlls | |
| Carrier tss | 2 | | $336.96 dlls | $1,347.84 dlls | |
| Total: | 8 | | $1,347.84 dlls | $5,391.36 dlls | **$0 dlls** |

## 4.5 Proposals presented regarding the use of time saved.

- Incorporation of preparation exercise at the beginning of the day.
- Practice of active breaks of 15 minutes in the middle of the day.
- Enrichment of the work by incorporating other types of operations.

- Reduction of overtime to comply with this process.
- Group feedback on the work of the lines to make contributions to improvement.

## 5. DISCUSSION/CONCLUSIONS

Methods engineering was a fundamental tool in the elaboration of this project, since it helps you to select the project depending on the problem you have or the improvement you want to make. The most important stage is the collection and presentation of data on the current situation, since with this data begins the analysis to develop proposals to help improve or solve the problem you have, and having data to review the variables you have and seek options for improvement and then present a method that solves the current situation.

Taking into consideration the workload of the staff was essential to detect areas of opportunity, which, in this case, consisted of eliminating unnecessary operations through the study of time, analysis of operations and economy of movement.

The savings obtained in time and money were significant both for the company and for the worker, since with the reduction in the workload the operator present greater productivity and at the same time, with the proposals made for the use of the time saved, he has the possibility of enriching his working condition.

As future research, an extension of the analysis to other areas of the company is proposed, in addition to the standardization, follow-up and control of complementary activities to avoid monotony, tedium and fatigue in the repetitive operations of the assembly lines.

## 6. REFERENCES

Alzate Guzman, N., & Sánchez Castaño, J. E. (2013). *Estudio de tiempos y métodos de la línea de produccióon tipo “clásico de dama” en la empresa de calzado Caprichosa para definir un nuevo método de producción y determinar el tiempo estándar de fabricación.* Universidad Tecnológica de Pereira.

Castillo Jaurégui, A. D. (2016). Propuesta de mejoramiento continuo para incrementar la efectividad en el área de operaciones de la empresa Sakura S.A. *Universidad Nacional de Trujillo*. Retrieved from http://dspace.unitru.edu.pe/handle/UNITRU/4416

Fred E, M. (2000). *Estudio de tiempos y movimientos para la manufactura ágil.* (2da.). Prentice Hall.

Niebel, B. W., & Freivalds, A. (2012). *Ingeniería Industrial. métodos, estándares y diseño del trabajo.* (12 a.). https://doi.org/10: 0-8400-5444-0

Render, B., & Heizer, J. (2014). *Principios de administración de operaciones* (Novena). México: Pearson Educación.

Wilches Arango, M. J. (2013). Aplicación de herramientas de manufactura esbelta para el mejoramiento de la cadena de valor de una línea de producción de sillas para oficina. *Dimensión Empresarial*, *11*(1), 126–136. https://doi.org/10.15665/rde.v11i1.166

# ANALYSIS AND EVALUATION OF UNSAFE CONDITIONS WITHIN THE CARPENTRY WORKSHOP

**Karen Araceli Castillo Diaz[1], Yulma Loreley García Pérez[1], Rosa Isela Rayas Salcido[1], Mario Abel Padilla Navarro[1], Rigoberto Zamora Alarcón[2]**

[1]Departamento de Ingeniera industrial
Instituto Tecnológico de Mexicali
Av. Instituto Tecnológico s/n, Plutarco Elías Calles21376 Mexicali, B.C.
karenaracastillo@gmail.com

[2]Departamento de Ingeniera industrial/ Ingeniería mecánica
Instituto Tecnológico de Mexicali / Universidad Autónoma de Baja California
Av. Instituto Tecnológico s/n, Plutarco Elías Calles 21376 Mexicali, B.C. /Blvd. Benito Juárez S/N 21100
mczamora02@yahoo.com.mx

**Resumen:** El presente proyecto se realizará dentro de una pequeña carpintería, en la que se realizan trabajos donde se requiere un gran esfuerzo físico, las consecuencias son aumento de los accidentes laborales, fatiga, problemas de visión, incidencia y prevalencia de lesiones asociadas a problemas ergonómicos como malas posturas, movimientos repetitivos. Estas enfermedades crónicas y acumulativas afectan la calidad de vida y capacidad de trabajo de las personas. Al mejorar el entorno laboral se consigue disminuir el grado de severidad causado por la tarea que realizan, así como incrementar la eficiencia en el trabajo.

En el taller se utilizan diferentes maquinas como Sierra de banco, caladora, lijadora, segueta, taladro, router, prensa, entre otros. En el caso de este proyecto tomaremos el proceso de atornillado debido a que al observar el proceso de detectaron deficiencias en el proceso, así como también los operadores comentaron que no se sentían seguros al realizar esta operación.

Debido a que es una pequeña empresa, no cuenta con una buena formación o acciones preventivas, por lo que se aplicaron las normas mexicanas correspondientes, se realizó un análisis ergonómico mediante el método *Suzanne Rodgers*, y el método Evaluación de Riesgos Ergonómicos del Lugar de Trabajo (WERA), posteriormente se aplicó la metodología 5´s que ayudo a tener una mejor organización, limpieza y áreas confortantes para los trabajadores. Por otro lado, se propone el diseño de una plantilla que mejore el proceso de taladrado.

**Palabras clave**: Carpintería, *Suzanne Rodgers*, WERA, Seguridad de los trabajadores.

**Relevancia para la ergonomía**: Se debe tomar en cuenta la seguridad de los trabajadores como prioridad para que se pueda realizar su labor correctamente.

La implementación de mejoras ergonómicas en un taller de carpintería para disminuir accidentes e incrementar la calidad de vida de los trabajadores.

**Abstract**: This project will be carried out inside a small carpentry, in which work is carried out where a great physical effort is required, the consequences are increased accidents at work, fatigue, vision problems, incidence and prevalence of injuries associated with ergonomic problems such as bad postures, repetitive movements.

These chronic and cumulative diseases affect people's quality of life and ability to work. Improving the work environment reduces the degree of severity caused by the task they perform, as well as increasing efficiency at work. In the workshop different machines are used such as bench saw, lime, sander, drill, router, press, among others. In the case of this project we will take the screwing process because when observing the process of detecting deficiencies in the process, as well as the operators commented that they did not feel safe when performing this operation.

Because it is a small company, does not have good training or preventive actions, so the corresponding Mexican standards were applied, an ergonomic analysis was carried out using the *Suzanne Rodgers* method, Workplace Ergonomic Risk Assessment method (WERA), subsequently applied methodology 5 S, It helps to have better organization, cleanliness and comforting areas for workers. On the other hand, it is proposed to design a template that improves the drilling process.

**Keywords:** Carpentry, *Suzanne Rodgers*, WERA, Workers' safety.

**Relevance to ergonomics:** Worker safety must be taken into account as a priority in order to be able to carry out their work properly. The implementation of ergonomic improvements in a carpentry workshop to reduce accidents and increase the quality of life of workers.

## 1. INTRODUCTION

The carpentry is a small company dedicated to the elaboration of furniture with specifications given by the client in which a great effort was noticed by the workers among them; accidents, poor postures, repetitive movements affecting the quality of the worker. For this reason, it sought to identify, analyze and evaluate the risks and inappropriate conditions that exist within the facilities of the work area to improve postures through an analysis, applying the Suzanne Rodgers method and the Risk Assessment method Workplace (WERA), safety the Mexican STPS standards applicable to the ergonomics and performance of each worker, as well as propose ergonomic solutions, and the proposal of the implementation of a template to carry out the process and another to improve order.

The importance of this study lies in finding a more comfortable and safe work area for workers, for this they used Mexican standards, ergonomic methods, anthropometric measures, basic tools of continuous improvement that allow to validate and improve workstations for operator comfort by seeing it as an improvement system for ergonomics and a template was developed to improve the poor posture that takes place when screwing.

## 2. OBJECTIVE

Identify, analyze and assess the risks and inappropriate conditions that exist within the work area facilities to improve the postures, safety and performance of each worker, as well as propose ergonomic solutions through an analysis, applying ergonomic risk assessment methods, the Mexican STPS standards applicable to ergonomics and the proposal of the implementation of a template to carry out the process.

## 3. METHODOLOGY

1.They applied the Mexican standards of the Secretary of Labor and Social Welfare (STPS), to validate the current physical conditions of the workplace, the NOM-011-STPS-2018 (Noise), NOM-025-STPS-2008 (lighting), NOM-015-STPS-2011 (Temperature), as well as to evaluate the operator at workstation NOM-017-STPS-2017 (Protection Equipment) and NOM-035-STPS-2018 (Psychosocial Risk Factors).

2. Considerations of working equipment sizing and operator anthropometry. The dimensions of the work area, as well as the anthropometry of the operators, were analyzed to relate them to the design of templates and their ergonomic assessment when performing their work.

3. Ergonomic risk analysis and assessment using the Suzanne Rodgers method and the Workplace Ergonomic Risk Assessment (WERA) method. To identify areas of opportunity in the design of work templates

4. Implementation of continuous improvement methodology, 5's to identify the best use of work templates starting with comfort and continuing in order in their frequency of use.

5. Proposal for improvement by designing templates, which allow to improve positions by having applied the previous methodologies.

## 4. RESULTS

### 4.1 Application of Standards of the Secretary of Labour and Social Welfare (STPS).

Mexican STPS standards were applied to validate the physical conditions of the workstation. Regarding compliance with NOM 017 STPS 2017 (PROTECTION TEAM), which talks about worker protection equipment, deficiencies were noted and validated that protective equipment is best suited to the operator, as shown in Table 1. For NOM 011 STPS 2018 (RUIDO), the workstation in some cases exceeds 80 decibels as shown in Figure 1, so measures such as wearing earplugs had to be taken.

Table 1. Proposed protective equipment for carpenter.

| Región anatómica | Equipo de protección |
|---|---|
| 1. Cabeza | Casco contra impacto |
| 2. Ojos y cara | Anteojos de protección |
| 3. Oídos | Tapones auditivos |
| 4. Aparato respiratorio | Mascarilla desechable |
| 5. Extremidades superiores | Guantes de trabajo |
| 6. Tronco | Overol |
| 7. Extremidades inferiores | Calzado contra impactos |
| 8. Otros | N/A |

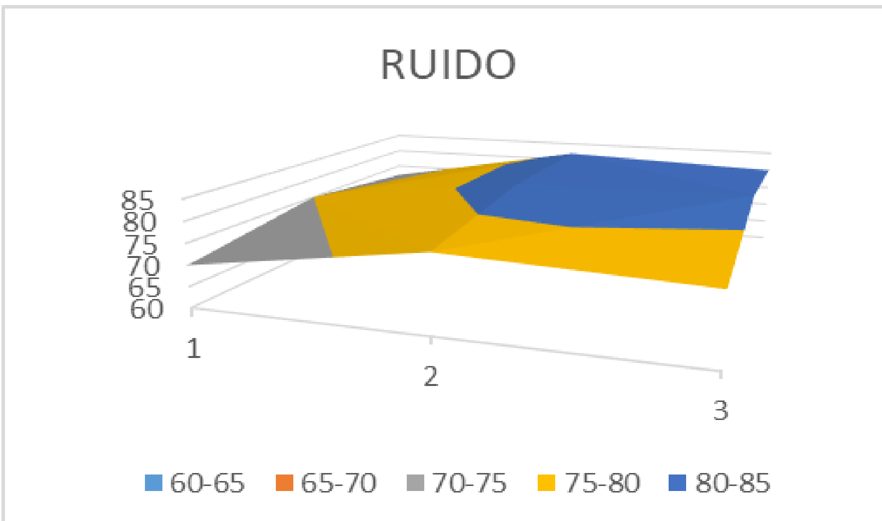



Figure 1. Noise intensity identification by areas of the work area.

As for THE NOM 025 STPS 2008 (ILUMINATION), a moderate distinction of detail is required by the process that is carried out, it was derived that the lighting is correct at certain times of the day, since at the end of the day the light becomes insufficient and is below the levels Permissible. As for the implementation of NOM-035-STPS-2018 (Work stress) the levels of work stress that were detected were very high, however, no violence was detected within the work area.

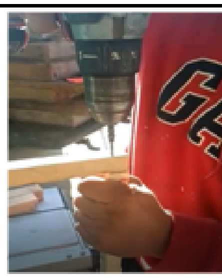
## 4.2 Considerations of working equipment sizing and operator anthropometry.

Workers' anthropometry was analyzed and a percentile table is attached, as can be seen in Table 2, to select the appropriate safety equipment, as well as the dimensions of the workbench, together the work template when working in a way horizontal rather than vertical, as was previously done. It was necessary to assemble the larger parts that had the highest processing frequency, in addition to the location, frequency and use of the tool used by the operators.

Table 2. Percentiles in relation to working dimensions and protective equipment.

| Medición | $P_{05}$ | $P_{50}$ | $P_{95}$ | Observación |
|---|---|---|---|---|
| 4. Altura al hombro | 132.56 | 145.33 | 158.11 | Herramienta vuelta posición |
| 5. Altura al codo flexionado | 103.46 | 111 | 118.54 | Diseño altura mesa trabajo |
| 6. Altura al nudillo | 56.14 | 72 | 87.86 | Alcance de palancas |
| 8. Alcance brazo frontal | 71.66 | 83.33 | 95 | Alcance mesa trabajo y plantillas 5 S |
| 11. Profundidad Máxima del cuerpo | 25.3 | 31 | 36.7 | Alcance mesa trabajo y plantillas 5 S |
| 15. Anchura codo-codo | 39.97 | 53.67 | 67.36 | Ancho mesa trabajo y plantillas 5 S |
| 17.Longtud de la mano | 17.15 | 19.67 | 22.18 | Equipo de protección y plantillas 5 S |
| 18. Longitud de la palma de la mano | 8.76 | 10.83 | 12.9 | Equipo de protección |
| 19. Diámetro de empuñadora | 3.38 | 4.33 | 5.28 | Mango de herramienta |
| 20. Longitud del pie | 23.15 | 25.67 | 28.18 | Calzado contra impactos |
| 21. Anchura del pie | 8.12 | 9.83 | 11.55 | Calzado contra impactos |
| 33. Perímetro de la cabeza | 55.15 | 57.67 | 60.18 | Equipo de protección |
| 34. Anchura de la cabeza | 12.91 | 16.33 | 19.76 | Equipo de protección |
| 35. Profundidad de la cabeza | 17.38 | 18.33 | 19.28 | Equipo de protección |
| 36 Longitud de la cara | 7.78 | 16 | 24.23 | Equipo de protección |

Table 3. The Suzanne Rodgers Method evaluating the operator when screwing.

| Área de Atornillado  | | Análisis Método Suzanne Rodgers | | | | | |
|---|---|---|---|---|---|---|---|
| | | Intensidad | Duración | Por minuto | Puntaje | Evaluación | |
| Cuello | | 1 | 2 | 3 | 5 | Moderado | |
| Hombros | IZQ | 1 | 2 | 3 | 5 | Moderado | |
| | DER | 2 | 2 | 3 | 8 | Alto | |
| Espalda | | 2 | 3 | 2 | 7 | Moderado | |
| Brazos y codos | IZQ | 1 | 2 | 3 | 5 | Moderado | |
| | DER | 2 | 2 | 3 | 8 | Alto | |
| Muñeca, Mano, dedos | IZQ | 1 | 2 | 3 | 5 | Moderado | |
| | DER | 2 | 2 | 3 | 8 | Alto | |
| Piernas y tobillos | IZQ | 1 | 2 | 3 | 5 | Moderado | |
| | DER | 1 | 2 | 2 | 2 | Bajo | |

### 4.3. Application of ergonomic risk assessment methods.

First we use the Analysis and Ergonomic Evaluation according to the Suzanne Rodgers method as seen in Table 3, based on the results of the application of the Suzanne Rodgers Method we can see that the area of the wrists, hands, arms and shoulders is having a high risk assessment especially on the right side of the body. Secondly, we use the Workplace Ergonomic Risk Assessment (WERA) method, as seen in Table 4, confirming what was analyzed by the previous method the shoulder and wrist have high values before applying the improvement with the templates. When applying the templates, we saw an improvement of 20 to 40 %, just as this was determined to impact vibration and contact stress with decreases of up to 40%.

Table 4. The WERA method applied to the operator when it is screwing.

| FACTOR DE RIESGO FISICO | ANTES DE MEJORA | DESPUES DE MEJORA | |
|---|---|---|---|
| | PUNTOS | PUNTOS | MEJORA |
| 1. HOMBR0 | 5 | 4 | 20 % |
| 2. MUÑECA | 5 | 3 | 40 % |
| 3. ESPALDA | 4 | 3 | 20 % |
| 4. CUELLO | 4 | 3 | 20 % |
| 5. PIERNAS | 4 | 3 | 20 % |
| 6. FUERZA | 3 | 2 | 20% |
| 7. VIBRACIÓN | 4 | 2 | 40 % |
| 8. ESTRÉS POR CONTACTO | 4 | 2 | 40% |
| 9. DURACIÓN DE TAREA | 3 | 3 | 0 % |
| TOTAL PUNTOS | 36 | 25 | MEJORA PROMEDIO |
| NIVEL RESPUESTA | MEDIO | BAJO | |
| ACCION | TAREA NECESITA MAS INVESTIGAR Y SON REQUIERIDOS CAMBIOS | BIEN ES ACEPTABLE | 24.24% |

### 4.4. Methodologies such as 5's within the workstation are validated.

Organize the materials and tools in order of use and make them easily clingable as shown in Figure 2 of the before and after application of the principle of storage of the tools used in the door assembly.

1. The Principles for the storage of templates, tools and tools to avoid useful, before complying with 20% of the principles now complies with 100% of them, improving by 80%.

2. Evaluating the Principles to reduce or eliminate the movements that traders perform previously comply with 15.3% of now applying the templates comply with 92.3% so they have improved by 77%.

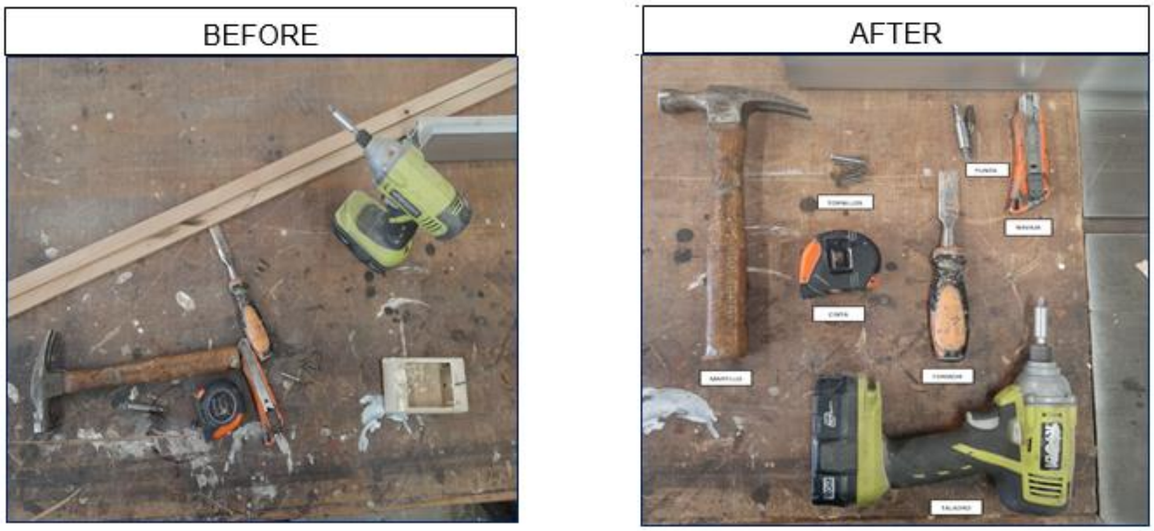



Figure 2. Samples of the before and after application of the principle of storage of the tools used in the door assembly.

**4.5. Quality Function Deployment Application (QFD) for clamping template design.** The proposal to implement a support template for supporting wooden structures was designed and analyzed (Figure 3). With the implementation of this template mainly greater safety was provided to the operator since it is a support to hold the wooden parts at the time of the screwing process.

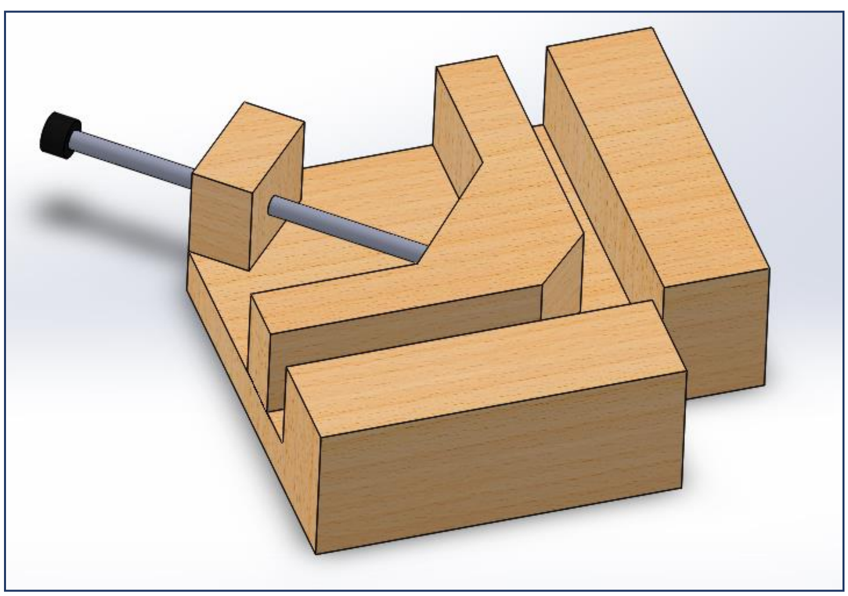


Figure 3. Wooden frame fastening insole for assembly screwing.

## 5. CONCLUSIONS

In conclusion, it is proposed that the designs of the jobs, work space, machinery and equipment, based on anthropometric data of workers in the carpentry workshop screwdriver process to create adequate working conditions to create adequate working conditions, be adapted contribute to increasing the efficiency of work by promoting the health, satisfaction and well-being of workers. Ergonomics is a science that adapts the work to man (and not this to work) in order to provide the greatest possible comfort in the exercise of any work activity since manual work remains the main working force for screwing that is why an ergonomic template is designed, due to the complexity of the processes within the workshop, which forces workers to perform tasks in which routine, repetitive movements, forced positions, the speed that does not provide rest for physical recovery, confined, poorly lit and ventilated spaces, long working days for poor planning. This new ergonomic evaluation method helps us quickly identify what aspects need immediate action since this represents a risk for the worker and in most cases are actions that can be taken from a quickly and without many resources and the results can justify any investment.

## 6. REFERENCES

Condiciones de seguridad e higiene en los centros de trabajo donde se genere ruido. NORMA Oficial Mexicana NOM-011-STPS-2001. Diario oficial de la Federación, 17 de abril de 2002. http://www.cucba.udg.mx/sites/default/files/proteccioncivil/normatividad/Nom-011.pdf

Condiciones de seguridad e higiene en los centros de trabajo donde se genere ruido. NORMA Oficial Mexicana NOM-011-STPS-2001. Diario oficial de la Federación, 17 de abril de 2002. http://www.cucba.udg.mx/sites/default/files/proteccioncivil/normatividad/Nom-011.pdf

Condiciones de iluminación en los centros de trabajo. NORMA Oficial Mexicana NOM-025-STPS-2008. Diario oficial de la Federación, 30 de diciembre de 2008. http://asinom.stps.gob.mx:8145/upload/noms/Nom-025.pdf

Equipo de protección personal-Selección, uso y manejo en los centros de trabajo. NORMA Oficial Mexicana NOM-017-STPS-2008. Diario oficial de la Federación, 9 de diciembre de 2008. https://www.stps.gob.mx/bp/secciones/dgsst/normatividad/normas/Nom-017.pdf

Factores de riesgo psicosocial en el trabajo-Identificación, análisis y prevención. NORMA Oficial Mexicana NOM-035-STPS-2018. Diario oficial de la Federación, 23 de octubre de 2018. https://www.dof.gob.mx/nota_detalle.php?codigo=5541828&fecha=23/10/2018

Hirano.H. (1990). 5 Pilares de la Fabrica Visual: La fuente para la implantación de las 5S. Tokyo, Japón: Copyright ©.

Organización Internacional del Trabajo. (1996). Ergonomic checkpoints. Ginebra: Copyright ©.

Secretaría del Trabajo y Previsión Social (2002). NOM-015-STPS-2001. Diario oficial de la Federación, 14 de junio de 2002.

*http://asinom.stps.gob.mx:8145/upload/noms/Nom-015.pdf*

# ERGONOMIC EVALUATION OF TWO AGRICULTURAL PRACTICES IN THE WORKPLACES OF THE PLANTING OPERATIONAL AREA AT THE GUASAVE HIGHER TECHNOLOGICAL INSTITUTE

**Grace Erandy Báez Hernández, Adalid Graciano Obeso, Oliver Guadalupe Aguilar Sánchez, Víctor Manuel Camacho Bobadilla, María Fernanda Cárdenas Pérez**

Department of Industrial Engineering
Instituto Tecnológico Superior de Guasave
Carretera a Brecha S/N, Ej. Burrioncito
Guasave, Sinaloa, CP. 81149
gracebaezh@gmail.com

**Resumen:** La evaluación de riesgos laborales constituye la base fundamental para la prevención de accidentes y enfermedades de origen laboral dentro de las organizaciones. En general todos los sectores productivos presentan fallas y deben ser estudiados continuamente para poder plantear estrategias que se adapten a los requerimientos de una sociedad y un mundo cambiante. Sin embargo, cuando se hacen estudios en sectores como el rural, donde la actividad agrícola es prioritaria y depende en gran medida de la mano de obra se tienen los factores naturales y económicos como prioritarios a la hora de buscar soluciones a las problemáticas encontradas, mientras que los que afectan directamente al ser humano pasan a un segundo. Así mismo, es importante estar consientes que existe la necesidad latente de incrementar la producción agrícola en el mundo, la cual debe ir acompañada de programas donde su prioridad sea la de mejorar la salud y la seguridad de los trabajadores agrícolas. Se realizó una evaluación ergonómica de dos prácticas agrícolas en los puestos de trabajo del área operativa de siembra del campo experimental del Instituto Tecnológico de Guasave, en donde se analizaron los niveles de riesgo laboral ergonómicos de dos procesos de siembra de manera manual y siembra utilizando un dispositivo. Las evaluaciones de riesgos fueron realizadas mediante el método RULA y complementadas con las tablas de Snook y Ciriello Liberty Mutual para obtener un análisis más completo de las dos prácticas y de las condiciones de trabajo.

**Palabras clave**: Agricultura, ergonómica, siembra, Jornaleros

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

**Abstract:** The evaluation of occupational risks constitutes the fundamental basis for the prevention of accidents and diseases of occupational origin within organization. In general all the productive sectors have mistakes that must be continuously studied to develop strategies that adapt to the requirements of a society and a changing word. However, when studies are carried out in sectors such as rural areas, where agricultural activity is a priority and depend largely on the labor force, natural and economic are given priority when it comes to seeking solutions to the problems presented, while the factors that directly affect the human being take second place. Likewise it is important to be aware that there is a latent need to increase agricultural production in the word, which must be accompanied by programs where its priority is to improve the health and safety of agricultural workers. An ergonomic evaluation of two agricultural practices was applied in the workplaces of the operational area of sowing of the experimental field of Guasave Technological Institute, where the ergonomic occupational risk levels of the manual seeding processes and using a device seeding processes were analyzed. The risk evaluation were carried out using the RULA method and complemented with the Snook and Ciriello Liberty Mutual tables to get a more complete analysis of both of the practices and working condition.

**Keywords:** Agriculture, ergonomics, planting, day laborers.

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

## 1. INTRODUCCIÓN

Agriculture is a volatile industry due to its seasonal period. The evaluation of occupational hazards constitutes the fundamental basis for the prevention of accidents and diseases of labor origin within organizations (Hoffman-Jaramillo, et.al., 2017).Ergonomics incorporates solutions destined to improves work conditions to eliminate or reduce the appearance of fatigue or muscle disturbance. (Vilela, Díaz, & Sanfeliz, 2003)The presence of musculoskeletal disorders is an important issue in public health among farmers. There is a small number of studies have examined the ergonomic risk and work conditions associated with the presence of these disorders. It has been shown that agriculture is an occupation that requires a large amount of physical demand that includes difficult movements and postures, repetitive and monotonous tasks and high possibility of suffer and accidents from falls because of the irregular land. (Garzon, Vázquez, & Molina, 2017) In general, all productive sectors have failures and must be continuously studied in order to propose strategies that adapt to the requirements of a changing society and world. However, when studies are carried out in sectors such as rural, where agricultural activity is a priority and depends largely on the workforce, natural and economic factors are a priority when looking for solutions to the problems encountered, while those that directly affect the human being go to a second (Jaramillo-Giraldo, 2015). Likewise, it is important to be aware that there is a latent need to increase agricultural production in the world, which should be accompanied by programs where its priority is to improve the health and safety of agricultural workers. According to Data from the Mexican Institute of Social Health in 2018, it was found that from 100 agricultural workers about 2.2% present work risks and 1.8% also can present work accidents.

(IMSS, 2019) Rapid Upper Limb Assessment is a method developed for evaluating the exposure of people to postures, forces and muscular activity, which are known for contributing to the appearance of musculoskeletal disorder in the upper extremities. (Rodríguez-Ruiz & Guevara-Velasco, 2011). Snook and Ciriello Tables are used to provide guidelines for evaluation and task design with manual handling loads considering the skills and limitations of workers. (Diego-Mas, 2015). Working conditions will be evaluated in two manual sowing practices and with a seeding device in corn and watermelon culture, 2 weeks of representative samples will be taken to perform the data analysis. After in the analysis carried out in the experimental field at the Guasave Technological Institute, it was carried out in an area of one-hectare with 32 furrows, with a distance of 2 meter from each other. 5 people work in the experimental field, which/who belong to an age range of 40 -50 years old.

## 2. OBJECTIVE

Carry out an ergonomic evaluation of two agricultural practices in the workplaces of the operative planting area of the experimental field of the Technological Institute of Guasave.

## 3. DELIMITATION

Analyze the ergonomic occupational risk levels in a qualitative level and quantitative way of two work processes in the operational area of manual sowing and sowing using a device.

## 4. METHODOLOGY

As a first step, the risk assessment was carried out in the experimental field of the Guasave Technological Institute, Allowing the analysis of the working conditions of two agricultural practices: the sowing of corn and watermelon manually and with help of a seeding device.
Based on the data obtained from the observations made at the workplace, the conversations held with the employees and the results of the measurements considered necessary, the Snook and Ciriello tables were used to determine the appropriate adjustments to improve the practices of planting carried out within the experimental field of the Guasave Technological Institute.

## 5. RESULTS

During the analysis, the practices of sowing in two crops Corn and Watermelon were evaluated to identify the conditions of work and validate the most effective practice in the sowing process where the worker operates

In Illustration 1 you can see how the worker sow manually watermelon seeds while he has a specific position, where he involves the movement of both arms, keeps the torso tilted and leans in both of his legs. During this process specifically is needed to sow the seeds at a distance of 90 cm to 1m between each seed. This indicates that the worker has to repeat the position several times while the sowing process is performed.

The “RULA“method was applied. The RULA method registers a score of 6, indicating that a necessary to do more research and modify positions soon. (Illustration2)

Figure1 Worker from the experimental field sowing watermelon seed

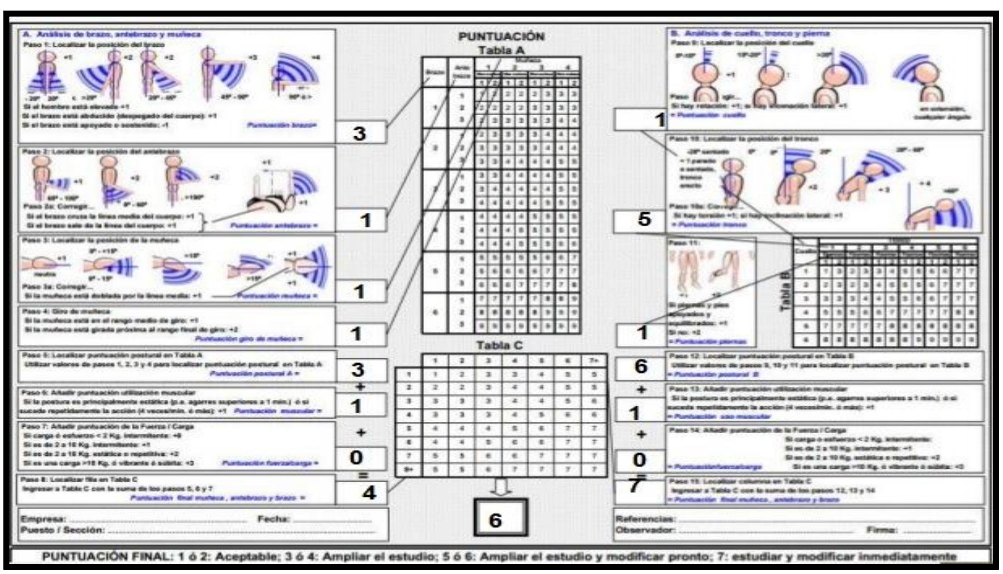



Figure 2. RULA method applied to the process of sowing watermelon seed

The Corn seeds sowing process is similar to the watermelon process, as observed in the illustration 3 the worker is leaning forward while is bending his knees and using his arms to sow the corn seed into the ground, this process need to be repeated every 20 cm approximately because around 5 to 7 seeds should be sown in each meter. This makes this process way more repetitive than the watermelon sowing.

The “RULA” ergonomic evaluation method was also applied to the manual sowing of corn seeds process (illustration 3), the result are similar as the ones obtained at the watermelon sowing seeds process analysis this is because both of the positions are very similar. The results of the RULA evaluation also showed a score of 6, which makes necessary to increase the research and modify the work positions for the agricultural workers.

Figure 3. Worker from the experimental field sowing corn seeds

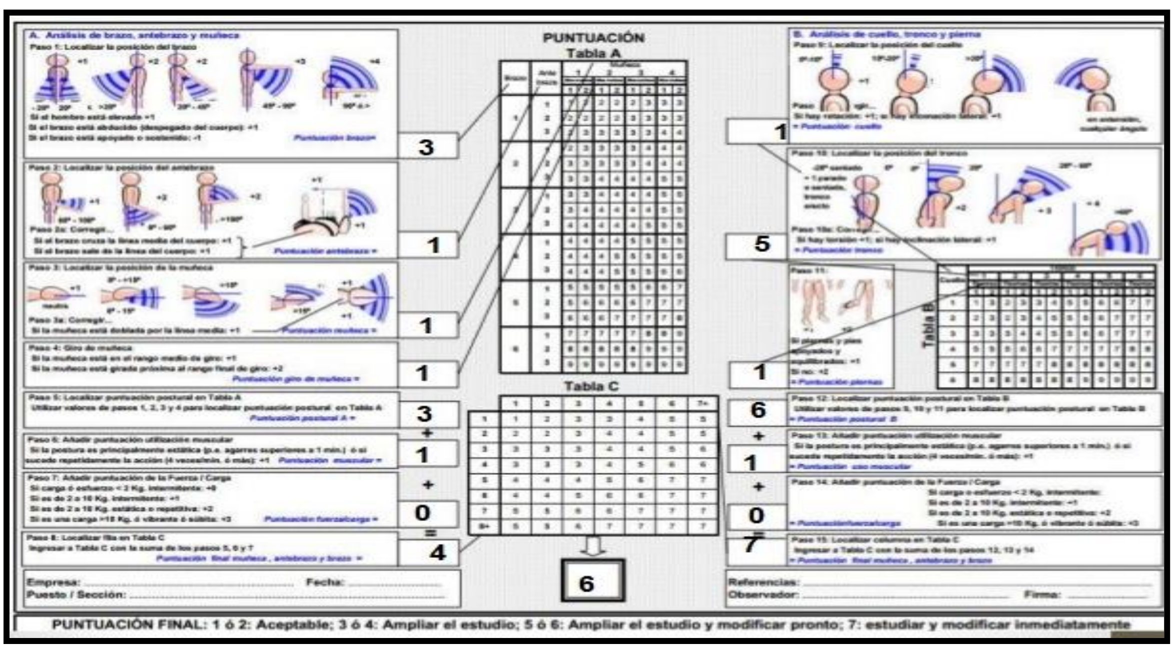



Figure 4 RULA Method applied to the process of sowing corn seeds

It was also evaluated the process of sowing with a seeding device that works with mechanical force, the worker pushes the device forward while it is sowing the seeds in the ground.

An ergonomic evaluation was applied too during the watermelon's seeds sowing process using a mechanical sowing device. The analysis was carries out through RULA method in which the score was 4 points which means that it is necessary to expand the study and do more research to improve the work conditions for agricultural workers.

Figure 5 process of sowing watermelon seeds using a mechanical device

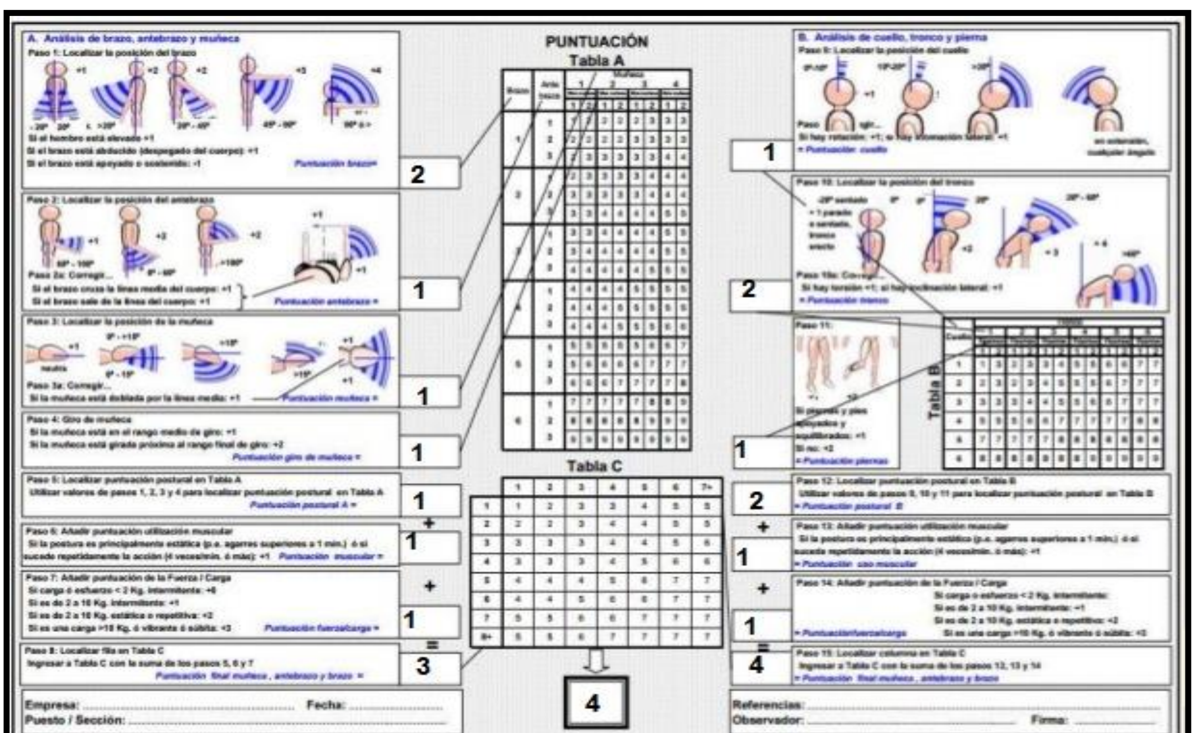



Figure 6 RULA method

In the same way it was analyzed the corn seeds sowing process using the mechanical seeding device.
The evaluation made through RULA results a score of 4, therefore it is necessary to expand research before do any change on the position adopted to manipulate the seeding device (Kong, Lee, Kyung-Suk, & Dae-Min, 2017).

Figure 7. Sowing process using a mechanical device

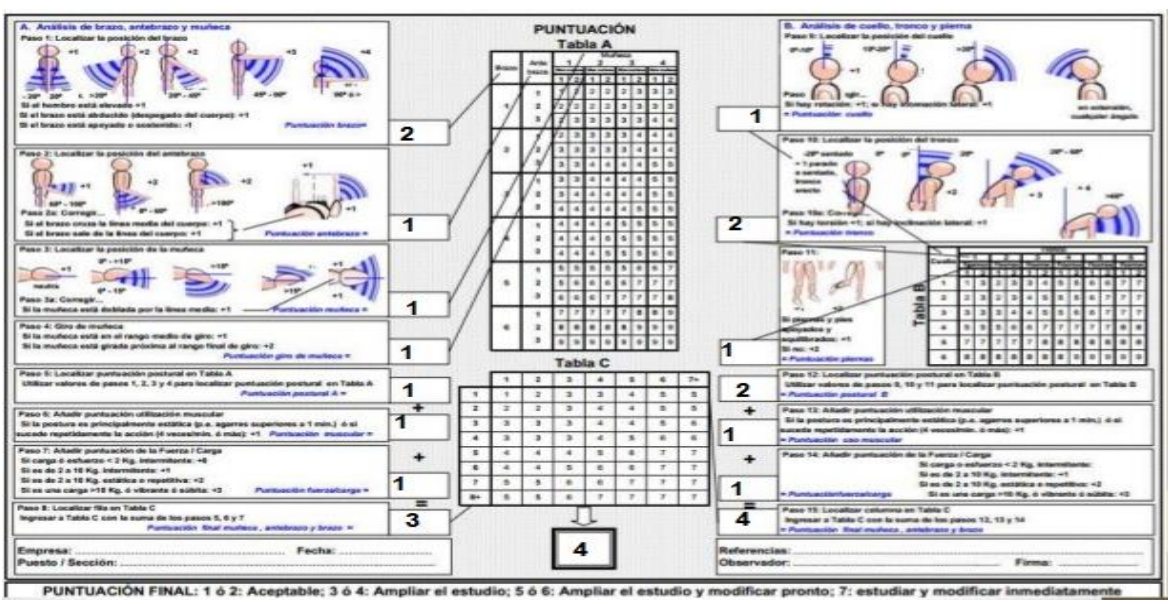


Figure 8. RULA Method

The Snook and Ciriello tables collect the different maximum accepted weight for the different kind of cargo handling. The objective of these tables is study the association between lower-back pain and completing task. According with the results that the table shows a task is considered as acceptable if it is over 90%, if the task has a score that goes from 90% to 75% that means that it is possible to improve the task, and if it is under 75% it is considered as a risky task.

## 7.- CONCLUSIONS

The ergonomic evaluation of two agricultural practices in the work stations of the experimental field of the Higher Technological Institute of Guasave, detects the levels of occupational risk to which the workers are exposed, when performing their daily tasks.

The application of the Rula Method in the two types of sowing, manual and device presents the most viable practice for field operations. In manual seeding a Level 6 is registered, which recommends an immediate change in operations. And in the practice of sowing with a device, a level 4 is registered, which changes to future operations. With this, it is confirmed that the manual with the highest risk is the manual and the time of completion was the same for both exercises.

The Snook and Ciriello analysis of the Liberty mutual tables, generates as a result that the classified task is acceptable with possible improvements, since it presents records above 90%. Indicating that if the task has a score that goes from 90% to 75% it means that it is possible to improve the task.

This analysis of operations is important because it develops information on the prevention of musculoskeletal injuries and allows detecting the risk factors to which workers are exposed when they perform operations in the agricultural field.

## 8.- REFERENCES

Cely-Ramos, A. (2015, Abril 16). *prezi.com*. Retrieved from https://prezi.com/-vgwoc8c7jg_/tablas-de-snook-y-ciriello/

Garzon, M., Vázquez, E., & Molina, J. (2017). Condiciones de trabajo, riesgos ergónómicos y presencia de desórdenes músculo-esqueléticps en recolectores de café de un municipio de Colombia. . *Rev Asoc Esp Med Trab*, 127-136.

IMSS. (2019). *Memoria Técnica 2018.* Ciudad de México: IMSS.

Diego-Mas, J. a. (2015). *Evaluación de la manipulación manual de cargas mediante las tablas de SNOOK y CIRIELLO*. Retrieved from ergonautas.upv.e: https://www.ergonautas.upv.es/metodos/snook_y_ciriello/snook-ayuda.php

Kong, Y.-K., Lee, S.-y., Kyung-Suk, L., & Dae-Min, K. (2017). Comparacion of Ergonomic Evaluation Tool (ALLA, RULA, REBA and OWAS) for Farm Work. *International Journal od Ocuppational Safety and Ergonomics*, 22-46.

Madriz, C., & Schulze, L. (2010). Análisis de a herramienta de medición del riesgo ergoñomico en la agricultura . *Conocimiento para innovar*, 4-17.

Rodríguez-Rui, Y., & Guevara-Velasco, C. (2011). Empleo de los métodos ERIN y RULA en la evaluación ergonómica de estaciones de trabajo. *Ingeniería*

*Industrial*, 19-27.

Ruiz-Ruiz, L. (2012). MAnipulación mnaual de tablas de snook y Ciriello ISO 11228. *Ministerio de trabajo e inmigración*, 1-16.

Vilela, J., Díaz, T., & Sanfeliz, A. (2003). Análisis ergonómicoen enfermería instrumentista: un enfoque descriptivo. *Sección Técnica*, 5-10.

# ERGONOMIC ANALYSIS OF THE MINI BELL PEPER PRE-SELECTED STATION OF THE PACKAGED PRODUCTION LINE, OF THE AGRICULTURAL COMPANY JMQ GUASAVE SINALOA

**Ángel Ahumada Gámez, Oscar Chavira Castro, José Miguel Vázquez Castro**
**Grace Erandy Báez Hernández**

Department of Industrial Engineering
Instituto Tecnológico Superior de Guasave
Carretera a Brecha S/N, Ej. Burrioncito
Guasave, Sinaloa, CP. 81149
Autec_9700@gmail.com, gracebaezh@gmail.com,

**Resumen**: En este estudio se hizo un análisis de las condiciones ergonómicas generales en las que se encuentra la empresa Agroexportadora JMQ, ubicada en Ejido Batamote, Guasave, Sinaloa, México, para identificar cual es la estación de trabajo con mayor riesgo de lesiones musculoesqueléticas, esto se realizó a través del método Rapid Upper Limb Assessment (RULA). Según IMSS (2017), se registraron un total de 457 casos de traumatismos en hombres y mujeres, ocasionados por riesgos laborales en operadores de instalación en relación con esta problemática. Se desarrolló la presente investigación teniendo como propósito principal analizar las condiciones ergonómicas de la estación de trabajo con mayor riesgo de lesiones musculoesqueléticas, con el objeto de evaluar las posturas del operador tomando en cuenta los principios ergonómicos, durante su jornada laboral e identificar los factores de riesgo que pueden ocasionar lesiones en las extremidades superiores del cuerpo. Identificando las áreas que requieren un rediseño y las condiciones de trabajo de los operadores cuando realizan las actividades

**Palabras clave:** Lesiones musculoesqueléticas, Método Rula, Principios ergonómicos.

**Relevancia para la ergonomía**: El presente estudio aporta a la ergonomía, debido a que brinda información para la realización de mejoras ergonómicas en las condiciones laborales en las cuales se encuentran los trabajadores en los empaques.

**Abstract:** In this study, an analysis was made of the general ergonomic conditions in which the Agroexportadora JMQ company is located, located in Ejido Batamote, Guasave, Sinaloa, Mexico, to identify which is the work station with the highest risk of musculoskeletal injuries, This was done through the Rapid Upper Limb Assessment (RULA) method. According to IMSS (2017), a total of 457 cases of injuries were registered in men and women, caused by occupational risks in installation operators in relation to this problem. The present research was developed with the main purpose of analyzing the ergonomic conditions of the workstation with the highest risk of musculoskeletal injuries, in order to evaluate the operator's postures taking into account ergonomic principles, during their working day and identify the factors of risk that can cause injury to the upper extremities of the body. Identifying the areas that require redesign and the working conditions of the operators when they perform the activities.

**Keywords**: Musculoskeletal injuries, Rula method, Ergonomic principles

**Relevance for the ergonomics**: This study contributes to ergonomics, because it provides information for making ergonomic improvements in the working conditions in which workers are in packaging.

## 1. INTRODUCTION

The Agriculture and its relationship with companies, such as agro-exporters, are a great economic engine in the state of Sinaloa. According to CODESIN (Council for the Economic Development of Sinaloa), the state of Sinaloa has been exporting vegetables for more than a century. Horticulture is one of the main economic activities in Sinaloa; not only because it is the main source of exports from the state (which in 2012-2013 reached 943 thousand tons), but also because during the winter it actively participates in the national supply with another million and a half tons. Its economic importance is highlighted by the attraction of foreign currency for more than 900 million dollars; employment for more than 150 thousand day laborers, mostly migrants and another 50 thousand temporary jobs for workers from Sinaloa in the upper and middle part of the state. (CODESIN, 2020).

Workers from different economic sectors develop diseases with a characteristic regionalization of musculoskeletal damage (Sánchez, Pérez and González, 2011). It is known that, in Mexico, for 2016, the IMSS registered 12,622 cases of occupational diseases, of which 4,683 (37.1%) were musculoskeletal, placing them among the groups of occupational diseases with the highest rate of occurrence. The above is equivalent to 2 out of 5 cases of work-related illnesses related to this type of illness (Work, 2017).

Musculoskeletal injuries have a huge and growing impact around the world, from the perspective of productivity and industry economics. In Mexico, musculoskeletal pathology is one of the main causes of morbidity, as established by the evidence according to IMSS statistics for 2011, where it is reported that the total number of occupational hazards was 536,322 cases (IMSS, 2014).

Patients with musculoskeletal disorders usually present in the arm and neck. The repetition of movements in the work process contributes to the symptoms in a significant proportion in these patients. Repetition, force, forced postures, vibrations, and jobs that require speed are occupational risk factors that can contribute to the development of these conditions.

In Mexico there are no records of ergonomic studies of musculoskeletal injuries in vegetable agro-exporters, which provide an analysis of the work stations and provide an increase in productivity and the worker's quality of life. An analysis was carried out of the general ergonomic conditions of the operating areas that are located in the Agroexportadora JMQ company located in the Batamote ejido, which has a total of 75 operators in the plant distributed in three 8-hour shifts. A work station was located that does not meet inappropriate working conditions and positions for workers. The main objective is to analyze and identify the musculoskeletal injuries of workers, applying an ergonomic evaluation, with the Rapid Upper Limb Assessment (RULA) method.

## 2. OBJECTIVES

Evaluate the mini bell peper preselection workstation in the packaging production line to identify cumulative trauma disorders at the JQM agricultural company located in Ejido Batamote Guasave Sinaloa.

## 3. METHODOLOGY

To develop this study, the activities were analyzed and the working conditions were identified:

1.-Make a diagnosis of the company, identifying the characteristics of the workers, work stations, and analyzing the physical conditions in which the facilities are located and the ergonomic principles.

2.-An analysis of the work stations of the different areas of the company was developed, identifying the risk factors in the station of the pre-selected mini bell peper process. It was observed that the positions in which the operators were found were not those indicated for the optimal development of their work, at the time of speaking with the operators they were dissatisfied with their position.

3.-The evaluation methods applied were the RULA Method and a checklist of ergonomic principles, which were applied to the operators of the station that was detected with the highest risk.

## 4. RESULTS

A diagnosis of the company was carried out, identifying the characteristics of the workers, work stations, analyzing the physical conditions in which the facilities are located, the ergonomic principles and application of the ergonomic evaluation method.

**Table 1. Mini Bell Peper Preset Station Conditions.**
**Mini Bell Peper Preset Station**

| | |
|---|---|
| Operations analysis | 3 shifts of 8 hours of work |
| Activity | All day in standing position |
| Operators | 6 operators all women aged 20 to 45 years. |
| Frequency of activity. | Repetitive work with more than 6 operations per minute. |

The physical conditions in which the workstation is located is viable, however, it is identified that it does not comply with 5 ergonomic principles that will be the basis for the design proposal.

**Table 2. Ergonomic principles check sheet**

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

Figure 1. Out of reach posture.

Figure 2. Uncomfortable platform for long working hours

## 5. DISCUSSION/CONCLUSIONS

Ergonomic analysis identifies risk factors at the agro-exporter mini bell peper preselection workstation. Risks and dangerous conditions were found for the operator, through ergonomic principles, overexertion, pressure on the body, unnecessary efforts, adjustment and change of inappropriate postures were detected, the controls and panels do not have good visualization, generating confusion in the operators when they carry out their activities.

The ergonomic evaluation indicates the working conditions to which the operator is exposed when performing the tasks. The RULA method evaluates the postures and risks associated with musculoskeletal disorders due to postural load, in the activities of the production process. As a result, it indicates a level 5, which represents a need for redesign of the task or workstation. AND Presenting a postural risk in the extremities of the legs, arms, upper and lower back. Generating fatigue and cumulative trauma disorders.

The improvement proposal for the work area is the placement of anti-fatigue mats, installing a separator on the conveyor belts which places the product at a distance closer to the operator and can be within reach. Reorient dashboards and controls to better fit operators' viewing when they are doing work. Consider STPS Official Mexican Standard 001 for the redesign of tasks. For the worker these improvements are significant, avoid bad posture or present some type of fatigue and low productivity, and do not cause injuries. With this modification, the quality of life of the operator and productivity would be increased, reducing staff turnover, generating a more productive operator.

The ergonomic evaluation method, which was applied was Rula Method, was obtained as a result of level 5.

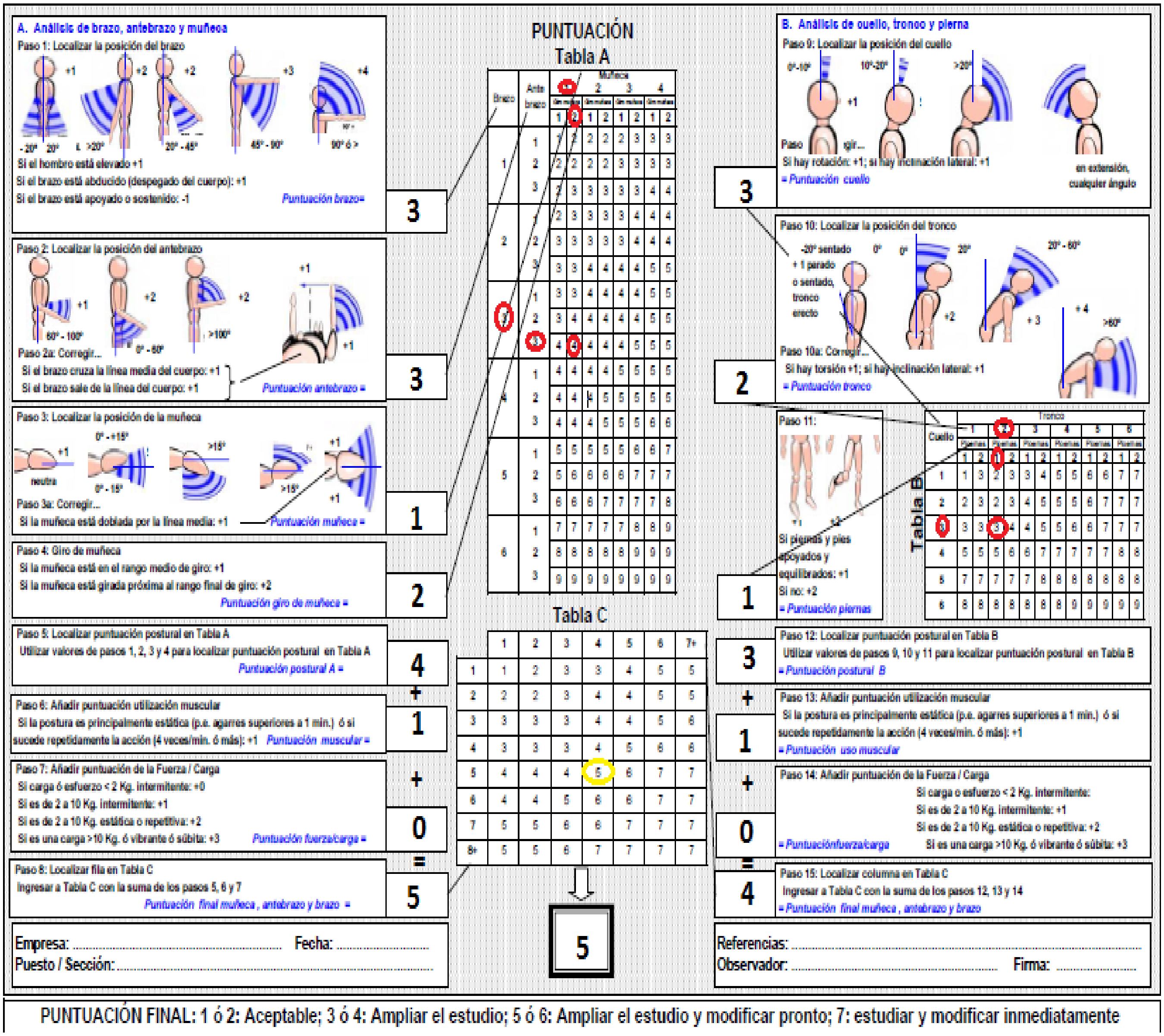



Figure 3. Application of the RULA method

## 6. REFERENCES

CODESIN. (3 de Septiembre de 2014). *codesin.mx*. Obtenido de codesin.mx: http://codesin.mx/news/reflexion-hortalizas-transformacion-de-la-agricultura-de-sinaloa/

IMSS. (2014). *Memoria.* MEXICO: IMSS.

Leticia Arenas-Ortiz, Ó. C.-G. (2013). Factores de riesgo de trastornos músculo-esqueléticos crónicos laborales. *Medigraphic-literatura biomédica*, 370-379.

McAtamney, L. &. (1993). Un método de encuesta para la investigación de trastornos del miembro superior relacionados con el trabajo. *Ergonomía aplicada*, 91-99.

Mónica Sánchez Aguilar, G. B.-M. (2011). Enfermedades derivadas de factores de riesgo presentes en la industria de producción de alimentos. *SciELO*, 300-312.

Mónica Sánchez Aguilar, G. B.-M. (2011). Enfermedades potenciales derivadas de factores de riesgo presentes en la industria de producción de alimentos. *SciELO*, 300-312.

Retamal, R. P. (2015). Programa de ergonomía participativa para la prevención de trastornos musculoesqueléticos. Aplicación en una empresa del Sector Industrial. *SciELO*, 128-136.

SEMAC. (16 de Marzo de 2020). *Sociedad de Ergonomistas de México*. Obtenido de http://www.semac.org.mx

Trabajo, G. M. (Octubre de 2017). *Secretaria del Trabajo y Previsión Social.* Obtenido de Secretaria del Trabajo y Previsión Social: https://www.gob.mx/cms/uploads/attachment/file/279153/Libro-Seguridad_y_salud_en_el_trabajo_en_Me_xico-Avances__retos_y_desafios__Digital_.pdf

# IDENTIFICATION OF CUMULATIVE TRAUMA DISORDERS IN THE IRRIGATION PROCESS DURING PLANTING IN GUASAVE MUNICIPALITY

**Victoria Guadalupe Álvarez Morales, Enoc Meza Pérez, Jaqueline Sauceda López, Patricia Lizbeth Valdez Gámez, Brenda Guadalupe Delgado Jiménez**.

Industrial Engineering Department
Instituto Tecnológico Superior de Guasave
Carretera a Brecha Sin Número, Ej. Burrioncito
Guasave, Sinaloa, State 81149

Corresponding author's e-mail: alvarezmoralesvictoria@gmail.com

**Resumen**: El siguiente estudio presenta un análisis de posturas ergonómicas de dos trabajadores en su acción de riego en cultivos de maíz, el primero ubicado en el Ejido Chino de los López y el segundo en el Ejido Leyva Solano, con la finalidad de identificar cuáles son las posiciones que provocan lesiones posturales en los trabajadores. Para este estudio se tomó como base las posturas ergonómicas según la Norma Oficial Mexicana NOM-036-1-STPS-2018 Factores de riesgo ergonómico en el trabajo-Identificación, análisis, prevención y control, donde se establecen los elementos para identificar, analizar, prevenir y controlar los factores de riesgo ergonómico, a efecto de prevenir alteraciones en la salud de los trabajadores, posteriormente se aplicó el método REBA el cual permite estudiar si las posturas de los jornaleros de diferentes edades repercuten en su salud durante el proceso de colocación de pipas como sistema de riego. Los resultados obtenidos por medio del método REBA permitieron identificar en ambos procesos los DTA de los jornaleros, así como las condiciones de trabajo y las posturas no adecuadas según las actividades que realizaban durante el trabajo. Los dos casos presentaron un desempeño similar en cuanto al resultado arrojado por el método REBA el cual indicó que es **"Necesario"** tomar medidas de seguridad, debido a que se generan problemas musco esqueléticos en los trabajadores.

**Palabras clave**: Ergonomía, Método REBA, Análisis postural, Principios Ergonómicos

**Relevancia para la ergonomía**: La ergonomía es la interacción entre los seres humanos y otros elementos de un sistema productivo. Este estudio aporta información relevante para los análisis de las operaciones que se realizan en el sector agrícola, donde se evalúan las condiciones de trabajo y poder realizar mejoras significativas.

**Abstract:** The following study presents an analysis of ergonomic postures of two workers in their irrigation action in corn crops, the first located in the Ejido Chino de los López and the second in the Ejido Leyva Solano, in order to identify which are positions that cause postural injuries in workers. For this study, the ergonomic postures were taken as a basis according to the Official Mexican Standard NOM-036-1-STPS-2018 Ergonomic risk factors at work-Identification, analysis, prevention and control, where the elements to identify, analyze, prevent and control ergonomic risk factors, in order to prevent alterations in the health of workers, later the REBA method was applied which allows studying whether the postures of day laborers of different ages affect their health during the process of placing the pipes as an irrigation system. The results obtained by means of the REBA method allowed identifying in both processes the DTA of the day laborers, as well as the working conditions and inappropriate postures according to the activities they carried out during the work. The two cases presented a similar performance in terms of the result obtained by the REBA method, which indicated that it is "necessary" to take safety measures, because musculoskeletal problems are generated in the workers.

**Keywords:** Ergonomics, REBA method, Postural analysis, Ergonomic Principles

**Relevance for ergonomics:** Ergonomics is the interaction between human beings and other elements of a production system. This study provides relevant information for the analysis of operations carried out in the agricultural sector, where working conditions are evaluated and significant improvements can be made.

## 1. INTRODUCTION

Through the years the ergonomics applied in the production processes has consolidated the daily activities of the industry. The Ergonomists Society of Mexico AC, indicates that it is the scientific discipline related to the knowledge of the interaction between the human being and other elements of a system, and the profession that applies the theory, principles, data and methods to design seeking to optimize the human welfare and the implementation of the Global System. (SEMAC 2018).

This science adapts equipment, tasks and tools to the needs and capacities of human beings, improving their efficiency, safety and well-being. Therefore, the ergonomic approach is to design equipment and jobs in such a way that they adapt to people and not the other way around. The continuous or repeated adoption of forced postures during work generates fatigue and in the long run can cause disorders in the musculoskeletal system. This static or postural load is one of the most important factors in the evaluation of working conditions, and its reduction is one of the fundamental measures for improvements at work.

Various methods have been developed to assess the risk associated with postural load in a job, each with a different scope of application and contribution of results. (Asensio-Cuest, Bastante Ceca, & Diego Más, 2012) The REBA (Rapid Entire Body Assessment) method was proposed by Sue Hignett and Lynn Mc Atamney, and published by the specialized journal Applied Ergonomics in 2000. The method is a result from the joint work of a team of ergonors, physiotherapists, occupational therapists and nurses, who identified around 600 positions for its elaboration. This method allows the analysis of some movements of the arm, wrist, trunk, neck and legs. It also considers the posture and rotation of the body to carry out the assessment and analysis of the task, to prevent the worker from suffering any bodily dysfunction due to the poor position she adopts when carrying out her work. (Obregón Sánchez, 2016).

In Mexico, one of the most common occupational diseases is those caused by musculoskeletal pathologies, as established by IMSS statistics, where it is reported that the total number of occupational hazards was 562,849 cases (IMSS, 2017).

Next, a study is presented where the manual irrigation process of 2 workers was analyzed, who used pipes (hoses of approximately 1.90 meters) as an irrigation system, these pipes facilitate the arrival of water to the sowing, water from canals, which in turn are connected to dams in the region and its surroundings. The irrigation process and accumulated trauma disorders caused by exposure to risk factors involving nerves, tendons, muscles and support structures such as intervertebral discs were analyzed. The application of the REBA method was proposed to identify cumulative traumatic disorders during a certain process. As well as, it was necessary to rely on the Official Mexican Standard NOM-036-1-STPS-2018, where ergonomic risk factors at work-identification, analysis, prevention and control are mentioned. The objective of the research is to

## 2. OBJETIVE

Identify the causes and propose solutions to reduce the injuries generated in the people involved in the process of irrigation with pipes of corn crops in the Guasave Sinaloa region.

## 3. METODOLOGY

To carry out this study, it was necessary to identify cumulative trauma disorders through the REBA method, complementing the analysis with the provisions of the Ergonomic Principles and Official Mexican Standards.

1. A diagnosis of the irrigation day of workers 1 and 2 was made, where some characteristics were identified such as age, sex, duration of work and irrigation area (see table 1), as well as the ergonomic postures that they presented to the carry out said activity.

| workers 1 | Workers 2 |
|---|---|
| Gender: Male | Gender: Male |
| Age: 49 years | Age: 42 years |
| Duration: 48 hours | Duration: 48 hours |
| Irrigation area: 9 hectares | Irrigation area: 12.5 hectares |

Table 1: Characteristics of workers

2. An exhaustive analysis of the Official Mexican Standard NOM-036-1-STPS-2018 was carried out, as well as the ergonomic principles, in order to have a greater knowledge of the subject and to be able to more easily determine the most critical positions caused during watering with pipes.

3. Application of the ergonomic evaluation method: The REBA Method to determine the risks of injuries associated with musculoskeletal postures.

## 2.1 PREVIOUS AND POST WORKER ACTIVITIES

In the irrigation process, it is necessary for the laborers to carry out previous and subsequent activities as shown in Table 2.

. **Table 2. Activities of day laborers**

| workers 1(9 Hectares) | | workers 2 (12.5 Hectares) | |
|---|---|---|---|
| before | after | Before | After |
| ✓ Make channels<br>✓ Bring the irrigation equipment<br>✓ Put tarps<br>✓ Accommodate pipes<br>✓ Open gates to release water from the channels | ✓ Remove equipment when watering is finished<br>✓ Delete channels | ✓ Make channels<br>✓ Bring the irrigation equipment<br>✓ Put tarps<br>✓ Accommodate pipes<br>✓ Open gates to release water from the channels | ✓ Remove equipment when watering is finished<br>✓ Delete channels |

## 4. RESULTS

Based on NOM-036-STPS-2018, the estimation of the risk of activities that involve lifting / lowering loads helps to identify that some activities such as: horizontal distance between the hands and the lower part of the back are within high risk level and indicates that prompt corrective action is required (see figure 1 and 2), as the arms lean out of the body and the torso leans forward. Similarly, the vertical lifting region is at ground level or below and indicating a high risk level. On the other hand, the properties of the surface where the worker walks or remains standing were identified, which is contaminated / wet or uneven as shown in figure 3 and 4.

This analysis also identified the DTAs that occur in workers who irrigate with pipes, as well as the working conditions and inappropriate postures for the activities they perform, generating musculoskeletal problems in the workers.

Figure 1 and 2. High risk level

Figure 3 and 4 wet or uneven surface

The REBA method was applied for each worker, analyzing the most critical postures of neck, legs, and trunk corresponding to group “A”, as well as arms, forearms and wrist of group “B”, yielding a result of 7 in final score for worker number 1 (see figure 5) and 4 in the final score for worker 2 (see figure 6), which means that the level of risk is Medium and that it is NECESSARY to recommend action on the evaluated posture.

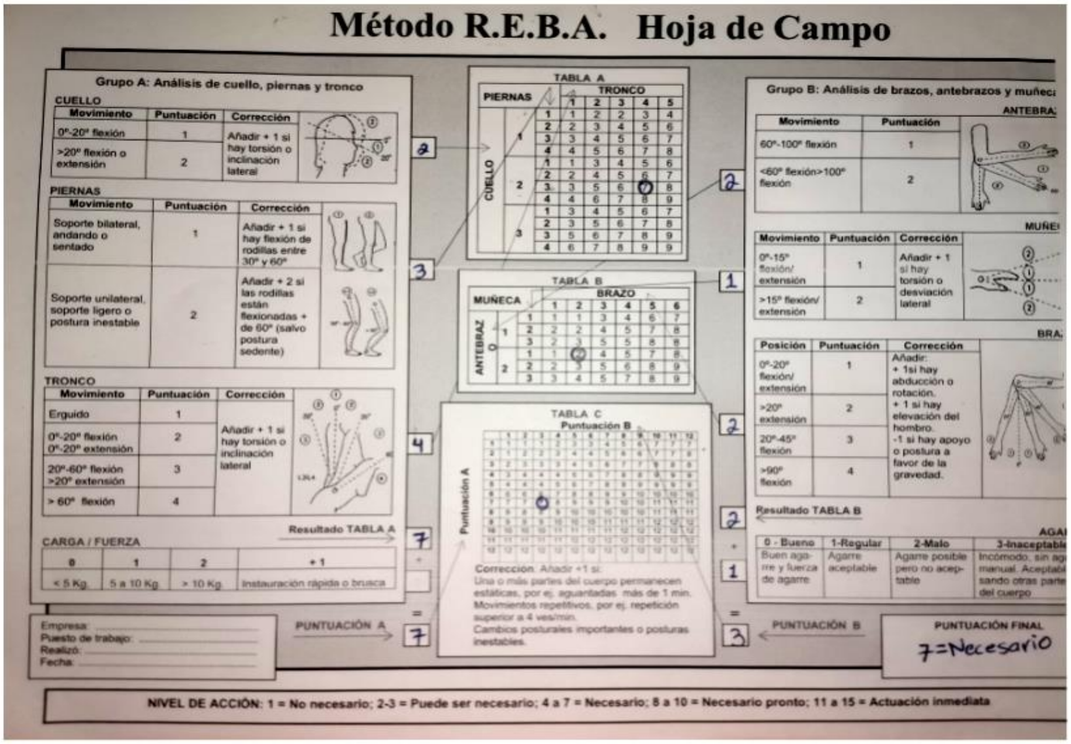



Figure 5. REBA Method, Worker 1

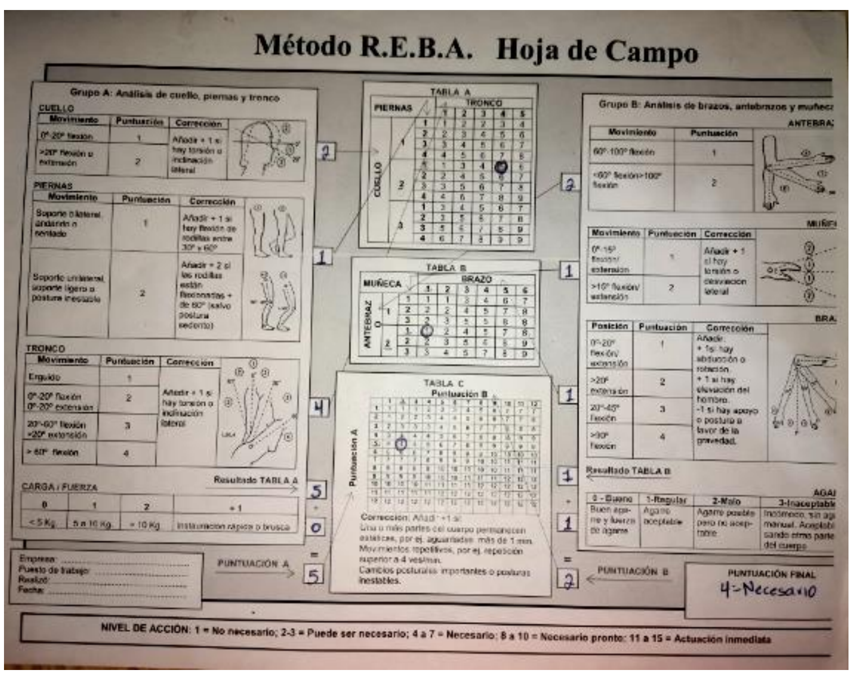



Figure 6. REBA Method, Worker 2

## 5. CONCLUSIONS

The application of ergonomic methods makes it possible to reduce injuries and illnesses, reduce disability and compensation costs, increase productivity, quality, safety, improve conditions and quality of life at work, hence the importance of correctly choosing the method of identification of risks.

For this study, the analysis of the Official Mexican Standard NOM-036-1-STPS-2018, the ergonomic principles and the application of the REBA Method was of great help, which allowed to verify that the postures that the day laborers perform are not adequate for the activities they carry out, and if they are not corrected they run the risk of presenting musculoskeletal damage in the short and long term.

The REBA Method is the ideal one for this type of study because it allows a joint analysis of the positions adopted by the upper body (arm, forearm, wrist), trunk, neck and legs. In addition, it defines other factors that are considered determining for the final assessment of the posture, such as the load or force handled, the type of grip or the type of muscular activity developed by the worker. It allows evaluating both static and dynamic postures, and incorporates as a novelty the possibility of signaling the existence of sudden changes in posture or unstable postures.

With the development of this research it can be concluded that it is necessary for day laborers to identify which are the appropriate postures so as not to affect their health, so it is recommended that they take training on ergonomic principles and economy of movement.

## 5. REFERENCES


Asensio-Cuest, S., Bastante Ceca, M. J., & Diego Más, J. A. (2012). *Evaluaciòn Ergonòmica de Puestos de Trabajo .* Editorial Paraninfo.

http://www.dof.gob.mx/normasOficiales/7468/stps11_C/stps11_C.html

IMSS. (2017). *Memoria.* MEXICO: IMSS.

Leticia Arenas-Ortiz,. Ó. C.-G. (2013). Factores de riesgo de trastornos músculo-esqueléticos crónicos laborales. *Medigraphic-literatura biomédica*, 370-379.

NORMA Oficial Mexicana. (28 de agosto de 2018). *NORMA Oficial Mexicana NOM-036-1-STPS-2018.* Obtenido de NORMA Oficial Mexicana NOM-036-1-STPS-2018, Factores de riesgo ergonómico en el Trabajo-Identificación, análisis, prevención y control. Parte 1: Manejo manual de cargas.:

Obregón Sánchez, M. (2016). *Fundamentos de ergonomia.* Mexico D.F.: Grupo Editorial Patria.

SEMAC. (22 de 02 de 2018). *Sociedad de Ergonomistas de México*. Obtenido de http://www.semac.org.mx.

# LOW BACK PAIN AND DYNAMIC SITTING PRACTICES IN COLLEGE STUDENTS

**Patricia Eugenia Sortillón González[1], Enrique Javier de la Vega Bustillos[2]**

[1]Departmento de Ingeniería Industrial
Universidad de Sonora
Rosales S/N
Hermosillo, Sonora 83000
Corresponding author's e-mail: patricia.sortillon@unison.mx

[2]DDivision de Estudios de Posgrado e investigación
Tecnológico Nacional de México/Instituto Tecnológico de Hermosillo
Av. Tecnológico S/N
Hermosillo, Sonora 83171

**Resumen**: La posición sedente durante períodos prolongados en el trabajo, se ha convertido en una práctica común. Los estudiantes universitarios pasan hasta el 80% de su tiempo total de clase en posición sedente, lo que potencialmente podría conducir a reducir los niveles de alerta y atención durante toda la experiencia de clase. El dolor lumbar (DL) es un trastorno músculo-esquelético relacionado con las posturas sedentes. Algunos estudios revelan que sentarse por periodos de más de 7 horas al día, podría aumentar el riesgo de DL, sin embargo, hay poca evidencia documentada de dolor lumbar relacionado con la postura sedente en estudiantes universitarios. Las posturas sedentes sostenidas podrían resultar en fatiga, malestar y dolor, y se sugiere que una postura por periodos prolongados podría ser una causa del dolor lumbar. El objetivo de este estudio fue comparar las relaciones entre el dolor lumbar y las posturas sedentes con prácticas dinámicas, así como con las posturas sedentes sin prácticas dinámicas en estudiantes universitarios, lo que podría dar orientaciones sobre las prácticas ergonómicas en el sector académico, con el fin de mejora la experiencia de aprendizaje durante una sesión de clase y reducir las molestias reportadas. Se realizó un estudio observacional transversal por un periodo de 5 semanas en un colegio estudiantil de la ciudad de Hermosillo, Sonora. Para evaluar la experiencia de dolor en la postura sedente y en la misma postura con prácticas dinámicas, se utilizó el cuestionario McGill, que se tradujo al español. El cuestionario se aplicó durante cinco semanas continuas. Se instruyó a un grupo con prácticas dinámicas para la postura sedente y al otro se dejó con la con las prácticas habituales en las posturas sedentes, en ambos grupos se aplicó el cuestionario durante los cinco días de cinco semanas consecutivas.

El objetivo de este estudio fue determinar si las sensaciones subjetivas de dolor tienen una relación directa con las posturas sedentes en estudiantes universitarios durante sus sesiones de clase, así como comparar estas sensaciones subjetivas después de promover prácticas para hacer dinámica la postura sedente. Los resultados de este estudio revelan que las prácticas para hacer más dinámica la postura sedente ayudan a reducir la puntuación del cuestionario de Mc Gill. Los resultados aquí encontrados pueden ser útiles para analizar los horarios académicos y los tiempos de descanso establecidos para los mismos, como una manera de mejorar el rendimiento. Se necesitan otros estudios para explorar la influencia de otros factores asociados con las sensaciones de molestias en la espalda, que incluyen la actividad laboral previa y probablemente se necesitan muestras mas grandes para evaluar el efecto de las características individuales tales como la edad y la experiencia laboral.

**Palabras clave**: Espalda, Dolor, postura, sedente

**Relevancia para la ergonomía**: Este estudio tiene como propósito analizar las relaciones entre el dolor de espalda baja y las prácticas de mantenerse sentado de forma dinámica, en los estudiantes. Dichas relaciones pueden dar pautas para el establecimiento de prácticas ergonómicas en el sector académico, con el fin de mejorar la experiencia de aprendizaje y reducir la sensación de no confort reportada.

**Abstract:** Seated position for extended periods at work, as well as during leisure time has become a common practice. College students spend up to 80% of their total class time in a seated position, that potentially could lead to reducing levels of alertness and attention during the entire class experience. Low back pain (LBP) is an associated musculoskeletal disorder related to prolonged seated position. Some studies reveals that being seated for periods of longer that 7 hour per day, could increase the risk of LBP; however, there is a little evidence of documented LBP in college students. sustained sitting postures could result in fatigue, discomfort and pain, and it is suggested that a posture for extended periods could be a cause of LBP. This study aimed to analyse the relationships between pain and dynamic sitting behaviour, in college students, which could give directions about ergonomic practices in the academic sector, in order to improve the learning experience during a class session and lower the reported pain discomfort. An observational cross-sectional study was conducted within 5-week period in a student college of the city of Hermosillo, Sonora. To assess pain experience it was used the McGill Pain Questionnaire (MPQ) that was translated to Spanish. The MPQ was applied from Monday to Friday during five continuous weeks. One group was instructed with dynamic sitting practices and the other was left with out it, in both groups it was applied the MPQ during the five days of the week, through a continuous five weeks period. In this study, we sought to determine whether subjective feelings of pain have a relationship with dynamic sitting practices in college students during its class sessions. We compared the MPQ scores of two groups of students, one with dynamic sitting practices and the other with out them. We found that dynamics sitting practices could help to lowering the MPQ score.

. This investigation is an approach that may be useful to analyze academic schedules and rest times for college students as a strategy to improve performance. Other studies are needed for explore the influence of other factors associated with pain feelings, which include the previous labor activity and probably a larger samples are necessary in order to evaluate the effect of individual characteristic such age and labor experience.

**Keywords**. Back, Pain, static Sitting

**Relevance to Ergonomics**: This study aimed to analyse the relationships between pain and dynamic sitting behaviour, in college students, which could give directions about ergonomic practices in the academic sector, in order to improve the learning experience during a class session and lower the reported pain discomfort.

## 1. INTRODUCTION

Seated position for extended periods at work, as well as during leisure time has become a common practice (Hadgraft et al., 2015). Among office workers, the prevalence of low back pain (LBP) has increased as a result of prolonged sitting behaviour (Collins and O'Sullivan, 2015). College students spend up to 80% of their total class time in a seated position, that potentially could lead to reducing levels of alertness and attention during the entire class experience.

Low back pain is an associated musculoskeletal disorder related to prolonged seated position (Vos et al., 2016). Some studies (Cho et al., 2012) reveals that being seated for periods of longer that 7 hour per day, could increase the risk of LBP; however, there is a little evidence of documented LBP in college students.

Other studies (da Costa and Vieira, 2009) do not offer an evidence that sitting duration is linked to LBP and found no significant association between them. The lack of evidence is mainly associated to the fact that LPB has a multifactorial nature and there is a weak in the process to get the data, as well as the use of subjective measurement instruments (Kwon et al., 2011) which could lead to the difficulties in the establishment of any causal relationships. Claus et al. (2013) proposed that sustained sitting posture could result in fatigue, discomfort and pain, and suggest that a posture for extended periods could be a cause of LBP. Davis and Kotowski (2014) suggest that regular small movements are beneficial for the prevention of LBP, and dynamic sitting behavior could provide biological and physiological benefits, due that postural variations can reduce spinal loads. Previous studies (Zemp et al., 2016) demonstrated that more static sitting behaviour in subjects is a premise of mild LBP. There is a lack of evidence in regards to how dynamic sitting practices could help to reduce LPB, mainly to the multifactorial nature of LBP, as well as from possible methodological weaknesses, including unreliable subjective measurement instruments, low measurement durations, and low number of subjects in the study, however, we can have an approximate idea of LBP behaviour and it relationship with sitting practices which could serve to initiate a deeper study. In this study we compared the LBP experienced by two groups of college students which one group have a dynamic sitting practices and the other is has not any dynamic sitting practices.

## 2. OBJETIVES

The goal of this study was to compare the level of LPB symptoms experienced by two groups of students, one treated with a routine of dynamic sitting practices during the class attendance, and the other with no dynamic sitting practices.

## 3. METHODOLOGY

### 3.1 Study design and participants

An observational cross-sectional study was conducted within 5-week period in a student college of the city of Hermosillo, Sonora. Students of the mid courses from Hermosillo College, routinely started their classes from 7:00 a.m. to 3:00 p.m. in a five continuous day basis in a week. Current investigation involved 35 students from ages of 18 to 25, which attended the above schedule. Participants were excluded if they were pregnant, or were currently undergoing medical treatment or they did not experience LBP symptoms. Data were collected during the morning period. Approval of the study was obtained from the Ethics Committee at the Hermosillo College. Participants received information of the study goals and after this, students who agreed to participate, signed a consent term. Participants were free to withdraw from the study at any time and were provided with their individual study results.

To assess pain experience it was used the McGill Pain Questionnaire (Melzack, 1975) that was translated to Spanish. The reliability and validity of modification were tested. The McGill Pain Questionnaire (MPQ) was applied from Monday to Friday during five continuous weeks. One group was instructed with dynamic sitting practices and the other was left with out it, in both groups it was applied the MPQ during the five days of the week, through a continuous five weeks period.

### 3.2 Data analysis

Data processing and analysis regarding to sociodemographic information of participants and MPQ results are briefly described below:

3.2.1 Sociodemographic information of participants

Average and standard deviation of students age was calculated, for both women and men. Percentages of students who have an employment relationship were also calculated.

**McGill Pain Questionnaire.** The MPQ is the most frequently used questionnaire for the multidimensional assessment of pain. The MPQ assesses three separate components of the pain experience: the sensory intensity, the emotional impact and the cognitive evaluation of pain. The MPQ is a three- part pain assessment tool which measures several dimensions of individuals pain experience. The first part consists of an anatomic drawing of the human form on which the subject marks where his or her pain is located. The second part of the MPQ is VDS that allows the subject to record the intensity level of his or her current pain experience. The third part of the MPQ is a pain verbal descriptor inventory consist of 72 descriptive adjectives. The individual is asked to review this list of pain descriptors and circle the ones that serve to best describe his or her current pain experience. Each part or dimension of the MPQ is individually scored and a cumulative total score is also recorded.

#### 3.3.3 Statistical analysis

Data management and statistical analysis were carried out using the software IBM SPSS (v24, SPSS Inc., Chicago, USA). In order to summarise gathered data, mean and standard deviation of participants age were calculated for both genders. MPQ score results were calculated for every individual of each group during five continuous days of five weeks. Overall mean and standard deviation were calculated for both groups, as well as mean and standard deviation for weeks. A normality test was performed on MPQ scores for both groups.

## 4. RESULTS

### 4.1 Participants

This study included at the beginning 300 college students, from which 2 participants (0.67%) were excluded due to pregnant, 15 were excluded by medical treatment , and 247 were excluded because they do not referred any pain symptom, resulting in a study sample of 36 participants, 16 women and 20 men (women age 20.25 ± 1.03 years, men 20.99 ± 1.42 years). Percentage of women who have an employment relationship was 69% and percentage of the men who also work was 98%. All participants answered the MPQ for the totality of the days and weeks of study.

The two most adopted sitting positions were the upright and forward inclined sitting positions with an average occurrence of 35% and 38% of the whole sitting time. Half the subjects clearly preferred one sitting position.

### 4.2 McGill Pain Questionnaire

The second component of the MPQ showed good internal consistencies with Cronbach's alpha values of 0.89. The corresponding MPQ score mean for weeks in the group with dynamic sitting practices (Fig. 1) were 17.167± 3.167 ($week_1$), 16.611 ± 3.032 ($week_2$), 17.555 ± 2.0356 ($week_3$), 17.944 ± 1.797 ($week_4$), and 18.166 ± 1.249 ($week_5$).

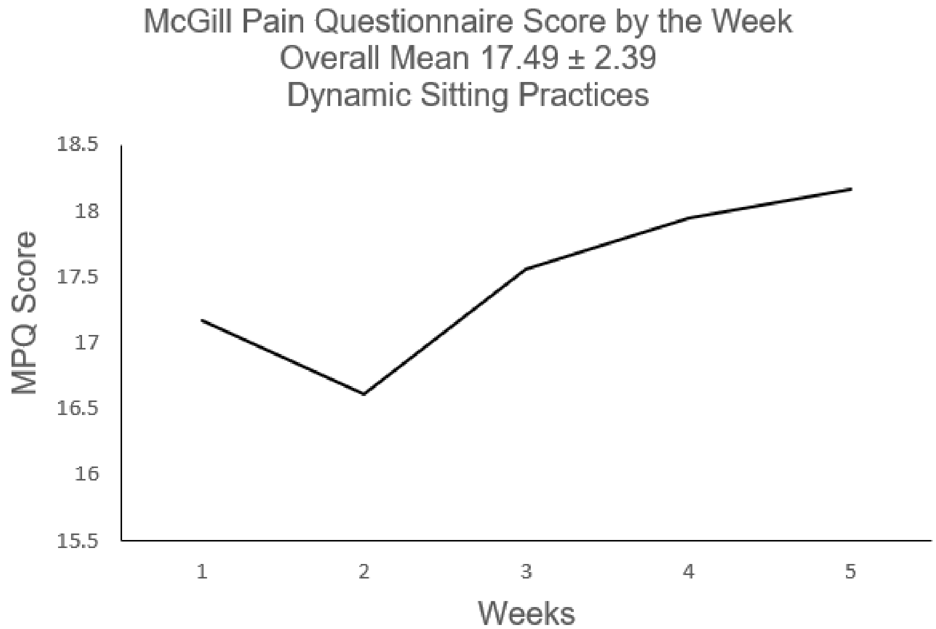



Fig. 1. MPQ Score Mean of the five weeks Group with Dynamic Sitting Practices

MPQ score values for weeks in group without dynamic sitting practices (Fig. 2) were 32.389 ± 2.704 ($week_1$), 32.611 ± 1.461 ($week_2$), 33.111 ± 1.079 ($week_3$), 32.333 ± 0.907 ($week_4$), and 32.777 ± 1.309 ($week_5$).

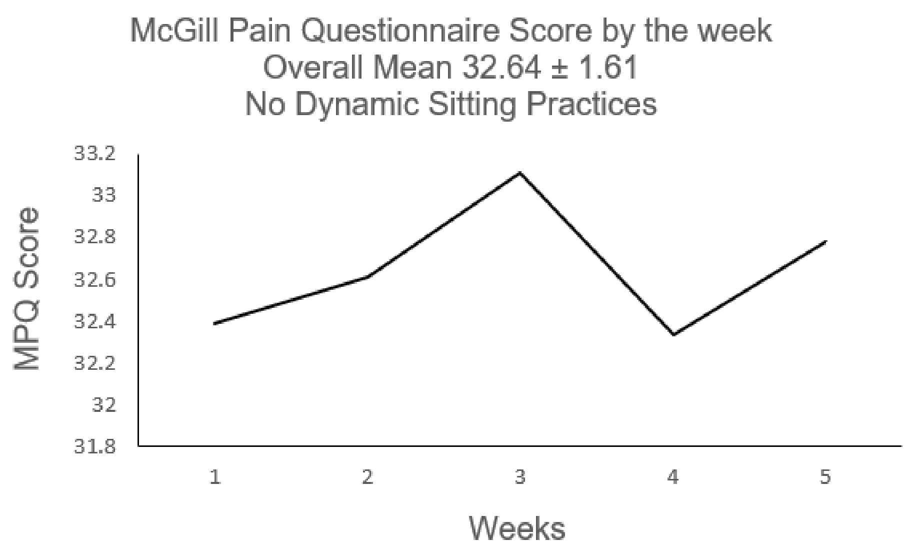



Fig. 2. MPQ Score Mean of the five weeks Group without Dynamic Sitting Practices

Data show normal behavior, according to the Kolmogorov-Smirnov trial.

## 5. CONCLUSIONS

There are several documented works that demonstrates that dynamic sitting practices have a relationship with experienced pain, after several hours of work (Akkarakittichoke and Janwantanakul, 2017), however, the lack of a stronger relationship between experienced pain and dynamic sitting practices, is due to the fact, that pain is a multifactorial phenomena (Hoy et al., 2010). Occupational musculoskeletal disorders especially those relationed to LBP chronic LBP) are common and scholar activity requires of prolonged periods of static sitting. Prolonged static sitting is thought to be associated with an increased risk of musculoskeletal disorders. (Kwon et al., 2011).

In this study, we sought to determine whether subjective feelings of pain have a relationship with dynamic sitting practices in college students during its class sessions. We compared the MPQ scores of two groups of students, one with dynamic sitting practices and the other with out them. We found that dynamics sitting practices could help to lowering the MPQ score.

Most of the students performed their working an upright and a forward inclined sitting position, whereas the reclined position was not present. Due to the fact that there is no ideal ergonomic sitting position that should be maintained for longer periods of time, this study revealed that a dynamic sitting behaviour is important to maintain the health of the back.

In this study the current low levels of pain intensity and disability within the students do not let us achieve a clear understanding of the influence of the different continuous pain scales on sitting behaviour. It has been shown according to results, that breaks in sitting time, regular changes between different sitting positions, as well as changing from a sitting to a standing working position all have a healthy effect on the human body.

Although only subjects without low back pain participated in this study, we were able to investigate differences in the sitting behaviour. However, students without dynamic sitting practices were slightly affected by back pain compared with those students with normal sitting practices. Dynamic sitting has been defined an increased motion in sitting, which is facilitated by the use of specific chairs or equipment. However, recent studies have shown that dynamic chair equipment is not sufficient to affect muscle activation, postures and core kinematics (O’Sullivan k. et al., 2012).

According to results obtained, it can be concluded that dynamic sitting practices should be actively stimulated, which can then be supported by dynamic chair mechanisms, indicating the requirement for a prescribed practice of dynamic sitting, however, this would require a valid information in terms of movement patterns and positional changes that reflect a normal physiological sitting behaviour, which has not yet defined. Dynamic sitting practices is thought to provide beneficial biological and physiological effects, since postural variations can reduce spinal loads (Davis and Kotowski, 2014). With many studies regarding to dynamic sitting practices, it seems that less dynamic sitting habits may result in discomfort and pain, especially in the lower back.

This investigation is an approach that may be useful to analyze academic schedules and rest times for college students as a strategy to improve performance. Other studies are needed for explore the influence of other factors associated with pain feelings, which include the previous labor activity and probably a larger samples are necessary in order to evaluate the effect of individual characteristic such age and labor experience.

With most research to date focused on pain among workers from different professional areas, that establish strong links between perceived pain in works that demand sitting for long periods, our results showed that pain among students had a similar trend.

As an alternative in the future, it would be interesting to carry out and experimental hourly evaluatin, using the MPQ questionnaire, in order to refine the results in shorter time intervals, in order to accurately determine the suitability of the class times and the required recess times, as well as to validate existing ones.

## 5. REFERENCES

Akkarakittichoke, P. Janwantanakul (2017). Seat pressure distribution characteristics during 1 hour sitting in office workers with and without chronic low back pain Saf. Health Work, 8, 212-219.

Arnrich, B., Setz, C., La Marca, R., Troster, G., Ehlert, U., (2010). What does your chair know about your stress level? Ieee T Inf. Technol. B 14, 207-214.

Balague, F., Mannion, A.F., Pellise, F., Cedraschi, C., (2012). Non-specific low back pain. Lancet 379, 482-491.

Baumgartner, D., Zemp, R., List, R., Stoop, M., Naxera, J., Elsig, J.P., Lorenzetti, S., (2012). The spinal curvature of three different sitting positions analysed in an open MRI scanner. TheScientificWorldJournal, 184-196.

Bouhassira D, Attal N, Fermanian J, Alchaar H, Gautron M, Masquelier E. (2004). Development and validation of the Neuropathic Pain Symptom Inventory. Pain. ;108(3),248-257.

Breivik, H., Collett, B., Ventafridda, V., Cohen, R., Gallacher, D., (2006). Survey of chronic pain in Europe: prevalence, impact on daily life, and treatment. Eur. J. pain 10, 287-333.

Claus, A. P. Hides, J.A. Moseley, G.L Hodges, P.W., (2009) Is 'ideal' sitting posture real?: measurement of spinal curves in four sitting postures Man. Ther., 14, 404-408.

Cho, C. Y. Hwang, Y.S., Cherng, R.J., (2012). Musculoskeletal symptoms and associated risk factors among office workers with high workload computer use J. Manip. Physiol. Ther., 35, 534-540.

Collins, J.D., O'Sullivan, L.W., (2015). Musculoskeletal disorder prevalence and psychosocial risk exposures by age and gender in a cohort of office based employees in two academic institutions ,Int. J. Ind. Ergon., 46, 85-97.

da Costa, B.R. E.R. Vieira, E.R., (2009) Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies Am. J Ind. Med., 53(3), 285-323.

Daian, I., van Ruiten, A.M., Visser, A., Zubic, S., (2007). Sensitive chair: a force sensing chair with multimodal real-time feedback via agent. In: Proceedings of the 14th European Conference on Cognitive Ergonomics: Invent! Explore! ACM. United Kingdom, London, 163-166.

Davis, K.G. Kotowski, S.E. (2014). Postural variability: an effective way to reduce musculoskeletal discomfort in office work Hum. Factors J. Hum. Factors Ergon. soc., 56, 1249-1261.

Dunk, N.M., Callaghan, J.P., (2005). Gender-based differences in postural responses to seated exposures. Clin. Biomech. 20, 1101-1110.

Fairbank, J.C., Pynsent, P.B., 2000. The Oswestry disability Index. Spine 25, 2940-2952.

Graf, M., Guggenbuhl, U., Krueger, H., (1995). An assessment of seated activity and postures at 5 workplaces. Int. J. Ind. Ergon. 15, 81-90.

Grandjean, E., Hunting, W., (1977). Ergonomics of posture - review of various problems of standing and sitting posture. Appl. Ergon. 8, 135-140.

Hadgraft, N.T., Lynch, B.M., Clark, B.K., Healy, G.N., Owen, N., Dunstan, D.W., (2015) Excessive sitting at work and at home: correlates of occupational sitting and TV viewing time in working adults, BMC Public Health, 15.

Hartvigsen, J., Leboeuf-Yde, C., Lings, S., Corder, E.H., (2000). Is sitting-while-at-work associated with low back pain? A systematic, critical literature review. Scand. J. public health 28, 230-239.

Hawker, G.A., Mian, S., Kendzerska, T., French, M., (2011). Measures of adult pain: visual analog scale for pain (vas pain), numeric rating scale for pain (nrs pain), McGill pain questionnaire (MPQ), short-form McGill pain questionnaire (SFMPQ), chronic pain grade scale (CPGS), short Form-36 bodily pain scale (SF-36 BPS), and measure of intermittent and constant osteoarthritis pain (ICOAP). Arthritis care & Res. 63 (Suppl. 11), S240-S252.

Healy, G.N., Dunstan, D.W., Salmon, J., Cerin, E., Shaw, J.E., Zimmet, P.Z., Owen, N., (2008). Breaks in sedentary time: beneficial associations with metabolic risk. Diabetes care 31, 661-666.

Healy, G.N., Matthews, C.E., Dunstan, D.W., Winkler, E.A., Owen, N., (2011). Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. Eur. heart J. 32, 590-597.

Hoy, D. Brooks, P. Blyth, F. Buchbinder, R. (2010). The Epidemiology of low back pain, Best Pract. Res. Clin. Rheumatology, 24, 769-781

Kamiya, K., Kudo, M., Nonaka, H., Toyama, J., (2008). Sitting posture analysis by pressure sensors. Int. C Patt Recog 2841-2844.

Klasen, B.W., Hallner, D., Schaub, C., Willburger, R., Hasenbring, M., (2004). Validation and reliability of the German version of the Chronic Pain Grade questionnaire in primary care back pain patients. Psycho-Social-Medicine 1, 1-12.

Kwon, B.K., Roffey, D.M., Bishop, P.B., Dagenais, S., Wai, E.K., (2011). Systematic review: occupational physical activity and low back pain. Occup. Med. 61, 541-548.

Lázaro, C., Bosch, F., Torrubia, R., & Baños, J.-E. (1994). The development of a Spanish questionnaire for assessing pain: Preliminary data concerning reliability and validity. *European Journal of Psychological Assessment, 10*(2), 145–151.

Lis, A.M., Black, K.M., Korn, H., Nordin, M., 2007. Association between sitting and occupational LBP. Eur. Spine J. 16, 283e298. Lueder, R.K., 1983. Seat comfort: a review of the construct in the office environment. Hum. factors 25, 701-711.

Melzack, R. (1975). The McGill Pain Questionnaire: Major properties and scoring methods. Pain, 1, 277-259.

Mutlu, B., Krause, A., Forlizzi, J., Guestrin, C., Hodgins, J., (2007). Robust, low-cost, non-intrusive sensing and recognition of seated postures. In: Uist 2007: Proceedings of the 20th Annual Acm Symposium on User Interface Software and Technology, 149-158.

O'Keeffe, M., Dankaerts, W., O'Sullivan, P., O'Sullivan, L., O'Sullivan, K., (2013). Specific flexion-related low back pain and sitting: comparison of seated discomfort on two different chairs. Ergonomics 56, 650-658.

O'Sullivan, K., O'Keeffe, M., O'Sullivan, L., O'Sullivan, P., Dankaerts, W., (2012). The effect of dynamic sitting on the prevention and management of low back pain and low back discomfort: a systematic review. Ergonomics 55, 898-908.

O'Sullivan, K., O'Sullivan, P., O'Keeffe, M., O'Sullivan, L., Dankaerts, W., (2013). The effect of dynamic sitting on trunk muscle activation: a systematic review. Appl. Ergon. 44, 628-635.

Pynt, J., Higgs, J., Mackey, M., (2001). Seeking the optimal posture of the seated lumbar spine. Physiother. Theory Pract. 17, 5-21.

Radbruch, L., Loick, G., Kiencke, P., Lindena, G., Sabatowski, R., Grond, S., Lehmann, K.A., Cleeland, C.S., (1999). Validation of the german version of the Brief pain inventory. J. Pain Symptom Manag. 18, 180-187.

Reinecke, S.M., Hazard, R.G., Coleman, K., Pope, M.H., (2002). A continuous passive lumbar motion device to relieve back pain in prolonged sitting. In: Kumar, S. (Ed.), Advances in Industrial Ergonomics and Safety IV. Taylor and Francis, London, 971-976.

Roffey, D.M., Wai, E.K., Bishop, P., Kwon, B.K., Dagenais, S., (2010). Causal assessment of occupational sitting and low back pain: results of a systematic review. spine J. off. J. North Am. Spine Soc. 10, 252-261.

Ryan, C.G., Grant, P.M., Dall, P.M., Granat, M.H., (2011). Sitting patterns at work: objective measurement of adherence to current recommendations. Ergonomics 54, 531-538.

Tan, H.Z., Slivovsky, L.A., Pentland, A., (2001). A sensing chair using pressure distribution sensors. Ieee-Asme T Mech. 6, 261-268.

Sugimoto, M., Inami, M., (2011). Finding the right way for interrupting people improving their sitting posture. In: Campos, P., Graham, N., Jorge, J., Nunes, N., Palanque, P., Winckler, M. (Eds.), Human-computer Interaction e INTERACT 2011. Springer Berlin Heidelberg, 1-17.

Vergara, M., Page, A., (2002). Relationship between comfort and back posture and mobility in sitting-posture. Appl. Ergon. 33, 1-8.

Vink, P., Hallbeck, S., (2012). Editorial: comfort and discomfort studies demonstrate the need for a new model. Appl. Ergon. 43, 271-276.

Von Korff, M., (2011). Assessment of Chronic Pain in Epidemiological and Health Services Research: Empirical Bases and New Directions. Handbook of Pain Assessment, second ed., 455-473.

Vos, T. Allen, C. , Arora, M. Barber, R.M. Bhutta, Z.A. Brown, A.(2016) Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015 The Lancet, 388, 1545-1602.

Womersley, L., May, S., (2006). Sitting posture of subjects with postural backache. J. Manip. physiol. Ther. 29, 213-218.

Zemp, R., Taylor,W.R., Lorenzetti, S., (2013). In vivo spinal posture during upright and reclined sitting in an office chair. BioMed Res. Int. 2013, pp. 5-15.

Zemp, R., Fliesser, M. Wippert, P.M., Taylor, W.R., Lorenzetti, R., (2016). Occupational sitting behaviour and its relationship with back pain – a pilot study, Applied Ergonomics 56, 84-91.

**ISBN: 978-0-578-79186-9**