ERGONOMÍA OCUPACIONAL

INVESTIGACIONES Y SOLUCIONES

VOL. 10

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

2017

ERGONOMÍA OCUPACIONAL

INVESTIGACIONES Y SOLUCIONES

VOL. 10

EDITADO POR:
CARLOS ESPEJO GUASCO
Presidente Fundador SEMAC

ENRIQUE DE LA VEGA BUSTILLOS
Presidente SEMAC 2002-2004

FRANCISCO OCTAVIO LOPEZ MILLAN
Presidente SEMAC 2014-2017

ISBN: 978-0-692-88140-8

Prefacio

Regresamos a Cd. Jurez, Chihuahua. La Sociedad de Ergonomistas de México A.C. (SEMAC), y su Congreso Internacional ha sido acogida, muy calurosamente, en Mexicali, Baja California, Tepic, Nayarit, Los Mochis, Sinalos, Hermosillo, Sonora y Tijuana Baja California y ahora en el año 2017 volvemos a la ciudad donde se vio nacer este Congreso Internacional.

El año pasado, la Secretaria del Trabajo y Previsión Social publicó en el Diario Oficial de la Federación la NOM-034-STPS-2016, Condicion es de seguridad para el acceso y desarrollo de actividades de trabajadores con discapacidad en los centros de trabajo, la cual entro en vigor el 4 de septiembre de ese mismo año, Ademas la STPS tambien publicó el proyecto de Norma Oficial Mexicana NOM-035-STPS, Factores de Riesgo Psicosocial - Identificación, Prevención y Seguimiento, cuyo objetivo es *"Establecer los elementos para identificar y prevenir los factores de riesgo psicosocial y promover un entorno organizacional favorable en los centros de trabajo",* el cual entrara en vigor dos años después de que sea publidada en el DOF como NOM.

Un gran paso que da la autoridad laboral con dos NOM que son necesarias para mejorar la salud ocupacional de nuestros compañeros, los trabajadores, que con su esfuerzo generan la riqueza de nuestro Paiz, Mexico.

Afortunadamente, ya se está trabajando por parte de la STPS en la NOM-036-STPS, Factores de Riesgo Ergonomicos y esperemos que este mismo año sea publicado en el DOF el proyecto de norma y seria un gran logro el que entre en vigor en el año 2018.

Como puede verse, este año tenemos grandes esperanzas en el ambito legal para los trabajores, empresarios, estudiante y academicos de los alcances y limitaciones de este nuevo instrumento legal. SEMAC ha estado y seguira trabajando al lado de la STPS para que esta nueva norma sea un instrumento eficaz y eficiente.

Este año reunimos un gran número de trabajos, tanto de investigaciones como soluciones en los puestos de trabajo que tienden a mejoran la calidad de vida de los trabajadores. Hemos seleccionado los mejores trabajos de las diversas áreas de la Ergonomía. En este libro encontrares colaboraciones de Instituciones de Educación Superior y Empresas con trabajos que se destacan tanto por su originalidad como por su pertinencia.

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

Enrique de la Vega Bustillos

Presidente SEMAC 2002 – 2004

CONTENT

ANTHROPOMETRY

COGNITIVE ERGONOMICS

DESIGN

EDUCATION

FATIGUE

INDUSTRIAL ERGONOMICS

OCCUPATIONAL HEALTH

PSYCHOSOCIAL FACTORS

WORK EVALUATION

COMITÉ ACADÉMICO

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
Valeo, Cd. Juarez

OSCAR ARELLANO TANORI
Instituto Tecnologico de Hermosillo

JESÚS RODOLFO GUZMÁN HERNÁNDEZ
Universidad de Sonora, Campus Caborca

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 RESEARCH FOR THE DESIGN OF FURNITURE FOR CHILDREN OF ELEMENTARY SCHOOL

Mauricio López Acosta, Fernanda Lucía Sandoval Siqueiros, Susana García Vilches, Allan Chacara Montes, Aarón Fernando Quirós Morales

Industrial Engineering Deparment
Instituto Tecnológico de Sonora,
Ramón Corona y Aguascalientes
Navojoa, Sonora. México 85860
Corresponding author's e-mail: *mauricio.lopez@itson.edu.mx*

Resumen: Este documento tiene como objetivo determinar las características antropométricas de niños de primaria con edad de 5 a 12 años, nacidos en el estado de Sonora. Se creó una carta antropométrica para la obtención de datos, utilizando la técnica de medición directa y se llevó a cabo en el lugar de estudio, con una muestra de 119 personas, teniendo en cuenta 10 tipos de medidas antropométricas. Una base de datos fue desarrollada con la información de cada carta antropométrica para el procesamiento, con el fin de realizar el análisis estadístico se presenta una media y desviación estándar de cada dimensión medida, además del cálculo de percentiles para cada sexo. Las dimensiones obtenidas en el presente estudio permiten afirmar que las características antropométricas en los niños son diferentes para cada grado escolar, esto se puede deber a distintos factores como crecimiento, alimentación o hasta cuestiones de salud.

Palabras clave: Antropometría, Diseño, Mobiliario escolar

Abstract: This document aims to determinate the anthropometric features of kids from elementary school with age from 5 to 12 years old, born in the State of Sonora. An anthropometric sheet was created to collect data, after that the study was held at the site of each subject of study, and the direct method was used to obtain the measurements, with a sample of 119 people, considering 10 types of anthropometric measures. A data base was developed with the information from each anthropometric sheet for processing; in order to perform the statistical analysis the study shows a mean and standard deviation of each measured dimension, in addition to the calculation of the percentiles for each sex. The dimensions obtained in the present study allow to affirm that the anthropometric features in children are different for each grade level, this may be due to various factors such as growth, feeding or health issues.

Keywords: Anthropometry, Design, School Furniture**.**

Relevance to Ergonomics: In this research was obtained relevant data such as the anthropometric characteristics of children from elementary school. It is essential for product designers to use anthropometric data that is appropriate and up-to-date for product design and development for users using this type of furniture. However, these data are scarce in Mexico, and is the main motivation of this study.

1. INTRODUCTION

Ergonomics in work environments has gained high attention from researchers over recent decades. Although school environment represents the ‘‘work’’ environment for billions of children, it has not attracted the proper attention from ergonomists. One of the essential elements for the good education of children is the furniture that is used, and in order for it to fulfill its function, it must respond to the characteristics of the population that uses it: so it is necessary that their dimensions are adapted to the anthropometric dimensions of boys and girls, and for this purpose, designers must have the information that allows them to fully achieve this requirement. (Madríz Quirós, Ramírez Coretti, & Serrano Montero, 2008).

Anthropometric sizes of students are an important factor that should be considered in designing school furniture. Some studies have confirmed the lack of conformity between anthropometric sizes of students and dimensions of used furniture. Moreover, the number of students suffering from musculoskeletal disorders is increasing. Headache, ache in neck and shoulder muscles, decrease in concentration, lack of spirit, and tiredness of eyes are very common among students and these problems are increasing. (Habibi, Asaadi, & Hosseinic, 2009). Not to mention, uncomfortable postures could be painful due to the prolonged periods children spend at school and several researchers have reported posture-related syndromes in students. Moreover, it is possible that children may maintain those postural behaviors for the rest of their lives. (Gouvali & Boudolos, 2005)

This document sets out the conclusions drawn from the first stage of the research which focused on the selection of an appropriate methodology for data collection, on its implementation and on the statistical processing of the resulting data.

2. OBJECTIVES

Determine the anthropometric characteristics of the population of children from elementary schools using the technique of direct measurement for the design of anthropometric measurements charts. Also, the results should serve as a support for more extensive researches that take as a basis the sample of elementary school children of this research.

This research comprises children of both sexes, with place of birth in the state of Sonora, who are in elementary school from first to sixth grade.

3. METHODOLOGY

3.1 Subject of study

The population subject to the research were people born in the state of Sonora with ages from 5 and 12 years. By selecting cases that met the specifications of the place of birth and age; getting a total of 119 samples, 63 males and 56 females.

3.2 Materials

The instruments used are:

- Anthropometer
- Stadiometer
- Weight Scale
- Anthropometric Stool
- Descriptive Charts

3.3 Procedure

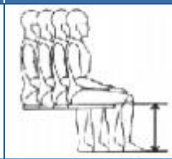
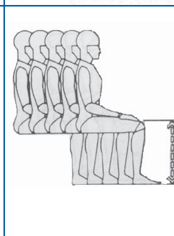
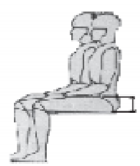
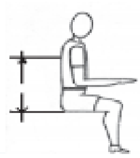
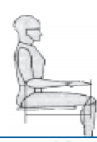
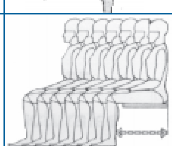
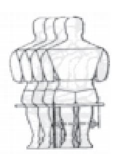
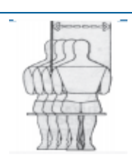
The present study is observational, cross-sectional, and non-experimental, the selection of personnel will be on a voluntary basis, special spaces will be used for the measurement and are excluded from this study children who did not meet the conditions of place of birth. Were considered 10 measures used in the anthropometric study of Madriz, Ramirez & Serrano, (2008) see table 1.

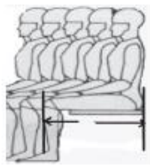
A manual data collection sheet was developed with the purpose of introducing the information in the Microsoft Excel software with: Registration number, age, sex, place of birth of the subject under study and family (parents), grade and each of the 10 anthropometric measures were registered for the purpose of performing the analysis using descriptive statistics, presented a mean, standard deviation of each anthropometric measurement and percentiles calculations.

The method for the development of the study was:

1. Qualification in the project, preparation of the work team to standardize the technique and carry out the measurements.
2. Fill in the columns of age, sex, place of birth, grade.
3. Take measurements.
4. Record of measurements made.
5. Calculation of Percentiles. In this stage, the calculations are used to determine the anthropometric dimensions according to the following percentiles: P5, P10, P25, P50, P75, P90 and P95. To do this, before calculating the percentiles, the values of the mean and standard deviation of each anthropometric variable must be taken into consideration.
6. Determination of anthropometric charts by grade-sex. At this stage all the studied variables were organized by percentile.

Table1. Anthropometric measures considered.

Measures	Diagram	Importance	Details
POPLITEAL HEIGHT		Provides the right height of the seat of the chair so your feet are resting comfortably on the floor.	Height of the flexor muscles of the knee that can be felt in the popliteal fossa, on the back of the knee. Consider
KNEE HEIGHT		It defines the degree of movement of the legs, determining factor to allow the variation of the posture. It can also have a great influence on the height at	Refers to the vertical distance that is taken from the ground to the ball joint. Consider the 95th percentile.
THIGH THICKNESS		It works in conjunction with the height of the knee, determining to what height the drawer of the desk should be designed.	Height from the vertical distance that is taken from the surface of the seat to the maximum height of the leg. Consider the 95th percentile.
SITTING HEIGHT TO THE BASE OF THE		The backrest has the function of helping to distribute the weight of the body and avoid that everything is supported by the pelvis	Height from the plane of the seat until it reaches the bottom of the scapula. Consider the 95th percentile
SITTING ELBOW HEIGHT		It allows you to know which is the proper height to find the top surface of the table in relation to the Chair.	Height of the elbow (flexed at 90 degrees) from the surface of the seat. Consider the 50th percentile
ELBOW-FINGERTIP LENGTH		Distance between the elbow and the tip of the fingers.	Allows the user to come as close as possible to the table, while continuing to effectively use the back of
BUTTOCK - POPLITEA		Defines the maximum depth of the seat plane, from its front part to the backrest.	Horizontal distance that is taken from the outer surface of the buttock to the back side of the knee. Consider
HIP BREADTH		Useful for setting tolerances on interior widths of chairs.	Maximum horizontal distance when the individual maintains their seated position. Consider the 95th
SHOULDER BREADTH (bideltoid)		It determines the chair backrest width, allows the freedom of movement and in turn helps to support the back	Maximum horizontal distance that separates deltoid muscles. Consider the

BUTTOCK-KNEE LENGTH		This is data that is managed to calculate the appropriate distance that must separate the back of the seat of any physical obstacle or any	It is the horizontal distance that is taken from the outer surface of the buttocks and up to the front face of the ball joint. Consider the

Source: Madríz, Ramírez & Serrano (2008).

4. RESULTS

From the analysis of the collected data, a final sample of 119 valid cases was obtained, which were used for the presentation of the results and for the statistical analysis. The following tables show the percentiles by age and sex, and summarize the results of the study for the different school ages.

FIRST GRADE (GIRLS)

No.	Body Dimension	Mean	Standard Deviation	Percentiles 5°	25°	50°	75°	95°
1	Popliteal Height	31.97	1.85	28.93	30.73	31.97	33.20	35.00
2	Knee Height	38.63	2.69	34.21	36.83	38.63	40.44	43.06
3	Thigh Thickness	7.93	1.13	6.08	7.18	7.93	8.69	9.79
4	Sitting Height To The Base Of The Scapula	25.71	2.62	21.39	23.95	25.71	27.47	30.03
5	Sitting Elbow Height	16.02	3.00	11.09	14.01	16.02	18.03	20.95
6	Elbow-Fingertip Length	32.71	1.14	30.84	31.95	32.71	33.47	34.58
7	Buttock-Popliteal Length	32.71	2.05	29.34	31.34	32.71	34.09	36.09
8	Hip Breadth	23.73	2.92	18.94	21.78	23.73	25.69	28.53
9	Shoulder Breadth (Bideltoid)	29.39	2.68	24.98	27.59	29.39	31.18	33.80
10	Buttock-Knee Length	40.64	2.05	37.27	39.27	40.64	42.02	44.02
11	Height	123.76	5.53	114.66	120.05	123.76	127.46	132.85
12	Weight	28.66	6.60	17.80	24.23	28.66	33.08	39.52
13	Age	6.33	0.50	5.51	6.00	6.33	6.67	7.16

SECOND GRADE (GIRLS)

No.	Body Dimension	Mean	Standard Deviation	Percentiles 5°	25°	50°	75°	95°
1	Popliteal Height	31.96	1.68	29.20	30.83	31.96	33.08	34.71
2	Knee Height	38.71	2.04	35.36	37.35	38.71	40.08	42.06
3	Thigh Thickness	8.74	1.82	5.75	7.52	8.74	9.96	11.74
4	Sitting Height To The Base Of The Scapula	27.12	3.53	21.31	24.76	27.12	29.49	32.93
5	Sitting Elbow Height	16.78	1.76	13.88	15.60	16.78	17.96	19.68
6	Elbow-Fingertip Length	33.27	1.12	31.43	32.52	33.27	34.01	35.10

7	Buttock-Popliteal Length	33.90	2.16	30.34	32.45	33.90	35.35	37.46
8	Hip Breadth	25.32	2.51	21.20	23.64	25.32	27.00	29.44
9	Shoulder Breadth (Bideltoid)	30.63	2.28	26.89	29.11	30.63	32.16	34.38
10	Buttock-Knee Length	41.77	2.65	37.41	39.99	41.77	43.54	46.12
11	Height	124.48	4.20	117.56	121.66	124.48	127.30	131.39
12	Weight	31.17	9.23	15.99	24.99	31.17	37.35	46.34
13	Age	7.22	0.44	6.50	6.93	7.22	7.52	7.95

THIRD GRADE (GIRLS)

				Percentiles				
No.	Body Dimension	Mean	Standard Deviation	5°	25°	50°	75°	95°
1	Popliteal Height	35.12	2.12	31.63	33.70	35.12	36.54	38.61
2	Knee Height	41.22	2.91	36.43	39.27	41.22	43.17	46.01
3	Thigh Thickness	8.98	2.10	5.53	7.57	8.98	10.39	12.43
4	Sitting Height To The Base Of The Scapula	28.53	2.39	24.60	26.93	28.53	30.13	32.46
5	Sitting Elbow Height	17.50	2.53	13.34	15.81	17.50	19.19	21.66
6	Elbow-Fingertip Length	35.38	2.72	30.90	33.55	35.38	37.21	39.86
7	Buttock-Popliteal Length	36.17	2.11	32.69	34.75	36.17	37.59	39.65
8	Hip Breadth	25.51	3.31	20.06	23.29	25.51	27.73	30.96
9	Shoulder Breadth (Bideltoid)	32.40	3.34	26.91	30.16	32.40	34.64	37.89
10	Buttock-Knee Length	44.90	2.74	40.39	43.07	44.90	46.73	49.41
11	Height	133.24	9.76	117.18	126.70	133.24	139.78	149.30
12	Weight	34.35	12.11	14.44	26.24	34.35	42.46	54.26
13	Age	8.50	0.53	7.63	8.15	8.50	8.85	9.37

FOURTH GRADE (GIRLS)

No.	Body Dimension	Mean	Standard Deviation	Percentiles 5°	25°	50°	75°	95°
1	Popliteal Height	37.10	1.76	34.20	35.92	37.10	38.28	40.00
2	Knee Height	43.69	1.99	40.42	42.36	43.69	45.02	46.96
3	Thigh Thickness	9.24	2.12	5.76	7.82	9.24	10.66	12.73
4	Sitting Height To The Base Of The Scapula	27.62	2.98	22.72	25.63	27.62	29.62	32.52
5	Sitting Elbow Height	18.50	2.19	14.89	17.03	18.50	19.97	22.11
6	Elbow-Fingertip Length	36.90	2.00	33.62	35.56	36.90	38.24	40.18
7	Buttock-Popliteal Length	37.53	2.42	33.56	35.91	37.53	39.15	41.51
8	Hip Breadth	25.48	3.98	18.94	22.81	25.48	28.14	32.02
9	Shoulder Breadth (Bideltoid)	32.86	3.62	26.91	30.43	32.86	35.28	38.80
10	Buttock-Knee Length	46.83	3.31	41.39	44.62	46.83	49.05	52.28
11	Height	139.22	6.39	128.71	134.94	139.22	143.51	149.74
12	Weight	34.35	12.11	14.44	26.24	34.35	42.46	54.26
13	Age	9.33	0.50	8.51	9.00	9.33	9.67	10.16

FIFTH GRADE (GIRLS)

No.	Body Dimension	Mean	Standard Deviation	Percentiles 5°	25°	50°	75°	95°
1	Popliteal Height	38.23	1.92	35.07	36.94	38.23	39.51	41.38
2	Knee Height	45.25	2.91	40.45	43.29	45.25	47.20	50.04
3	Thigh Thickness	9.51	1.64	6.81	8.41	9.51	10.61	12.21
4	Sitting Height To The Base Of The Scapula	30.65	3.27	25.27	28.45	30.65	32.84	36.02
5	Sitting Elbow Height	18.13	2.21	14.49	16.64	18.13	19.61	21.77
6	Elbow-Fingertip Length	38.26	3.94	31.79	35.63	38.26	40.90	44.74
7	Buttock-Popliteal Length	39.03	3.58	33.13	36.63	39.03	41.43	44.92
8	Hip Breadth	26.78	1.77	23.87	25.59	26.78	27.97	29.70
9	Shoulder Breadth (Bideltoid)	33.44	2.01	30.12	32.09	33.44	34.79	36.75
10	Buttock-Knee Length	49.09	4.03	42.46	46.39	49.09	51.79	55.72
11	Height	143.25	8.37	129.48	137.64	143.25	148.85	157.01
12	Weight	39.49	10.02	23.01	32.78	39.49	46.20	55.97
13	Age	10.36	0.50	9.53	10.03	10.36	10.70	11.19

SIXTH GRADE (GIRLS)

No.	Body Dimension	Mean	Standard Deviation	Percentiles 5°	25°	50°	75°	95°
1	Popliteal Height	38.75	2.10	35.29	37.34	38.75	40.16	42.21
2	Knee Height	46.56	2.84	41.89	44.66	46.56	48.47	51.24
3	Thigh Thickness	9.94	1.51	7.45	8.93	9.94	10.95	12.42
4	Sitting Height To The Base Of The Scapula	31.24	3.58	25.34	28.84	31.24	33.64	37.13
5	Sitting Elbow Height	20.05	3.25	14.71	17.87	20.05	22.23	25.39
6	Elbow-Fingertip Length	40.30	3.14	35.14	38.20	40.30	42.40	45.46
7	Buttock-Popliteal Length	40.53	2.58	36.29	38.80	40.53	42.25	44.76
8	Hip Breadth	28.16	2.24	24.48	26.66	28.16	29.66	31.85
9	Shoulder Breadth (Bideltoid)	34.93	2.83	30.27	33.03	34.93	36.82	39.58
10	Buttock-Knee Length	50.90	3.20	45.64	48.76	50.90	53.04	56.16
11	Height	150.23	8.14	136.84	144.77	150.23	155.68	163.61
12	Weight	42.09	9.20	26.95	35.92	42.09	48.25	57.23
13	Age	11.38	0.74	10.15	10.88	11.38	11.87	12.60

FIRST GRADE (BOYS)

No.	Body Dimension	Mean	Standard Deviation	Percentiles 5°	25°	50°	75°	95°
1	Popliteal Height	32.30	2.79	27.72	30.43	32.30	34.17	36.88
2	Knee Height	37.30	2.68	32.89	35.50	37.30	39.10	41.71
3	Thigh Thickness	7.32	1.48	4.88	6.32	7.32	8.31	9.76
4	Sitting Height To The Base Of The Scapula	25.16	3.29	19.75	22.96	25.16	27.37	30.58
5	Sitting Elbow Height	15.95	2.33	12.12	14.39	15.95	17.51	19.78
6	Elbow-Fingertip Length	31.91	1.65	29.19	30.80	31.91	33.02	34.63
7	Buttock-Popliteal Length	29.99	2.29	26.22	28.46	29.99	31.53	33.76
8	Hip Breadth	22.75	2.90	17.98	20.81	22.75	24.70	27.53
9	Shoulder Breadth (Bideltoid)	28.65	2.31	24.85	27.10	28.65	30.19	32.45
10	Buttock-Knee Length	37.86	3.44	32.21	35.56	37.86	40.17	43.52
11	Height	110.12	36.40	50.24	85.73	110.12	134.51	170.00
12	Weight	24.17	7.00	12.67	19.49	24.17	28.86	35.68
13	Age	6.27	0.47	5.50	5.96	6.27	6.59	7.04

SECOND GRADE (BOYS)

No.	Body Dimension	Mean	Standard Deviation	Percentiles 5°	25°	50°	75°	95°
1	Popliteal Height	32.63	3.49	26.89	30.29	32.63	34.96	38.36
2	Knee Height	39.75	1.91	36.60	38.46	39.75	41.03	42.89
3	Thigh Thickness	8.00	0.95	6.43	7.36	8.00	8.64	9.57
4	Sitting Height To The Base Of The Scapula	26.02	2.15	22.49	24.58	26.02	27.46	29.55
5	Sitting Elbow Height	15.75	2.73	11.26	13.92	15.75	17.58	20.25
6	Elbow-Fingertip Length	34.07	1.45	31.69	33.10	34.07	35.04	36.45
7	Buttock-Popliteal Length	32.40	2.24	28.72	30.90	32.40	33.90	36.08
8	Hip Breadth	23.22	2.02	19.90	21.87	23.22	24.57	26.54
9	Shoulder Breadth (Bideltoid)	30.29	1.35	28.07	29.39	30.29	31.19	32.51
10	Buttock-Knee Length	41.15	2.33	37.32	39.59	41.15	42.72	44.99
11	Height	127.76	4.35	120.61	124.85	127.76	130.68	134.92
12	Weight	28.17	3.29	22.76	25.97	28.17	30.38	33.59
13	Age	7.45	0.52	6.60	7.10	7.45	7.80	8.31

THIRD GRADE (BOYS)

No.	Body Dimension	Mean	Standard Deviation	Percentiles 5°	25°	50°	75°	95°
1	Popliteal Height	36.67	2.25	32.98	35.17	36.67	38.17	40.36
2	Knee Height	42.67	2.38	38.76	41.08	42.67	44.26	46.58
3	Thigh Thickness	8.91	1.26	6.84	8.07	8.91	9.75	10.98
4	Sitting Height To The Base Of The Scapula	27.30	2.96	22.42	25.31	27.30	29.29	32.18
5	Sitting Elbow Height	17.07	2.88	12.34	15.14	17.07	19.00	21.80
6	Elbow-Fingertip Length	36.41	1.73	33.56	35.25	36.41	37.57	39.26
7	Buttock-Popliteal Length	34.89	3.07	29.84	32.83	34.89	36.95	39.94
8	Hip Breadth	25.48	2.86	20.77	23.56	25.48	27.40	30.19
9	Shoulder Breadth (Bideltoid)	32.50	2.99	27.58	30.49	32.50	34.51	37.42
10	Buttock-Knee Length	42.94	4.09	36.22	40.20	42.94	45.68	49.66
11	Height	136.47	5.62	127.23	132.71	136.47	140.23	145.71
12	Weight	36.45	10.35	19.42	29.51	36.45	43.39	53.48
13	Age	8.60	0.70	7.45	8.13	8.60	9.07	9.75

FOURTH GRADE (BOYS)								
				Percentiles				
No.	Body Dimension	Mean	Standard Deviation	5°	25°	50°	75°	95°
1	Popliteal Height	37.55	1.04	35.84	36.86	37.55	38.25	39.27
2	Knee Height	43.75	1.86	40.69	42.50	43.75	44.99	46.80
3	Thigh Thickness	8.95	1.26	6.88	8.10	8.95	9.79	11.01
4	Sitting Height To The Base Of The Scapula	26.75	2.27	23.02	25.23	26.75	28.28	30.49
5	Sitting Elbow Height	17.63	1.44	15.26	16.66	17.63	18.59	20.00
6	Elbow-Fingertip Length	37.05	1.94	33.85	35.74	37.05	38.35	40.24
7	Buttock-Popliteal Length	36.59	2.01	33.29	35.24	36.59	37.94	39.90
8	Hip Breadth	25.31	3.05	20.29	23.27	25.31	27.35	30.32
9	Shoulder Breadth (Bideltoid)	32.03	2.81	27.40	30.14	32.03	33.91	36.66
10	Buttock-Knee Length	45.53	2.58	41.29	43.80	45.53	47.25	49.77
11	Height	139.03	5.68	129.69	135.22	139.03	142.83	148.37
12	Weight	35.40	6.38	24.90	31.12	35.40	39.68	45.90
13	Age	9.27	0.47	8.50	8.96	9.27	9.59	10.04

FIFTH GRADE (BOYS)								
				Percentiles				
No.	Body Dimension	Mean	Standard Deviation	5°	25°	50°	75°	95°
1	Popliteal Height	36.33	1.17	34.40	35.54	36.33	37.11	38.25
2	Knee Height	42.76	1.39	40.47	41.83	42.76	43.70	45.06
3	Thigh Thickness	9.43	1.48	7.00	8.44	9.43	10.41	11.85
4	Sitting Height To The Base Of The Scapula	27.94	1.33	25.74	27.04	27.94	28.83	30.13
5	Sitting Elbow Height	17.08	2.26	13.36	15.56	17.08	18.59	20.79
6	Elbow-Fingertip Length	37.23	1.56	34.67	36.18	37.23	38.27	39.78
7	Buttock-Popliteal Length	37.36	1.39	35.07	36.43	37.36	38.29	39.65
8	Hip Breadth	26.18	2.92	21.36	24.22	26.18	28.13	30.99
9	Shoulder Breadth (Bideltoid)	33.45	2.16	29.90	32.00	33.45	34.90	37.00
10	Buttock-Knee Length	46.73	1.27	44.63	45.87	46.73	47.58	48.82
11	Height	139.30	3.53	133.49	136.93	139.30	141.67	145.11
12	Weight	35.95	6.22	25.72	31.78	35.95	40.12	46.18
13	Age	10.38	0.52	9.52	10.03	10.38	10.72	11.23

SIXTH GRADE (BOYS)								
				Percentiles				
No.	Body Dimension	Mean	Standard Deviation	5°	25°	50°	75°	95°
1	Popliteal Height	39.04	2.24	35.36	37.54	39.04	40.54	42.72
2	Knee Height	46.28	3.85	39.95	43.70	46.28	48.87	52.62
3	Thigh Thickness	9.66	1.92	6.51	8.38	9.66	10.95	12.82
4	Sitting Height To The Base Of The Scapula	28.97	4.05	22.31	26.26	28.97	31.68	35.63
5	Sitting Elbow Height	18.69	2.59	14.43	16.96	18.69	20.43	22.95
6	Elbow-Fingertip Length	40.91	2.22	37.25	39.42	40.91	42.40	44.56
7	Buttock-Popliteal Length	39.59	2.12	36.11	38.17	39.59	41.01	43.07
8	Hip Breadth	27.37	3.14	22.20	25.26	27.37	29.48	32.54
9	Shoulder Breadth (Bideltoid)	34.75	2.43	30.76	33.13	34.75	36.38	38.75
10	Buttock-Knee Length	49.69	3.37	44.15	47.43	49.69	51.95	55.24
11	Height	150.04	8.67	135.77	144.23	150.04	155.85	164.31
12	Weight	41.64	11.63	22.51	33.85	41.64	49.43	60.77
13	Age	11.54	0.52	10.68	11.19	11.54	11.89	12.39

5. DISCUSSION AND CONCLUSIONS

The dimensions obtained in the present study allow to confirm the anthropometric characteristics on children are different for each grade; this can be due to diverse factors like growth, feeding or even health issues. Further studies are required to determine the differences between grades, however, with this information emphasis is placed on the need to consider the anthropometric variances in the design of spaces, equipment among others, since during the study it was observed that the same products are used for all school grades and children are being forced to adapt to them, which carries the possible risk of suffering a disorder while being educated or other possible effects on the education.

Acknowledgements
We thank the participants for their support and the *Instituto Tecnológico Sonora* for their facilities; This publication has been funded with resources from PFCE 2016.

6. REFERENCES

Gouvali, M., & Boudolos, K. (2005). Match between school furniture dimensionsand children's anthropometry. ELSEVIER.

Habibi, E., Asaadi, Z., & Hosseinic, S. M. (October de 2009). Proportion of elementary school pupils' anthropometric characteristics with dimensions of classroom furniture in Isfahan, Iran. Journal of Research in Medical Sciences, 2.

Madríz Quirós, C., Ramírez Coretti, A., & Serrano Montero, R. (2008). Estudio antropométrico para el diseño de mobiliario para niños de edad escolar en Costa Rica. Tecnología en Marcha, 21(4), 17-28.

ANTHROPOMETRIC MEASUREMENT OF IRONING WORKERS IN THE CITY LOS MOCHIS

Karina Luna Soto, Alberto Ramírez Leyva, Nely Melina Gámez Mokay, Maria Alejandra Miramontes Ayala, Ana Victoria Ayala Carrillo.

Department of Industrial Engineering
Technological Institute of Los Mochis
Boulevard Juan de Dios Batiz
E-mail: karinaluna1@yahoo.com

Resumen: Una planchadora es una "persona que plancha o tiene por oficio planchar" según la definición del diccionario de La Real Academia de la Lengua Española. El siguiente documento presenta la realización de toma de las medidas antropométricas de las trabajadoras de negocios de planchado de la ciudad de Los Mochis. Se tomaron las medidas de 21 planchadoras, con la ayuda de un antropómetro Clarita. Se calcularon datos estadísticos con el fin de conocer los percentiles necesarios para el futuro rediseño de la estación de trabajo.

PALABRAS CLAVE: Salud ocupacional, planchado, Antropometría, Percentiles

Abstract: This paper presents anthropometric measures taken from ironing women workers in the city of Los Mochis, Sinaloa. The main contribution of this research is to obtain anthropometric data, which will serve for future redesigns of workstations for the mentioned workers, as well as hand tools used by them in order to eradicate possible CTS' or even fatigue, and that they in time can be used in the region or even in the state for beneficial purposes to the society. It seeks to enable and facilitate the redesign of workspace ironing workers. The anthropometric measures were taken in 21 ironing women who worked in the downtown area of Los Mochis city.

KEYWORDS: Occupational Health, Anthropometry, percentile, ironing

Relevance to Ergonomics: The data collected above may provide a basis for further work in the rest of the country on the economically active population. Anthropometry gives a great contribution in order to prevent risks related barbers using their own equipment, furniture and tools. Thus, enable them to prevent musculoskeletal injuries.

1. INTRODUCTION

The following document presents the realization of the anthropometric measures taken to the ironing workers in the city of Los Mochis, with the purpose of obtaining a database that later will be useful to elaborate a redesign of the current workstation of these workers.

The origin of the word anthropometry comes from the greek anthropos (Man) and metrikos (measure) and is dedicated to the quantitative study of the physical characteristics of men.

Anthropometry is extremely important in the workplace and ergonomics. It allows the creation of a workspace suitable for the user's characteristics, optimizing their work performance and preventing injuries caused by poor design.

2. OBJECTIVE

The overall objective of the research focuses on having a current anthropometric data base of ironing working women in the city of Los Mochis.

Specific objectives:

- Take the antropomethic data of a significant sample of ironing working women in the downtown area of Los Mochis, Sinaloa.
- Record in a software, through spreadsheets, the percentils calculated with the antropomethic data.

3. METHODOLOGY

The measures were taken of 21 women who work with an industrial iron and who are dedicated exclusively to the ironing of clothing. The anthropometric measurements were taken with the help of an anthropometer.

3.1 Determination of sample

Due to the lack of information about the workers in the ironing area, the total number of ironing workers in the city of Los Mochis is unknown, so it was decided to limit the investigation to the downtown area, counting with a number of ironers that adequately represent the population.

3.2 Delimitation

The study was made with traditional ironing workers from the downtown area of Los Mochis, Sinaloa, due to the lack of information about the total population of ironing workers, and, because in this section of the city there is the biggest congregation of ironing workers who were able to cooperate in this research, so delimitation was established as can be seen in Figure 1.

Figure 1. Study area delimitation

3.3 Measurement taking

The anthropometric variables considered for the elaboration of the database were:

1. Height to elbow by 90 °. To determine the ideal height that should have the ironing table without too much crouch and avoiding possible damages.
2. Height at elbow at 45 °. Complementary with the previous variable, because when they perform their work is not in a static way and the height should be ideal when the arm is in both positions (with the elbow bent at 45 and 90 °).
3. Height at the waist. It is considered that this can be very useful for the redesign because it could determine the height of the legs or other elements of the ironing table.
4. Length of the arm from the vertical. To determine the separation between the table and the area in which the operator is positioned.
5. Fist length. This anthropometric variable complements the previous one because, when the operator is working continuously, she lays the hand.
6. Arm length. It complements the two variables above to determine the separation of the ironing table with the body of the worker.
7. Length of the hand.
8. Length of palm of hand
9. Grip diameter. These last three variables (7,8 and 9) are basic if the redesign of the station includes a redesign of the hand tool, in this case of the industrial iron, to determine the dimensions of the handle.

3.4 Information record

The data obtained through measurements were recorded using Microsoft Excel software, it were determined stadistical data as stadistic median, standard deviation and percentiles.

3.5 Elaboration of Conclusions

The conclusions were made with the results obtained previously and it was determined if the objectives were achieved and the hypothesis was verified.

4. RESULTS

Data analysis and presentation of results of various measures is observed here. Once the measures were defined it proceeded to complete the database with percentiles 95, 50, & 5.

Table 1: Percentils

Medidas (cm) / Datos	Altura al codo en 90°	Altura al codo en 45°	Altura a la cintura	Largo del brazo desde la vertical	Largo de puño	Largo del brazo	Largo de la mano	Largo palma de mano	Largo palma de mano	Diámetro de agarre
Máximo	109.4	109.8	110.5	92.0	82.4	83.5	19.5	11.0	11.0	47.0
Mínimo	95.5	93.5	91.6	71.0	60.0	66.0	16.2	9.5	9.5	29.0
Media	102.1	100.97	101.3	81.5	68.7	75.4	17.9	10.5	10.5	37.4
Desviación	3.0	3.54	4.2	4.78	7.2	5.5	0.8	0.41	0.4	4.2
Percentil 5%	98	95.8	94.5	71	61.3	68	16.7	10	10	30
Percentil 50%	102.5	101.5	102	82.1	65.5	76	18.2	10.5	10.5	38
Percentil 95%	106.8	107	108.5	87	82	83.4	19.4	11	11	42

5. CONCLUSIONS

Anthropometry is a tool that allows a design appropriate to the proportions of workers. A work station that can not adapt to the measures of the operator can make difficult the performance of its activities, besides influencing the development of an injury. It contributes to the design of a workstation that allows optimum operation of the operator, minimizing the possibility of injury.

6. REFERENCES

Cueva, M. d. (2007). *Universidad de Guanajuato*. Recuperado el 18 de agosto de 2016, de Revista interiorgráfico: http://www.interiorgrafico.com/edicion/tercera-edicion-mayo-2007/antropometria

Patiño, G. (25 de abril de 2011). *Gicelap.blogspot*. Recuperado el 18 de agosto de 2016, de http://gicelap.blogspot.mx/2011/04/antropometria-dinamica.html

Sánchez Rivera, A. (S.F.). *Ergonomía. Sánchez Rivera Anayelit*. Recuperado el 18 de agosto de 2016, de https://sites.google.com/site/ergonomiasanchezriveraanayelit/1-2-definicion-de-antropometria

Valero, E. (S.F.). *Instituto Nacional de Seguridad e Higiene en el Trabajo.* Recuperado el 18 de Agosto de 2016, de INSHT: http://www.insht.es/Ergonomia2/Contenidos/Promocionales/Diseno%20del%20puesto/DTEAntropometriaDP.pdf

Vidaurrázaga, Y. (2004). Diseño de una estación de trabajo en función de las medidas antropométricas. . *Sociedad de Ergonomistas de México, A.C. Memorias del Vi Congreso Internacional de Ergonomía*, 44-52.

ANTHROPOMETRIC MEASURES OF TECHNICIANS IN MEDICAL EMERGENCIES WORKING IN MEXICAN RED CROSS OF DELEGATION FROM LOS MOCHIS.

Martha Guadalupe Valdez Ochoa, Alberto Ramirez Leyva, Esther Alicia Limon Valenzuela, Rosa Alicia Lopez Leal

Department of Industrial Engineering
Technological Institute of Los Mochis
Boulevard Juan de Dios BatizI
Corresponding author's e-mail: *marval_o@yahoo.com*

RESUMEN: En todos los países se necesitan paramédicos para brindar el servicio que es de gran importancia para toda sociedad es difícil de asimilar que no existen estudios sobre medidas antropométricas de los Técnicos en Urgencias Médicas que laboran en Cruz Roja Mexicana delegación Los Mochis, de ahí el interés de realizar dicha investigación. El objetivo que se tiene, es la realización de una base de datos antropométrica lo cual sirva como referencia para investigaciones futuras. Para la búsqueda de información del presente estudio se acudió a las instalaciones de Cruz Roja Los Mochis durante un periodo de una semana, creando un perfil antropométrico para cada uno de ellos.

PALABRAS CLAVE: Paramédico, Ergonomía, percentil.

ABSTRACT: In all countries, paramedics are needed to provide the service that is of great importance for any society, it is difficult to assimilate that there are no studies on anthropometric measures of the Technicians in Medical Emergencies who work in the Mexican Red Cross delegation Los Mochis, hence the Research. The aim is to carry out an anthropometric database which serves as a reference for future research. To search for information from the present study, the Cruz Roja Los Mochis facilities were visited for a period of one week creating an anthropometric profile for each of them.

KEY WORDS: Paramedics, Ergonomics, percentile.

1. INTRODUCTION

The Royal Academy of the Spanish Language defines a paramedic as "one who has a relationship with medicine without belonging to it (Real Academia Española, s.f.)." In all countries, paramedics are needed to provide the service that is of great importance for any society, it is difficult to assimilate that there are no studies on anthropometric measures of the Technicians in Medical Emergencies who work in the Mexican Red Cross delegation Los Mochis, hence the interest To conduct such an investigation.

Anthropometry (Roebuck, 1993) is the science of measurement and the art of physical geometry of the set of applications, mass properties and endurance capabilities of the human body. It is considered as the science that studies the human body measures, to establish differences between individuals, groups, races, among others.

Another aspect to take is that many people work in this type of institutions is therefore the importance of anthropometric measurements in this type of work for their design of work areas, and in turn the reduction of accidents at work, diseases and fatigues

The main problem is that the work areas for Emergency Medical Technicians are not designed properly for the workers, the space they have in the ambulances is very small and they have a poor accommodation of materials and work tools.

Regardless of the situation, it is often detrimental on several factors like productivity, the health of the patient who is at risk, and the well-being of the worker himself.

The results of this study will benefit both the Emergency Medical Technicians (TUM) and the patients they attend, as well as increasing the productivity and quality of life of those mentioned above.

2. OBJECTIVE

The main objective of this investigation is the realization of an anthropometric database of technicians in medical emergencies of the Mexican Red Cross of the city of Los Mochis, Sinaloa.

This is to have a reference for future research, which will be support for some redesign of the equipment and workstations of the technicians in medical emergencies

3. METHODOLOGY

For the search of information of the present study, we went to the facilities for a week to carry out the anthropometric evaluation of the workers, creating an anthropometric profile for each of them. The tool used to carry out the research was the anthropometer.

To do this, a survey was carried out by the workers of the Mexican Red Cross of the Los Mochis delegation. The relevant measurements were applied, which refer to the vertical distance from the ground to the upper surface of the knee. It is necessary that the technician in medical emergencies be shown in a sedentary position, erect with knees and ankles at right angles. Another measure taken into account is the vertical distance from the horizontal to the vertex, placing the aforementioned in a straight position with footwear, with the upper limbs on both sides of the body, the palms and fingers of the straight and extended hands Down, facing forward, standing upright, with the weight evenly distributed on both feet (Milian, Mondaca Chévez, & Borjas Leiva, 2014).

Subsequent to the aforementioned, a database was generated, whose information was collected and analyzed using software. For the search of information of the present study, we went to the facilities for a week to carry out the anthropometric evaluation of the workers, creating an anthropometric profile for each of them. The tool used to carry out the research was the anthropometer.

To do this, a survey was carried out by the workers of the Mexican Red Cross of the Los Mochis delegation. The relevant measurements were applied, which refer to the vertical distance from the ground to the upper surface of the knee. It is necessary that the technician in medical emergencies be shown in a seated position, erect with knees and ankles at right angles. Another measure taken into account is the vertical distance from the horizontal to the vertex, placing the aforementioned in a straight position with footwear, with the upper limbs on both sides of the body, the palms and fingers of the straight and extended hands Down, facing forward, standing upright, with the weight evenly distributed on both feet (Milian, Mondaca Chévez, & Borjas Leiva, 2014).

Subsequent to the aforementioned, a database was generated, whose information was collected and analyzed using software.

4. RESULTS

The study was carried out at the facilities of the Mexican Red Cross of the city of Los Mochis where the TUMs perform their work. Taking into account the results obtained according to the anthropometric analysis, the database was completed with 100, 95, 75, 50 and 5 (cm) percentile

TABLE OF PERCENTILES LENGTH OF THE FOOT TO THE KNEE															
PERCENTILES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
100	48.4	59.3	53.2	52.5	56.1	58.4	58.8	59.1	57.3	57.9	49.4	46.7	51.6	60.2	53.8
95	45.98	56.335	50.54	49.875	53.295	55.48	55.86	56.145	54.435	55.005	46.93	44.365	49.02	57.19	51.11
75	36.3	44.475	39.9	39.375	42.075	43.8	44.1	44.325	42.975	43.425	37.05	35.025	38.7	45.15	40.35
50	24.2	29.65	26.6	26.25	28.05	29.2	29.4	29.55	28.65	28.95	24.7	23.35	25.8	30.1	26.9
5	2.42	2.965	2.66	2.625	2.805	2.92	2.94	2.955	2.865	2.895	2.47	2.335	2.58	3.01	2.69

TABLE OF PERCENTILES HEIGHT OF THE BODY															
PERCENTILES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
100	169	172	162	171	163	187	178	161	174	182	158	175	158	179	164
95	160.55	163.4	153.9	162.45	162.45	154.85	177.65	169.1	152.95	165.3	172.9	150.1	166.25	150.1	170.05
75	126.75	129	121.5	154.33	128.25	122.25	140.25	133.5	120.75	130.5	136.5	118.5	131.25	118.5	134.25
50	84.5	86	81	146.61	85.5	81.5	93.5	89	80.5	87	91	79	87.5	79	89.5
5	8.45	8.6	8.1	139.28	8.55	8.15	9.35	8.9	8.05	8.7	9.1	7.9	8.75	7.9	8.95

5. CONCLUSIONS

With the body percentiles identified, new strategies can be developed to improve the spaces within the ambulances, which are the work stations, adapting the work area to according to the body of the workers, thus facilitating the activities to be performed and increase The physical well-being of these with which you can increase productivity within your work, without doing a total redesign of the workstation. The research must go beyond, beyond the city of Los Mochis, and add more accurate data with their respective measurement tools.

This research consists of the obtaining of anthropometric data that serve for future redesigns of workstations for technicians in medical emergencies (TUMs), as well as hand tools used by them with the objective of eradicating possible DTA's or even fatigue and that these In turn can be used in the region or even in the state for purposes beneficial to society.

6. REFERENCES

Milían, L. C., Mondaca Chévez, F. A., & Borjas Leiva, E. W. (2014). Manual de Medidas Antropométricas. SALTRA.

Real Academia Española. (s.f.). Obteined from de Real Academia Española: http://dle.rae.es/?id=RrW4L8J

Roebuck, J. (1993). Anthropometric Methods: Designing to Fit the Human Body (HF. Society, Ed..). Santa Mónica, California, USA: HFES.

ANTHROPOMETRIC STUDIES WITH 2D TECHNOLOGY AND DIRECT METHOD

Mauricio López Acosta[1], Susana García Vilches[1], Jesús Enrique Sánchez Padilla[1], Aarón Fernando Quirós Morales[1], Luis Carlos Montiel Rodríguez[1].

[1] *Industrial Engineering Deparment*
Instituto Tecnológico de Sonora,
Ramón Corona y Aguascalientes
Navojoa, Sonora. México 85860
Corresponding author's e-mail: *mauricio.lopez@itson.edu.mx*

Resumen: El presente estudio muestra un caso sobre la comparación de la adquisición de datos antropométricos utilizando el Método Directo y utilizando Tecnología 2D, se seleccionaron cuatro variables antropométricas de la mano del estándar ISO 7250 de una muestra de 70 estudiantes (35 mujeres y 35 hombres) con edades entre 18 y 28 años; se elaboró una base de datos con la información de cada hoja de recogida de datos para su procesamiento, con la finalidad de realizar el análisis estadístico, presentado una media y desviación estándar de cada una de las dimensiones tomadas y se determinó la correlación de las variables para mano dominante y mano no dominante comparando la medición directa/tecnología 2D. Resultados: Se obtuvieron las características antropométricas de los estudiantes y se presenta un valor de correlación de Pearson de 0.986 en mano dominante y 0.979 en mano no dominante en el caso de las mujeres, y de 0.961 en mano dominante y 0.948 en mano no dominante el caso de los Hombres, lo que permite considerar el método 2D utilizando cámaras para estos estudios.

Keywords: Antropometria, Tecnologia 2D, Diseño

Abstract: This research shows a case about the comparison in the acquisition of anthropometric data using the Direct Method and 2D Technology, four anthropometric variables were selected based on the ISO 7250 standard of a sample of 70 students (35 women and 35 men) from a age range between 18 and 28 years; a data base was elaborated with the information obtained from every Data Collecting sheet for processing, with the purpose of performing a statistical analysis, presenting an average and a standard deviation of each of the taken dimensions and a correlation was determined for the dominant hand and the no dominant hand comparing the direct measurement against 2D technology. Results: Anthropometric characteristics from students were obtained and a Pearson correlation value of 0.0961 for the dominant hand and 0.0979 in the no dominant hand was presented in women, and a 0.0961 in dominant hand and a 0.948 value in the no dominant hand was presented in men, which allows the consideration of the 2D method using cameras for this studies.

Keywords: anthropometry, 2D Technology, Design

Relevance to Ergonomics: In this research we obtained relevant data such as the anthropometric characteristics of hands, using direct measurement technique and using the 2D technique, statistical analyzes showed that the use of this technique can be reliably used and can be used to generate anthropometric hand charts of workers for the design of manual tool or for other purposes.

1. INTRODUCTION

Among the professionals dedicated to the area of occupational health in our country, there is a constant concern to assure that work activities do not harm the integrity of workers, and this concern aims at addressing the safety and health aspects at work. Part of this interest is the design of suitable jobs, which include the ergonomic aspects.

The latter has to do with the adaptation of machinery or tools not manufactured in our country and that should take into account the characteristics of Mexican workers. However, in general there is lack of complete and accurate information on the anthropometric characteristics of Mexican workers (Trujillo, Quintana, Peñuelas and Anzaldo, 2005). Anthropometry is the science that deals with the measurements of the human body, mainly those that refer to its size, the size of its segments, forms, strength and capacity of work and is one of the fundamental bases of ergonomics (Ramírez, 2006).

For the collection of anthropometric data, most conventional methods use the palpation technique to locate the characteristic points of the body. However, the manual measurement procedure tends to be tedious and may involve human errors (Neuez, 2002). Due to the human variations involved in the manual measurement process, optoelectronic technology offers an alternative for anthropometric measurement (Meunier and Yin, 2000).

A study carried out in athletes by Gittoes, Bezodis & Wilson (2009) concludes that the image-based approach provides a successful alternative to direct measurement to obtain the required anthropometric measurements, they assure that it is potentially beneficial for obtaining anthropometric measurements of large samples of subjects or for the studies of elite athletes for whom the data collections consume them a time that may be undesirable.

Another study conducted by Meunier & Yin (2000) concluded that imaging studies are capable of providing anthropometric measurements that are quite comparable to traditional measurement methods (performed by qualified meters), both in terms of accuracy and repeatability . On the other hand Lin & Wang (2011) mention that the automatic extraction of human body characteristics from 2D images provides a quick and easy method to collect anthropometric data for many applications.

One of the main limitations encountered when carrying out anthropometric studies is the availability of the persons to perform their measurements, mainly for the time that has to be assigned to each subject to be measured. This is one of the main motivations for this study, which seeks the comparison of the anthropometric data obtained with 2D technologies and with the direct method, since applying the

2D technologies the times that are asked to the subject for measurement are significantly decreased.

2. OBJECTIVE

To determine if the anthropometric measurements made with the method of 2D technologies give the same results as the direct method, in order to take advantage of the optical method that is non-invasive and that is faster than the direct.

The study considers people of both sexes, born in the State of Sonora with ages between 18 and 28 years. This study presents only the anthropometric measurements of the hands.

3. METHODOLOGY

2.1 Sample

The population subject to the study was people born in the State of Sonora with ages from 18 to 28 years. Selecting only the cases that fulfilled the specifications of the place of birth and age, obtaining a total of 35 male subjects and 35 female subjects.

2.2 Materials

They were required specialized instruments such as anthropometers (a small anthropometer to measure length, width and depth of the hand, this anthropometer has a range of 0 to 30 cm in 0.1 cm increments), a NIKON 1 Model J5 digital camera, tripod and the Digimizer software.

2.3 Process

The data collection process was carried out in the university's ergonomics laboratory, explaining to the participants the purpose of the activity and its importance. To measure the dimensions of the hands, participants were asked to adopt the defined posture for the measurement (subject seated), they were asked for information about age, sex, place of birth, occupation and dominant hand; The measurements were taken with the corresponding instruments and recorded on the data collection sheet.

Anthropometric dimensions

In this research, morphological, macroscopic, phenotypic and surface measurements are considered as anthropometric dimensions, which are performed to the people under a measurement protocol and according to techniques recognized in the international scientific literature. For this research, anthropometric measurements are considered according to ISO 7250 (2008), with the following study variables:

1. Hand Length
2. Length of Palm
3. Palm Width
4. Hand Width

Once the information was obtained, each measurement chart was entered into a database for statistical processing. For its analysis it is presented with measures mean and standard deviation and the percentiles 5, 40, 50, 80 and 95 are considered.

The images were processed for data analysis using a software named Digimizer, this software allows the user to escalate dimensions from an image through a scalar reference, by applying this method the values of the four variables under study in each image were obtained, until every subject (70) was processed , see Figure 1.

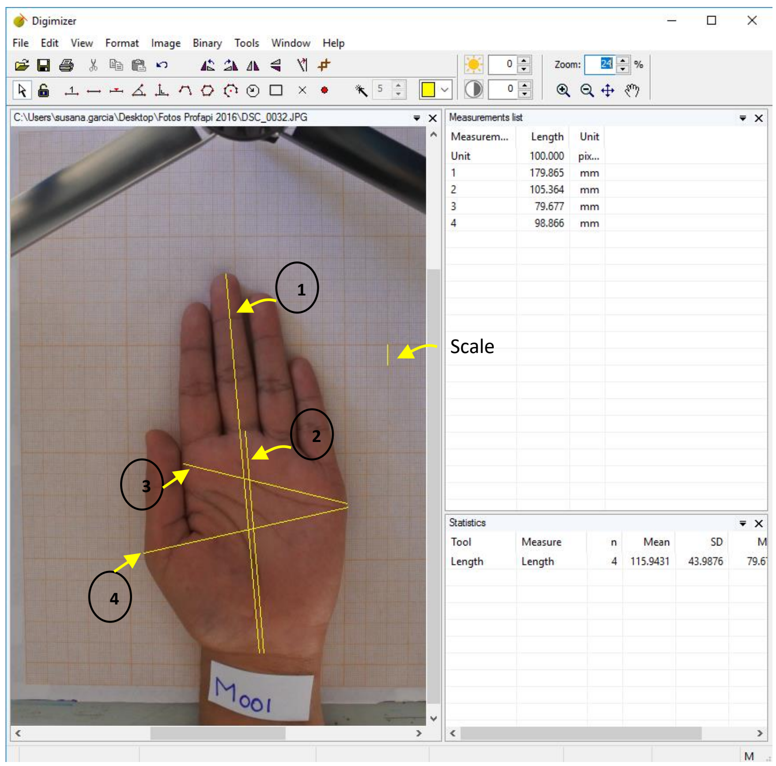


Figure 1. Hand Length

Finally, statistical analyzes were carried out to determine the correlation between the variables under study. All the measured values are expressed in millimeters.

4. RESULTS

The following are the anthropometric characteristics obtained in the study, making the comparison between the direct measurement and the use of the camera for dominant hand and non-dominant hand by gender and a second section with the correlation analysis between the variables:

- Direct and with the Camera Measurement for Dominant Hand
- Direct and with Camera Measurement for Non-Dominant Hand

and for both Women and Men.

4.1 Anthropometric Characteristics

1. Hand Length

Perpendicular distance of the line drawn between the styloid process and the tip of the middle finger, figure 2.

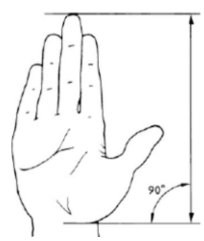


Figure 2. Hand Length

Dominant

	Mean	S. D.	P5	P10	P25	P50	P75	P90	P95
Direct W	17.25	0.92	15.74	16.07	16.63	17.25	17.87	18.43	18.76
Camera W	17.99	0.98	16.38	16.74	17.33	17.99	18.64	19.24	19.60
Direct M	18.26	1.37	16.00	16.50	17.34	18.26	19.18	20.02	20.52
Camera M	20.83	1.06	19.09	19.48	20.12	20.83	21.54	22.19	22.58

Non Dominant

	Media	Desv	P5	P10	P25	P50	P75	P90	P95
Direct W	17.20	0.96	15.61	15.96	16.55	17.20	17.85	18.44	18.79
Camera W	17.74	0.88	16.30	16.62	17.15	17.74	18.33	18.86	19.18
Direct M	18.69	1.33	16.50	16.98	17.79	18.69	19.58	20.39	20.87
Camera M	20.76	1.05	19.04	19.42	20.06	20.76	21.47	22.11	22.49

2) Length of Palm

Distance of a line drawn between the styloid processes to the proximal of the middle finger in the palm of the hand, figure 3.

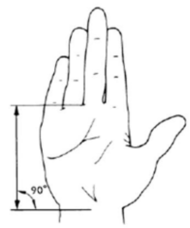


Figure 3. Length of Palm

Dominant

	Mean	S. D.	P5	P10	P25	P50	P75	P90	P95
Direct W	10.03	0.96	8.45	8.80	9.39	10.03	10.68	11.26	11.61
Camera W	10.07	0.63	9.04	9.27	9.65	10.07	10.50	10.88	11.11
Direct M	11.10	0.40	10.44	10.59	10.83	11.10	11.37	11.61	11.76
Camera M	12.45	0.70	11.29	11.55	11.98	12.45	12.92	13.35	13.61

Non Dominant

	Mean	S. D.	P5	P10	P25	P50	P75	P90	P95
Direct W	9.93	1.03	8.24	8.62	9.24	9.93	10.62	11.25	11.62
Camera W	9.83	0.62	8.81	9.04	9.41	9.83	10.24	10.62	10.84
Direct M	11.11	0.35	10.54	10.67	10.88	11.11	11.35	11.56	11.69
Camera M	12.39	0.69	11.25	11.51	11.93	12.39	12.86	13.28	13.53

3) Palm Width

Projected distance between the radial and cubital metacarpals at the level of the metacarpal heads of the second to fifth metacarpal, figure 4.

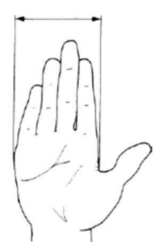


Figure 4. Palm Width

Dominant

	Mean	S. D.	P5	P10	P25	P50	P75	P90	P95
Directa W	7.46	0.33	6.91	7.03	7.24	7.46	7.68	7.89	8.01
Camera W	8.18	0.47	7.41	7.58	7.87	8.18	8.50	8.79	8.96
Direct M	8.64	0.36	8.05	8.18	8.40	8.64	8.88	9.10	9.23
Camera M	9.40	1.65	6.68	7.29	8.29	9.40	10.50	11.51	12.11

Non Dominant

	Mean	S. D.	P5	P10	P25	P50	P75	P90	P95

Direct W	7.33	0.35	6.75	6.88	7.10	7.33	7.56	7.78	7.91
Camera W	7.98	0.49	7.17	7.35	7.65	7.98	8.31	8.61	8.78
Direct M	8.6	0.5	7.8	8.0	8.3	8.6	9.0	9.3	9.4
Camera M	9.4	1.5	6.9	7.4	8.3	9.4	10.4	11.3	11.8

4) Hand width
Distance between the heads of the second and fifth metacarpal from its most lateral area, figure 5.

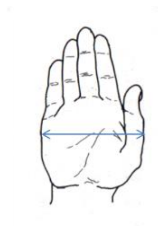


Figure 5. Hand width

Dominant

	Mean	S. D.	P5	P10	P25	P50	P75	P90	P95
Direct W	8.60	0.46	7.84	8.01	8.29	8.60	8.91	9.20	9.37
Camera W	9.50	0.45	8.76	8.92	9.20	9.50	9.80	10.08	10.24
Direct M	10.06	0.63	9.02	9.25	9.64	10.06	10.49	10.87	11.10
Camera M	11.06	0.46	10.31	10.47	10.75	11.06	11.36	11.64	11.81

Non Dominant

	Mean	S. D.	P5	P10	P25	P50	P75	P90	P95
Direct W	8.58	0.52	7.73	7.92	8.23	8.58	8.93	9.25	9.44
Camera W	9.48	0.48	8.70	8.87	9.16	9.48	9.80	10.09	10.26
Direct M	9.72	0.70	8.56	8.82	9.25	9.72	10.19	10.62	10.88
Camera M	10.63	1.76	7.74	8.38	9.46	10.63	11.81	12.88	13.52

4.2 Correlation Analysis

The values obtained were considered to be very good, a Pearson correlation value was obtained from 9,986 in dominant hand and 0.979 in non-dominant hand in the case of females (see Figure 6) and of 0.961 in dominant hand and 0.948 in non-dominant hand Dominant the case of Men (see Figure 7).

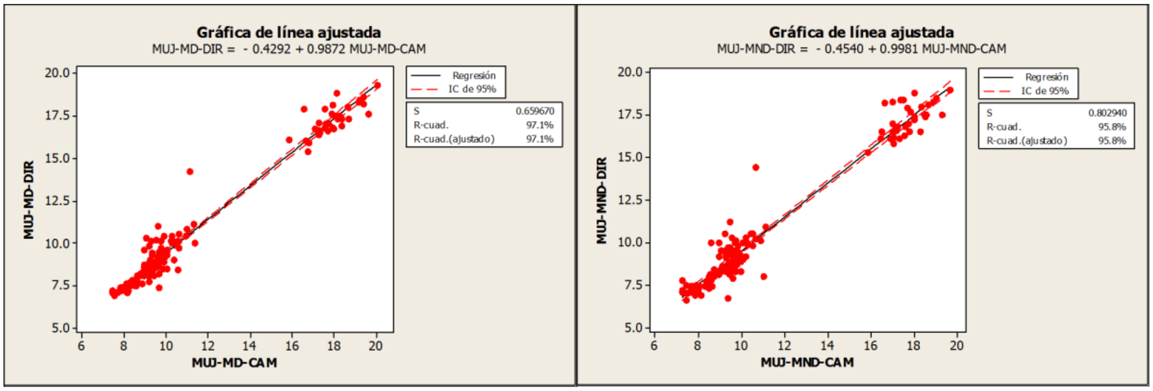


Figure 6. Correlation Analysis Women (W)

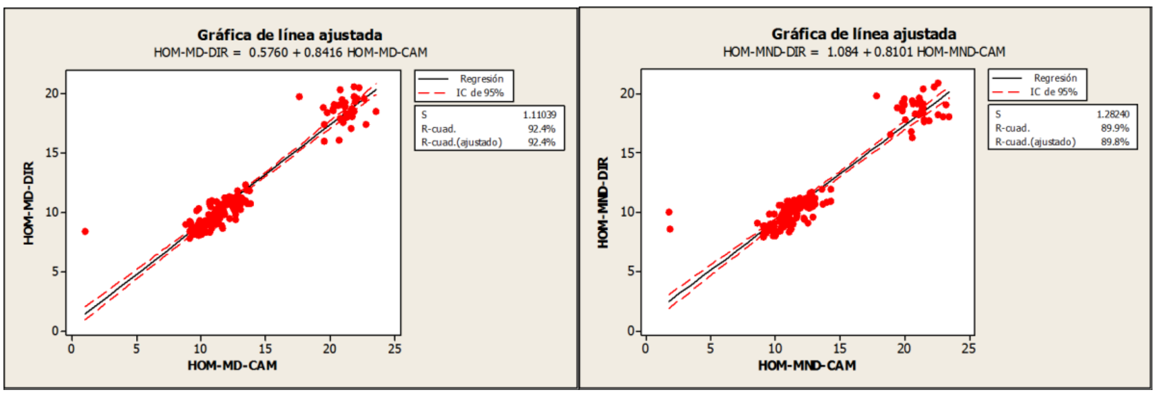


Figure 7. Correlation Analysis Men (M)

5. DISCUSSION AND CONCLUSIONS

The values obtained in the present study allow us to affirm that the anthropometric characteristics obtained with the use of 2D technology (cameras) are as valid as those obtained with the Direct Measurement technique only that give measurements slightly superior to those of the direct method (you can see that the slope of the line is less than 1). Another very important element to consider in the study is that it was observed that using 2D technology consumes less time and there is no contact with the user.

Acknowledgements
We thank the participants for their support and the *Instituto Tecnológico Sonora* for their facilities; This publication has been funded with resources from PFCE 2016.

6. REFERENCES

Gittoes, M., Bezodis, I., & Wilson, C. (2009). An Image-Based Approach to Obtaining Anthropometric Measurements for Inertia Modeling. Journal Of Applied Biomechanics, 25(3), 265-270.

Meunier, P., & Yin, S. (2000). Performance of a 2D image-based anthropometric measurement and clothing sizing system. Applied Ergonomics, 31445-451.

Lin, Y., & Wang, M. J. (2011). Automated body feature extraction from 2D images. Expert Systems With Applications, 382585-2591.

Lu, J., & Wang, M. J. (2008). Automated anthropometric data collection using 3D whole body scanners. Expert Systems With Applications, 35407-414.

Neuez, G. (2002). Range camera imaging: From human body measurements to very large 3D points scenes visualization. PhD thesis, Department of Signals and Systems, Chalmers University of Technology.

Meunier, P., & Yin, S. (2000). Performance of a 2D image-based anthropometric measurement and clothing sizing system. Applied Ergonomics, 31445-451

Simmons, K. P., & Istook, C. (2001). Comparison of 3-dimensional body scanner for use potential. Textile Asia, 48–52.

Ramírez AV. (2006) Antropometría del trabajador minero de la altura. An Fac med.;67(4):298-309

Trujillo J, Quintana F, Peñuelas E, Anzaldo P. (2005). Estudio antropométrico en trabajadores de transportación ferroviaria mexicana (TFM, S.A. de C.V.). Rev. Fac. Med. UNAM;;48(3):106-110.

ERGONOMIC AND ANTHROPOMETRIC ANALYSIS APPLIED IN THE MAKING OF SCHOOL DESK

Teresita Alely Lucero de la Toba, Jesús Guadalupe Sánchez Galindo, Oscar Fabián Carmona Alvarez, Frania Berenice Jiménez Dominguez and Betsaida Vega Romero

Instituto Tecnológico Superior de Ciudad Constitución
Marcelo Rubio Ruiz. S/n entre Márquez de León y Pablo L. Martínez
Col. 4 de Marzo Ciudad Constitución, Baja California Sur,
México. C.P. 23643
Corresponding author's e-mail:E-mail: tlucero14@itcc.edu.mx,

Resumen: El objetivo principal de este proyecto es que el alumno trabaje en un espacio educativo de bienestar, tomando como prioridad que se reduzcan los riesgos óseo-musculares que una mesa banco normal pudiese causarle al alumnado general. A su vez se consideran las oportunidades de provecho como consecuencia de la aplicación de este nuevo diseño, como de mejorar el servicio de educación, proporcionando una herramienta para desarrollar los diversos trabajos, deberes y tareas y demás actividades de clase, pero teóricamente de manera más confortable. Este proyecto de rediseño es resultado de varios análisis ergonómicos, más concisamente fue llevado a cabo mediante un análisis antropométrico, de todos los alumnos de la carrera de ingeniería industrial, del Instituto Tecnológico Superior de Ciudad Constitución (ITSCC). Dicho análisis sentó las bases fundamentales para encontrar las medidas aproximadas o el intervalo de medidas adecuadas para la elaboración de un nuevo diseño ergonómico de mesa banco y que este cumpliera con todos los requisitos que la antropometría y ergonomía general pudiese plantearle. El proyecto de un re-diseño de mesa banco ergonómico, es una herramienta pensada para cumplir con posturas ergonómicas en el área de clases, para la comodidad y el bienestar del alumno. Todo lo mencionado anteriormente aporta como resultado, de manera teórica, grandes beneficios no solamente para la salud física (muscular, óseo-motriz) de los alumnos y una disminución en su estado psicológico de carga de estrés, además es de apoyo al sector estudiantil a tener un mejor rendimiento en las clases y la Institución será reflejada con los resultados en la aplicación de estos diseños, gozando de una mejora en su servicio educativo. Este proyecto fue pensado a raíz de la inconformidad que los alumnos presentan con respecto al mobiliario escolar en las aulas de la institución.

Palabras clave: Ergonomía, Mobiliario escolar, Antropometría

Abstract: The main objective of this project is that the student work in an educational space of well-being, taking as a priority reducing the musculoskeletal hazards than a table normal Bank would cause to the general student body. At the same time opportunities are considered for benefits as a result of the application of this new design, as to improve the education service, providing a tool for developing different jobs, duties and tasks and other activities of class, but theoretically more comfortably.

This project's redesign is the result of several ergonomic analyses; more concisely was carried out using an anthropometric analysis of the students of industrial engineering, of the Instituto Tecnológico Superior de Ciudad Constitucion (ITSCC). This analysis laid the fundamental basis to find the dimensions or the range of appropriate measures to make a new ergonomic school desk design and comply all the requirements that Anthropometry and ergonomics general could ask. A school desk ergonomic redesign project is a tool developed to meet ergonomic postures in the area of classes, for the comfort and well-being of the student. All above mentioned brings as result, in a theoretical way, great benefits not only to physical health (muscle, osseus-motricity) students and a decrease in their psychological state of stress load, is also supporting the student sector to have a better performance in classes and the institution will be reflected with the results in the application of these designs enjoying an improvement in its education service. This project was intended as a result of the dissatisfaction that students have with respect to the school furniture in the classrooms of the institution.

Key words: Ergonomics, school desk, Anthropometry

Contribution to ergonomics: Becomes the application of anthropometric measurements in school areas, covering the necessary measures for the development of a school desk, whereas the percentiles of the population, complemented by the application of statistical tools and results interpretation, all immersed in an ergonomic context, this reached the goal of creating a comfortable work location safe and healthy.

1. INTRODUCTION

In the enough amounts of educational classrooms of the Mexican region is evident and necessary use of material and, more specifically, furnishing of stationary instructional use, such a test is the Bank. There are variations between layouts of this building is expected, through scientific basis that study the human proportions and the appropriate conditions so that an environment is considered healthy and safe (Quiros, 2006), find a design that reaches to cover gaps and needs covering these failures to occupational ergonomics (Lucas, 2015). This project was developed through anthropometric analysis, composed of all students of industrial engineering of the ITSCC. This analysis laid the foundations to find the range of appropriate dimensions for the elaboration of a new design for table Bank and that it met all the requirements that the ergonomics could ask (Adriazola and Rivas, 2010) (Gutierrez, 1992).

1.1 OBJECTIVE

The main objective of this project is that the student works in a space of comfort that will reduce the risks that a regular school desk would cause the student. At the same time improve the service of education, providing a tool for developing different works but more comfortably (Gianikellis, 1998). In addition to the above, other side to highlight goals is to define the physical characteristics and most common traits of a student population sample, how they behave and what are their main needs at the time of using school furniture and the difficulty of adapting to this (Velasquez, 2014).

1.2 METHODOLOGY

Firstly the total ITSCC industrial engineering students were measured (Chaurand, 2001). These measures were:

- Sitting height (shoulder)
- Elbow sitting height
- Knee-Gluteus distance
- Elbow-wrist distance
- Low body part sitting height
- Knee sitting height
- Shoulders width
- Hips wide
- Body depth
- Abdominal depth

1.2.2 INSTRUMENTS

The instruments used were:

- Tape anthropometric
- Segmometer

2 EQUATIONS

Once With documented data, the next step was making calculations:

- Standard deviation
- Media
- 5% and 95% percentiles

Such data is vital to base the new design measures.

3. FIGURES AND TABLES

The results are discussed below:

Height sitting (Shoulders)	Height elbow sitting	Knee-gluteus	Elbow - wrist	Bottom (sitting)
104	72	54	28	45
107.5	68.5	50.5	29	46
105.7	69.5	57	25.7	45.5
101.6	66.7	56.4	28	45.3
95.6	63.3	56	26.8	38.6
96.4	64.6	60	25.6	42.3
104.4	69.7	60	26.1	43.4
98.2	64.6	54.4	28	42.5
94.9	63.8	52.3	24.6	41.2
105.6	72.8	60.2	27.5	45.7
100.7	69.8	57	26.9	46.2
99.7	65	56	24.5	37.9
107.5	69.6	61.3	32.7	43.9
100.7	65.7	51.4	25.4	44.5
100	69	58	26	45
105	70	63.5	29.5	45
96.5	64	52.5	25.5	42
109	70	57.5	28	45.4
100	62.5	60.5	30	41
100.5	64.5	55	28	40.5
96.5	61.5	54	26.5	41
102	70	58	30	45
106	69	59	30.5	44.5
100.5	64.5	55	31	45
104	68.7	58	30	44.3
99	65.5	54.5	28	44
102.5	67.5	57	32	44.2
101.5	67.5	60	30.5	44
100	67	58	30	44.3
102	69.5	53.5	31	43.5
103.5	71.5	60	31.5	42.3
99.5	64	61	32	42.5
101.5	67	56	30	43.8

Table 1. It shows Anthropometric tables results.

Knee (Sitting)	Width shoulders	Wide hips	Depth of the body	Depth abdominal
52	38.4	37.2	22.2	22.9
55.7	43	35.5	23	21
51.4	36.4	35.3	19.5	18.7
54	45.8	36.7	22.6	20.6
49.3	39.5	34.5	18.2	18.2
51.3	36.6	37.9	19	20.5
51.6	38	36.6	20	16.6
49.2	38.1	33	21.1	20
46.2	35.5	34.4	18	17.6
54	39.1	36.5	20.4	17.9
51.1	37.5	32.5	18.2	16.5
49.9	40	37	23	21.3
50.5	42	40.5	20	22.5
50	43.3	37.7	25.5	29
52	40.4	37.8	21.2	22.8
52	38.4	41.1	24	24.5
48	38.5	35.4	20.5	20
53.5	40.6	34.3	21.6	21.8
51.5	46.3	37.5	26.2	26.8
51	45.4	36.1	23.7	25
51	42.6	34.4	23	20.1
54	45.5	39.4	23.8	24.3
55	45	41	22.8	22.5
53.5	43.3	35.6	19.5	18.6
52.5	42	40.3	23.1	25
52	41	35.9	22.7	23.2
55	43.1	39	23.5	20.2
55	42.2	36.8	26.5	22.8
51.5	41.5	38.1	226.5	26.1
54.5	47.5	38.7	28.3	30.7
55.5	51.6	42.6	29.9	31.2
56	48.3	42	30	32.2
55	45.2	37.1	24.9	24.4

In table of results anthropometric is used statistical data on the distribution of measures body of the population to optimize the measures of the redesign school desk. As a result is showed a change evident in the distribution of the measures giving a negative relationship between anthropometry and furniture used, compared to the good reception the redesign has these results and must choose to considerer the new dimensions with traditional (Cordoba, 2002).

Table 2. It shows statistical calculation results. Mean, Standard deviation and 5 and 95 percentile.

Measurements	Mean	Standard deviation	5 Percentile	95 Percentile
Sitting height (Shoulders)	101.52	4.03	95.39	107.50
Elbow sitting height	66.79	3.44	61.71	71.79
Knee-Gluteus distance	57.71	3.56	52.15	63.50
Elbow-wrist distance	28.58	2.11	25.28	32.00
Low body part sitting height	43.45	2.41	38.60	46.29
Sitting knee height	53.04	2.90	48.76	58.00
Shoulders width	42.60	3.91	36.47	48.66
Hips wide	37.37	3.10	32.35	42.18
Body depth	25.77	23.68	18.20	28.99
Abdominal depth	23.39	4.22	17.42	30.85

4. RESULTS

As a result is showed a change evident in the distribution of the measures giving a negative relationship between anthropometry and furniture used, compared to the good reception the redesign has these results and must choose to considerer the new dimensions with traditional (Cordoba, 2002).

The table and the graph presented above show us the results of the calculations made in order to obtain the appropriate actions that the Bank required to meet all the main requirements of ergonomics and Anthropometry.

The analysis can be concluded the measures that the new design of the table Bank should have to be implemented in the students of industrial engineering at the Instituto Tecnológico Superior de Ciudad Constitución.

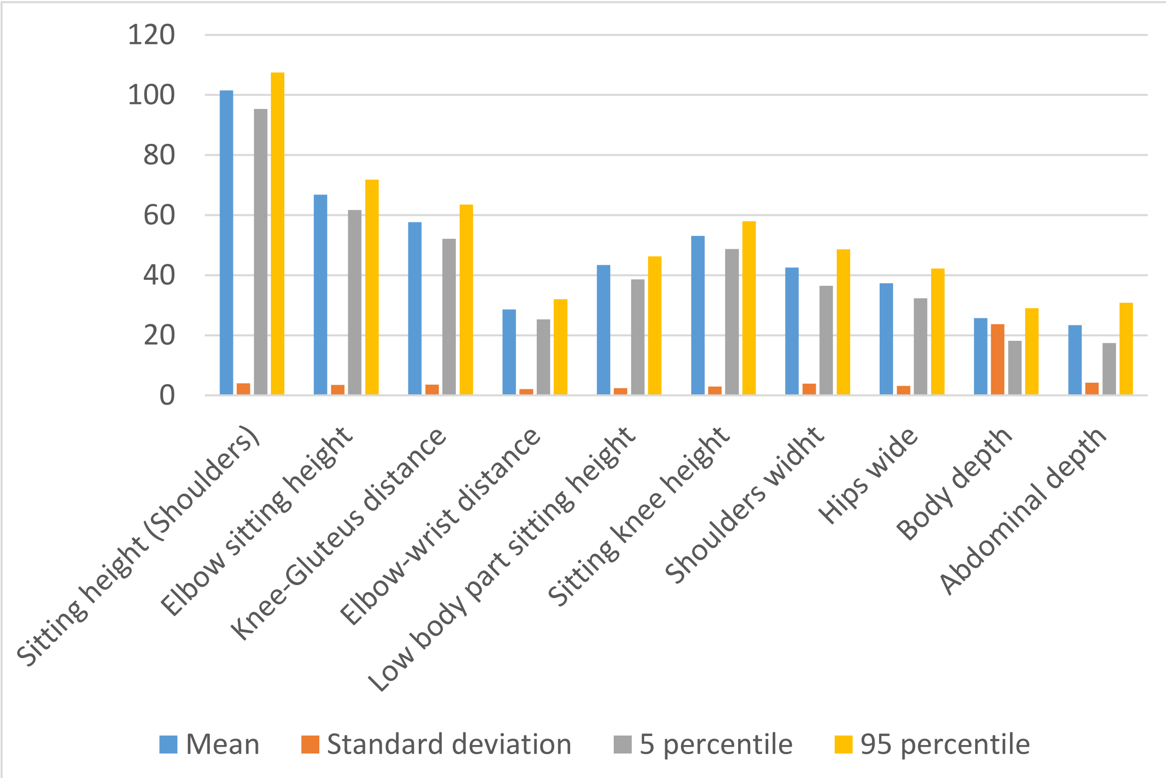


Figure 1. Graphed results for statistical analyses according measurements

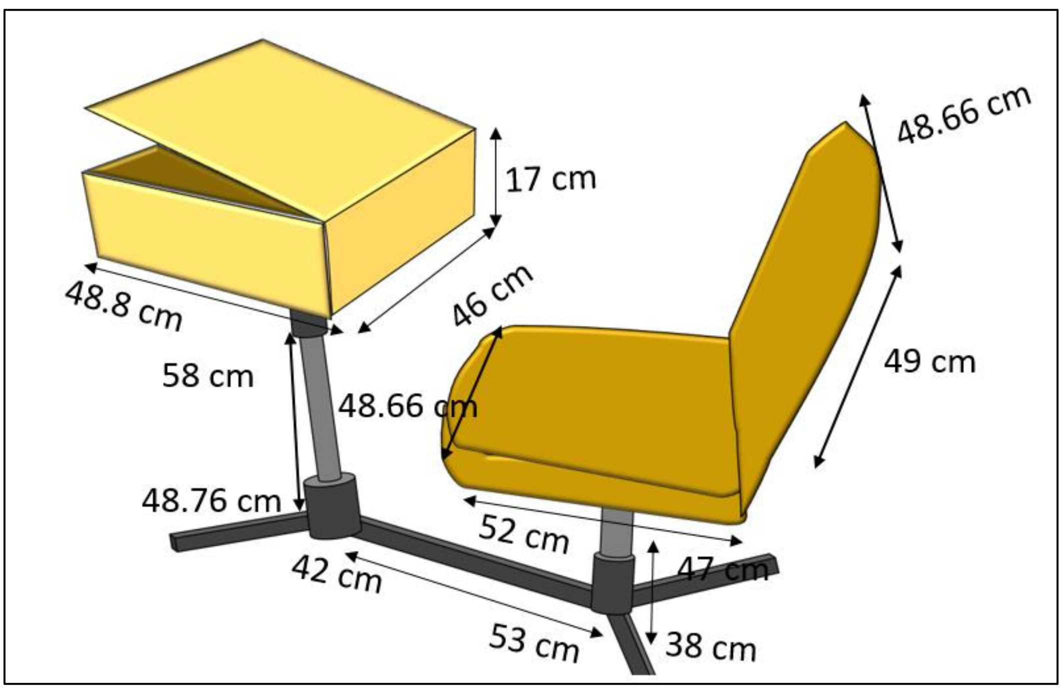


Figure 2. Graph showing the dimensions of the new design

5. References

Adriazola and Rivas. (2010). *ERGOESCOLAR.* ERGOESCOLAR.

Chaurand, R. A. (2001). *Estudio ergonomico para determinar las dimensiones del mobiliario.*

Gianikellis, K. (1998). *Evaluacion de Mesa banco ergonomico y sus resultados.* Extremadura, España.

Gutierrez, M. (1992). *Ergonomia aplicada al diseño de mobiliario escolar.* Concepcion, Chile: PDF.

Lucas, P. A. (2015). *Silla ergonomica.* TGF.

Quiros, C. M. (2006). *Solucion antropometrica a problemas ergonomicos.* Costa Rica: Tec.

Velasquez, R. P. (2014). *Aplicacion de ergonomia y antropometria.* Mexico: Facultad de ingenieria de Mexico.

ANTHROPOMETRIC STUDY IN THE INDUSTRIAL MAQUILADORA COMPANY VALLERA DE MEXICALI S.A. de C.V. MASIMO DIVISION

Jesús Mercado-Diaz[1], Melchor Martínez-Sánchez[1], Leoberilda Valdez Juarez[1], Yanet Villarreal-González[2], Rigoberto Zamora Alarcon[3]

[1]Industrial Vallera de Mexicali S.A. de C.V. División MASIMO
Calzada del Oro # 2001 Parque Industrial Palaco
Mexicali Baja California.
jmercado@masimo.com, memartinez@masimo.com,
leoberildadoc@hotmail.com

[2]Instituto Tecnológico de Mexicali
Av. Tecnologico S/N. Elías Calles
Mexicali Baja California.
mcvillarrealy@hotmail.com

[3]Universidad Autonoma de Baja California
Boulevard Benito Juarez S/N
Mexicali Baja California.
zamora@uabc.edu.mx

RESUMEN

En el proceso que a continuación se analiza se hace referencia a la importancia y la necesidad de los datos antropométricos para el diseño y rediseño de puestos que se emprenderán en la empresa Industrial Vallera de Mexicali S.A. de C.V. Division Masimo, como nos aporta el autor “Rosalio Ávila Chaurand” (Dimensiones antropométricas de población latinoamericana segunda edición 2007) donde nos plasma la importancia y necesidad de los datos obtenidos en la cedula antropométrica.

En el presente trabajo se detallan los resultados obtenidos en la aplicación de las mediciones en alcances de pie, alcances sentado, anchos de cuerpo, dimensiones de cabeza, manos y pies.

La antropometría es la rama de la ergonomía que estudia las dimensiones y características físicas del cuerpo humano esto con la finalidad de diseñar estaciones de trabajo de acuerdo a la estructura de la población medida.

Palabras clave: Antropometría, Percentiles de mediciones Antropométricas, Ergonomía

ABSTRACT: In the process that is analyzed below, reference is made to the importance and necessity of anthropometric data for the design and redesign of posts to be undertaken at the company Industrial Vallera de Mexicali S.A. de C.V. Division Masimo, as the author "Rosalio Ávila Chaurand" (Anthropometric Dimensions of the Latin American population second edition 2007) gives us the importance and necessity of the data obtained in the anthropometric cedula.

In this paper we report the results obtained in the application of the measurements in foot ranges, seated ranges, body widths, dimensions of head, hands and feet are detailed.

Anthropometry is the branch of ergonomics that studies the dimensions and physical characteristics of the human body with the purpose of designing workstations according to the structure of the population measured.

Key words: Anthropometry, Percentile of anthropometric measurements, Ergonomics

Contribution to Ergonomics

In the ergonomic contribution we find that the anthropometric chart is an improvement that will help the health of the workers, as studies of this type will give companies tools to design or redesign stations ergonomically to stand or sit.

Objective

To know the Anthropometric variability of the workers of the company Industrial Vallera de Mexicali S.A. Of C.V. Masimo Division as well as similarities or differences with other populations of companies in Mexicali Baja California.

Delimitation:

The delimitation of the anthropometric work was determined from the universe of employees of the Company, Industrial Vallera de Mexicali S.A. Of C.V. Masimo Division. Which is 2,338 Employees of which were measured a total of 250 Employees which were divided into two groups the first was 190 women of the 5 modules and 2 shifts, For the second group were taken the measurements of 90 men of the 5 Modules of the company of the 2 shifts.

Methodology

For this activity, the Clarita I Model Anthropometric Kit was used, which was used to determine the size of the employees. Procedure: The method used consisted of taking the anthropometric dimensions of the staff of Industrial Vallera de Mexicali S.A. de C.V. Masimo Division. Which were the Following.

No.	Dimension Socket	No.	Socket Dimension
1	Height	18	Foot Length
2	Height to Eye	19	Foot Width
3	Shoulder Height	20	Heel Width
4	Height at Bended Elbow	21	Seated Height
5	Height at Knuckle	22	Height at shoulder blade
6	Height at the Knee	23	Height at the Sitting Elbow
7	Reach Front Arm	24	Heel Height Sitting
8	Reach to Side Arm	25	Seated Knee Height
9	Depth of Thorax	26	Popliteal Height
10	Maximum Body Depth	27	Nipple-Popliteal Length
11	Reach Vertical Arm	28	Hip Width Sitting
12	Maximum width Bideltoidea	29	Arm Length
13	Thorax Width	30	Forearm Lengt
14	Elbow-Elbow Width	31	Head Perimeter
15	Width of Hand	32	Width of Head
16	Hand Length	33	Head Depth
17	Length of the palm of the hand	34	Length of the face.

For the collection of these samples, four measuring stations were placed, the first station placed was used for weight-taking and filling of the Anthropometric Cedula (Ávila, 2016). In the second Posta The dimensions Height and Height of the feet were made which consist of: height to the eyes, shoulders, elbow, etc .; Arm reaches and depth of body. In the third post were taken the measurements for sitting postures which consisted of: maximum height, height to the shoulder blade, height to the thigh, among others; As well as the lengths of the arms and the widths of the body, finally the fourth post was placed, where the dimensions of the head, hand and feet were determined. All this in order to have the information that will help determine the anthropometric variability of the workers of the company.

Results.

This anthropometric study gave us the tables with the measurements of the personnel of industrial Vallera de Mexicali Division Masimo which are identified in the Attached Table.

Dimensiones			Percentiles					
		D.E	Min	5	25	50	75	95	Max
1	Estatura	90	1408	1463	1542	1595	1656	1761	1985
2	Altura al ojo	84	1290	1353	1437	1491	1540	1641	1763
3	Altura al Hombro	77	1158	1201	1272	1321	1369	1463	1563
4	Altura al codo flexionado	58	840	902	957	994	1032	1106	1137
5	Altura al nudillo	47	609	631	670	696	723	783	830
6	altura a la rodilla	40	373	394	428	450	481	527	590
7	Alcance brazo frontal	51	504	530	574	600	634	702	777
8	Alcance brazo lateral	54	579	651	689	720	758	817	898
9	Profundidad de Tórax	41	160	202	236	264	294	336	395
10	Profundidad Max. del Cuerpo	44	176	205	237	271	301	348	402
11	Alcance brazo vertical	121	1633	1711	1819	1890	1977	2131	2275
12	Anchura máxima bideltoidea	43	360	385	416	444	472	526	600
13	Anchura del tórax	49	223	241	276	300	331	384	542
14	Anchura de codo-codo	59	290	388	427	460	509	573	673
15	Anchura de la mano	9	69	78	86	92	100	109	130
16	Longitud de la mano	14	108	152	163	170	180	195	210
17	Longitud de la palma de la mano	8	68	82	90	95	100	110	117
18	Longitud del pie	18	162	217	229	241	254	272	290
19	Anchura del Pie	7	74	83	89	94	97	105	119
20	Anchura de talón	7	50	54	60	65	69	76	93
21	Altura sentado	45	540	781	817	845	874	913	956
22	Altura al omoplato	49	249	328	390	430	455	483	531
23	Altura al codo sentado	30	166	211	237	252	269	302	434
24	Altura al muslo sentado	56	86	118	135	148	164	200	546
25	altura a la rodilla sentado	45	383	424	465	485	511	557	857
26	Altura Poplítea	32	262	345	372	388	406	448	519
27	Longitud nalga-poplítea	34	343	393	424	451	474	507	543
28	Anchura de cadera sentado	46	320	342	377	406	432	485	744
29	Longitud de Brazo	26	253	297	317	334	352	379	443
30	Longitud de antebrazo	32	333	397	424	443	466	505	526
31	Perímetro de la cabeza	25	460	509	528	547	562	591	646
32	Anchura de la cabeza	16	98	111	144	151	156	164	170
33	Profundidad de la cabeza	13	141	155	174	183	190	201	206
34	Longitud de la cara	10	150	169	176	182	191	200	215

Conclusions

Providing comfortable workstations to operators is the responsibility of companies, that is why this information can be used in conjunction with other measurements of different companies in the locality to determine the anthropometric dimensions of the personnel working in the various maquiladoras in the city Of Mexicali.

With the determination of the percentiles tables ergonomic improvements can be applied in the plants of the company Industrial Vallera de Mexicali S.A de C.V. Masimo Division as well as in the new acquisition plant of San Luis Rio Colorado, Sonora. As well as the redesign of the current stations that require improvements.

5. REFERENCES

Ávila, Rosalio (2007), Dimensiones Antropométricas de Población Latinoamericana.

CARMONA A. Aspectos antropométricos de la población laboral española aplicados al diseño industrial. Madrid: INSHT, 2003. ISBN: 84-7425-655-0.

Norma técnica sobre el diseño de puestos de trabajo. UNE-EN ISO 7250-1:2010. Definiciones de las medidas básicas del cuerpo humano para el diseño tecnológico. Parte 1: Definiciones de las medidas del cuerpo y referencias

HIERARCHIC TASK ANALYSIS, MENTAL WORKLOAD AND HUMAN ERROR ASSESSMENT APPLIED IN THE USE OF A PILLBOX FOR ELDERLY PEOPLE

Mario Osmar Antonio Moreno García[1], Aidé Maldonado Macías[2], Juan Luis Hernández Arellano[1]

[1] Departamento de diseño,
Universidad autónoma de ciudad Juárez.
mario.moreno@uacj.mx, luis.Hernández@uacj.mx

[2] Departamento de ingeniería industrial y de sistemas,
Universidad autónoma de Ciudad Juárez.
amaldona@uacj.mx

Resumen: este artículo presenta un estudio integral que realiza el análisis de tareas cuando adultos mayores utilizan un dispensador de medicamentos. Se aplicaron los métodos Análisis Jerárquico de Tareas (HTA por sus siglas en inglés), NASA-TLX para evaluar la carga de trabajo y SHERPA para analizar el error humano. Con el HTA se dividió la tarea principal del uso del dispensador en cinco subtareas considerando el uso del dispensador que se utiliza los siete días de la semana. El método NASA-TLX permitió conocer el nivel de carga mental que fue de 47% el cual es considerado como de nivel medio que se presentan cuando las actividades mentales y físicas son desarrolladas en combinación. El método SHERPA permitió conocer que el error humano ocurre en los siguientes casos: revisión, selección, comunicación y acción, donde el error más común fue en la subtarea de apertura de compartimientos donde se guarda el medicamento. Se recomienda rediseñar los elementos de apertura del dispensador y mejorar las instrucciones para evitar consumir el medicamento equivocado.

Palabras clave: Diseño para adulto mayor, Análisis Jerárquico de Tareas, dispensador de medicamentos, NASA-TLX, SHERPA.

Abstract: This article presents an integral study related with the tasks performed when a pillbox is used by elderly people. Different methods to develop task analysis (Hierarchical Task Analysis, HTA), to assess workload (NASA-TLX), and to assess human error (SHERPA) were applied. In the hierarchical analysis of tasks, tasks were divided into five subtasks considering the use of a 7-day medication organizer. The NASA-TLX method allowed knowing the level of mental load during the use of the medicine dispenser resulting in an average of 47% of mental load which is considered as medium. The levels of mental load considered as "means" occur when mental and physical activities are performed in combination. The SHERPA method allowed us to know that human error occurred in the following cases: revision, selection errors, communication, and action, where opening compartments errors

were the most frequent. Therefore, it is recommended to redesign the opening elements of the pillbox and improve the instructions to prevent consuming the wrong medication.

Keywords Design for elderly people, Hierarchical Task Analysis, Medicine dispenser, NASA-TLX, SHERPA.

Relevance to Ergonomics Identify the problem and meet the needs of nurses responsible for providing medicines to the elderly and develop solutions that make this task easier and safer.

1. INTRODUCTION

1.1 Problem statement

The medicine organizer/dispenser (commonly known as a pillbox) for the elderly people used in this study has compartments in which the medicines are organized by day, time, and weekly. The main problem with this device is the complexity to coordinate the intake of medicine, being the most common risk to intake the wrong medication. This can result from an allergic reaction to severe intoxication, and the extreme case, the death.

Adverse drug events are classified as preventable when they are caused by a medication error, and in non-preventable, when they occur despite the appropriate administration of the drug, known as adverse drug reactions, (López, M. O., Jané, C. C., Alonso, M. T., & Encinas, M. P. 2003). Further, in the U.S. alone medical errors are estimated to cause more than one million injuries and up to 98,000 patient deaths each year (Kohn et al, 1999). This is the reason because we develop this study considering the importance of ingest in drugs erroneously.

1.2 Objectives

1.2.1 General

Develop an integral study related with the tasks performed when a pillbox is used by elderly people.

1.2.2 Specific

- To perform a hierarchic task analysis of the use of the pillbox.
- To perform an analysis of mental load with the NASA-TLX method on the use pillbox by the staff of an elderly nursing home.
- To perform the analysis of human error using the SHERPA method on the use of pillbox

1.3 Theoretical frame

Next, the methods used to perform the research will be displayed

1.3.1 Hierarchical Task Analisis (HTA)

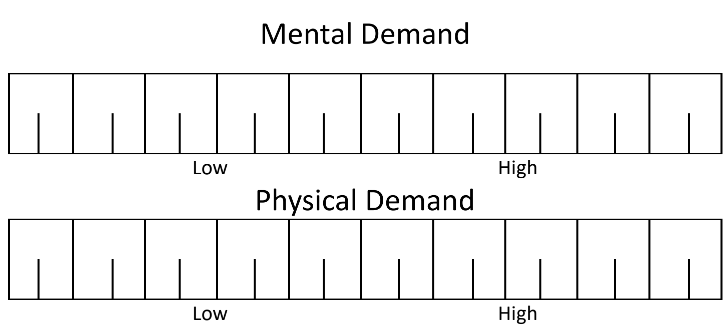
The HTA is based on the theory of human performance, which is at the same time based on a behavior focused on a task that has sub-tasks linked by plan Stanton 2006 therefore, each one of the tasks that the user performs were analyzed, and with this be able to breakdown the activities and give an index of importance and follow up to perform activities properly. The steps to follow according to Stanton, Hedge, Brookhuis, Salas, & Hendrick (2004) are: Define the task to be analyzed, recollection of data, general objective, determine sub-objectives of the task, decompose the sub-objectives, analysis of plans, generate, and if possible, test the hypothesis relative to the execution of tasks. The use of an HAT gives the user a great comprehension of the analysis task.

1.3.2 Workload and the NASA-TLX method

It is the portion of processing resources that a person needs to perform a task (Cañas et al., 2001). Wickens (1992) distinguishes different dimensions of mental load according to the type of processing resources required by the task, mental load measurement analyzes the levels of workload imposed by an activity or system with the aim of identifying and eliminating the demands Performance-related workloads (Wilson, Russell, & Davis, 2006).

According to Stanton et al. (2005), the NASA-TLX method is a subjective assessment tool for mental load during a task, using a multidimensional index to derive the total load index based on an average of six sub-scales: mental demand, demand Physical, temporal demand, performance, effort and level of frustration, with these participants evaluate each subscale with a value from 0 (low) to 20 (high), then a comparison is made with possible combinations (15 possible) with The participants analyze which of them has the greatest effect on the mental load, subjectively analyzing the mental load, this method has been used in different areas of aeronautics, some of its advantages are that it provides a simple and fast technique to estimate the subscales are generic, so the technique can be applied in any domain and the method has been evaluated to be And has been the subject of numerous validation studies.

In Figure 1, people value the task or subtask that they have just completed in each of the dimensions, marking a point in the scale presented to them.



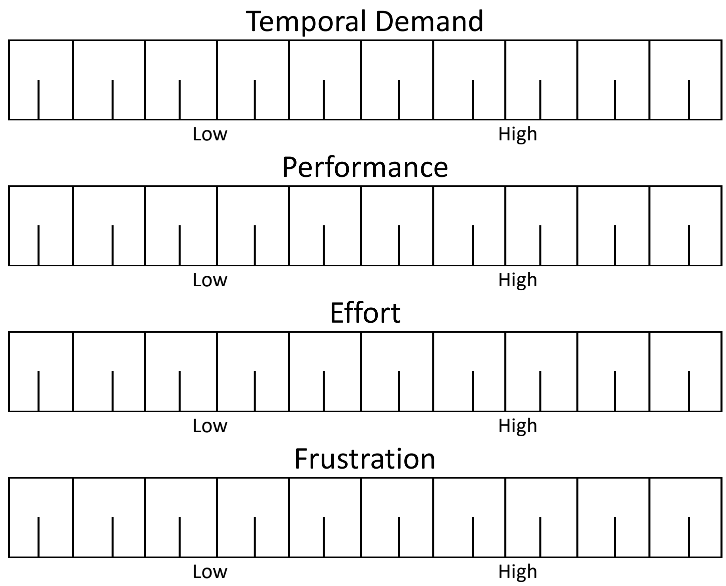


Figure 1. The format of the NASA-TLX Questionnaire.

1.3.3 Human error

According to Sanders and McCormick (1993), human error is defined as an inappropriate or undesirable decision or behavior that reduces. Or has the potential to reduce, the effectiveness, security, or execution of the system. Cañas & Waerns (2001) divide the human error as error by omission, this is when the user forgets to perform any activity, error by assignation, this applies when the activity is done incorrectly and this last one is divided into two parts: error of sequence and error of time, which influence the performance of the task.

While the prospect of uncovering an infallible method for predicting human error given an interface and task still seems distant, the present state of theory and research on human error in the fields of human-computer interaction (HCI) and cognitive science seems sufficient to provide an improvement over currently techniques. This will prove invaluable if successfully applied in the medical arena where human lives are consistently at stake (Chung, P. H., Zhang, J., Johnson, T. R., & Patel, V. L., 2003).

1.3.4 SHERPA method

This method is a technique that qualitatively and quantitatively evaluates the human reliability and makes concrete recommendations to reduce the probability of human error, especially in procedures, staff training, and equipment design. Developed by Embrey in 1986, which describes it as a Systematic Method of Reduction and Prediction of Human Errors (SHERPA), which aims to provide guidelines for the reduction and quantification of human errors in a wide range of human systems - machines. The approach uses the current cognitive models of human performance as its basis (Embrey, 1986).

1.3.5 Controls

The controls are about devices for response or interaction with the information. They allow entering information into a machine or process. Some criteria to select a type of control: according to the kind of task the kind of variable to be controlled, operation form (fingers, hands, arms or feet). Types of controls: Pulsations, keyboards, switches, rotating, sliding lines, levers (Medina, 2006).

1.4 Study limitations

The study was only carried out to 10 people, Therefore it is considered that the sample is very small, applied only to patients and not to attendees it was applied in a single care home location, very specific tasks were evaluated, only one type of device was evaluated, 5 men and 5 women were evaluated.

2. Methodology

2.1 Pillbox description

The medication dispenser or pillbox is a device that allows the organization and logical distribution of medications for their daily intake, at appropriate times and established by a physician. In this study, a pillbox with 7 removable compartments was used and analyzed. Ideal for treatment administration. Figure 2 shows the device analyzed.

Figure 2. Organizador semanal de medicamento.
https://ritatalks.files.wordpress.com/2014/07/pill-case-as-ring-holder.jpg

2.2 Study design

A transversal and descriptive study was developed to determine the mental load level and human error when the pillbox is used. The study was carried out in a care home for elderly people. A total of 10 elderly participated in the study. All of them without senile difficulty.

2.3 Procedure

Once the pillbox was chosen, we asked for permission to develop the study in the assistance house. 10 elderly people without senile problems were chosen with the help of the staff of the assistance house.

The hierarchical Task Analysis was developed recording the tasks performed by the users when a medicine/pill is ingest. NASA-TLX method was applied to analyze the workload and the SHERPA method was applied to known and to reduce the probability of human error

3. Results

The previously established methods were developed and these are the results

3.1 Hierarchical Task Analysis (HTA)

The HTA of the use of the 7-day pillbox is presented in Figure 2, which shows the different tasks and sub-tasks that the users perform when using this type of products.

4.2 NASA-TLX

The NASA-TLX method shows that the pillbox produces an average of 47% of mental load when the pillbox is used. Table 1 shows the result of workload for each participant and the overall average for the 10 participants.

Table 1. Summary of the NASA-TLX results

Participant	Weighted average
1	37
2	47
3	57
4	52
5	46
6	41
7	36
8	60
9	48
10	51
Average	47

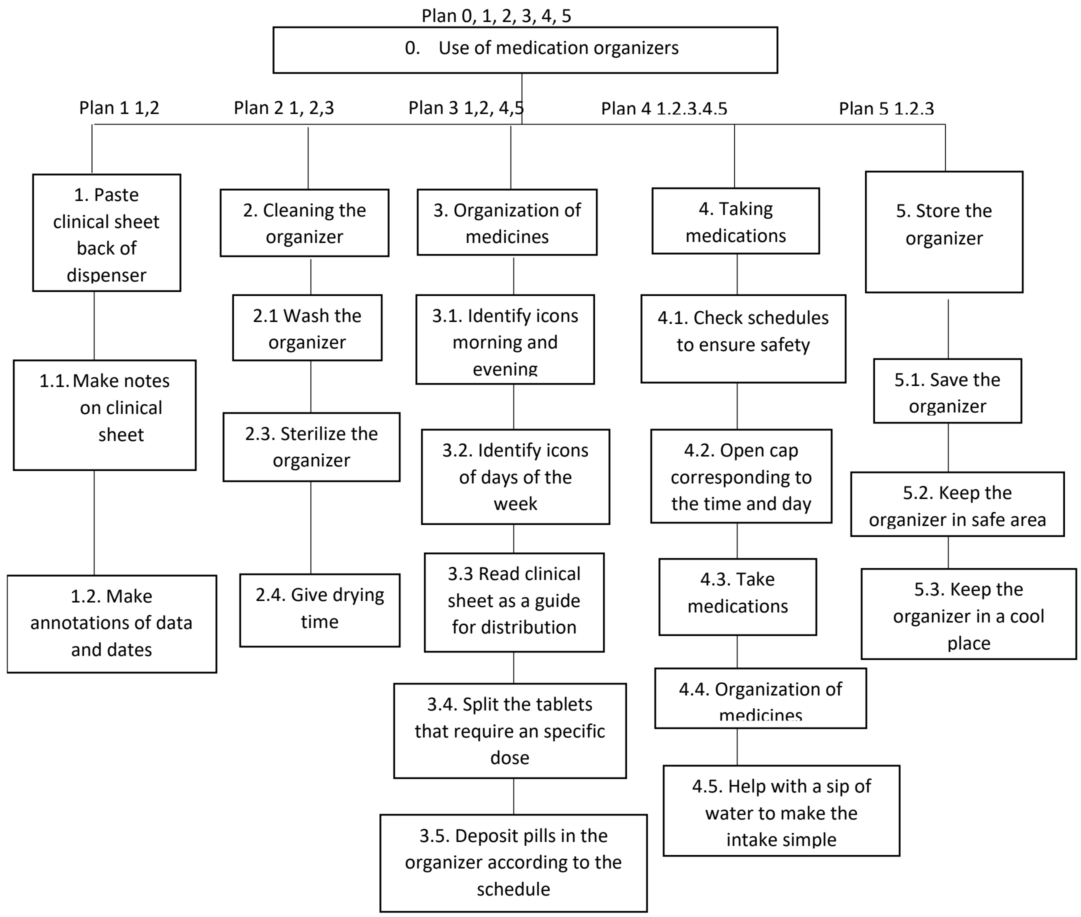


Figure. 3 Hierarchical task analysis of the use of the 7-day pillbox

4.3 SHERPA method

With the SHERPA method, we found that in the HTA 4 common errors are observed: 1) revision errors, 2) selection errors, 3) communication errors, and 4) action errors. All of them are considered very important because of their high probability of being repeated constantly. Also, for the critical consequence if the user ingest a wrong medication. Table 2 shows a summary of the human error analysis.

Task step	Error made	Description	Consequence	Recovery	P	C	Remedial measures
1.1	C1	Not having updated the clinical sheet	Bad information and no treatment	No	M	H	Coordinate better the activation of clinical sheet
3	S1	Having the medication disorganized	Failure to take medication	No	H	H	Follow the clinical sheet
4.2	I 3	Not having enough graphics in the organizer for use	Error opening compartment s that are not suitable	No	H	H	Redesign of the product with systems to open only when necessary
4.4	A8	The patient omits the information given by the caregiver, physician, or clinic sheet	Taking the wrong medication	NO	H	H	Keep in constant observation all the elements of the task and redesign elements of alarm

Table 2. Summary of human error analysis

5. Conclusions and recommendations

The application of the three methods used allowed us to identify the weak points of the product. For example, it was found that the opening mechanism is deficient. As a result, this part generates more mental load and physical work than other tasks. Also, we know the main critical issues when the user interact with the pillbox and performs the tasks. Therefore, the application of the NASA-TLX and SHERPA was successful because now we know that the product generates more mental load and physical load when the user opens the compartments of the dispenser.

It is recommended to emphasize the redesign of the opening elements of the dispenser. If the opening elements are easier, the workload will be less than the actual design. Also, it is necessary to improve the instructions to avoid intake wrong medications by nursing home users.

References

Cañas, J. J., & Waerns, Y. (2001). Ergonomía Cognitiva: Aspectos Psicológicos de la interacción de las personas con la tecnología de la información. Ed. Médica Panamericana.

Chung, P. H., Zhang, J., Johnson, T. R., & Patel, V. L. (2003). An extended hierarchical task analysis for error prediction in medical devices. In AMIA Annual Symposium Proceedings (Vol. 2003, p. 165). American Medical Informatics Association.

Embrey, D. E. (1986). SHERPA: A systematic human error reduction and prediction approach. In Proceedings of the international topical meeting on advances in human factors in nuclear power systems.

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. Advances in psychology, 52, 139-183.

Kohn, L. T., Corrigan, J. M., & Donaldson, M. S. (1999). To err is human: building a safer health system. Institute of Medicine (US) Committee on Quality of Health Care in America.

López, M. O., Jané, C. C., Alonso, M. T., & Encinas, M. P. (2003). Errores de medicación: estandarización de la terminología y clasificación. Farm Hosp, 27, 137-149.

Medina, A. R. (2006). Ergonomia cognitiva y usabilidad. SUMA Campus virtual.
Sanders, M. S., & McCormick, E. J. (1993). Human Factors in Engineering and Design. USA: McGraw-Hill.

Sanders, M. S., & Mc Cormick, E. J. (1993). Human error, accidents, and safety. SANDERS, MS; Mc Cormick, EJ Human Factors in Engineering and Design, 7, 655-695.

Stanton, N. A., Hedge, A., Brookhuis, K., Salas, E., & Hendrick, H. W. (Eds.). (2004). Handbook of human factors and ergonomics methods. CRC press.

Stanton, N. A., Salmon, P. M., Walker, G. H., Baber, C., & Jenkins, D. P. (2005). Human Factors Methods. Hampshire: Ashgate Publishing Limited

Wickens, C. D. (1992). Engineering psychology and human performance. HarperCollins Publishers.

Wilson, G. F., Russell, C. A., & Davis, I. (2006). The importance of determining individual operator capabilities when applying adaptive aiding. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (Vol. 50)

TRAFFIC LIGHTS FOR COLOR BLIND PEOPLE

Alberto Ramírez Leyva, Ruiz Ibarra Jesús Iván, Barajas González Karime Liliana, Salinas Torres Juan Alberto

Instituto Tecnológico de Los Mochis
Industrial Engineering Department
Authors' e-mails: klbg96@gmail.com, jnsaliinas@gmail.com

Resumen: Los tableros son instrumentos que nos muestran el estado de un sistema, la aplicación de éstos es muy amplia, están presentes en nuestro día a día y son muy útiles. Podemos encontrar diferentes tipos y una gran diversidad, cada uno diseñado específicamente con las características necesarias según la situación. Además como es sabido, debemos procurar que éstos sean incluyentes, es decir, que puedan ser captados por la mayor parte de la población posible, sin importar sus discapacidades o limitaciones. En esta propuesta decidimos hacer un rediseño del semáforo habitual de manera que sea más fácilmente interpretado por más personas, tomando en cuenta también los distintos criterios para la elección del mismo. Con este rediseño se procura, mejorar la velocidad de respuesta que tiene la población a los cambios de este, así como hacerlo más fácil, Y en consecuencia, quizás hasta mejorar el flujo del tráfico.

PALABRAS CLAVE: problemas visuales, tablero visual, vialidad

APORTACIÓN A LA ERGONOMÍA: Adecuación de los semáforos para facilitarles el manejo a las personas daltónicas agilizando su respuesta a los cambios de éstos.

Abstract: Boards are instruments that show us the state of a system, the application of these is very broad, they are present in our daily life and are very useful. We can find different types and a great diversity os these, each one designed specifically with the necessary characteristics according to the situation.
In addition, as we know, we must ensure that they are inclusive, that is, that they can be captured by the majority of the population, regardless of their disabilities or limitations. In this proposal it was decided to redesign the usual traffic light for it to be more easily interpreted by more people, taking into account also the different criteria for the choice of the same. With this redesign is sought to improve the speed of response that the population has to the changes of the traffic lights, as well as make it easier, and consequently, improve the flow of traffic.

KEYWORDS: visual problems, visual board, road

CONTRIBUTION TO ERGONOMICS: Adequacy of traffic lights to facilitate the conduction for color blind people by streamlining their response to changes in these.

1. INTRODUCTION

When we drive, most of the information we perceive gets by our eyes, which is not a problem for people who enjoy good visual health, but what if they do not?

If someone has a visual limitation, there are more risks. A clear example is color blindness, a disease that interferes with the perception of colors. There are different types of this condition and although the absolute blindness of colors is very rare, what does occur relatively frequently is a difficulty to appreciate shades such as green and red or even confuse them with each other, colors on traffic lights.

It is because of this that we decided to redesign this board. Although when the color-blind driver is at a traffic light there is no greater problem to know the location of each light, seeing that one light shines more than another, knowing if the signal is giving way or not, this can be done more Easy for them without affecting the perception of other people.

The proposal to do so is to represent each signal emitted by these traffic lights not only by colors as it is currently applied but also by shapes, making precisely not necessary the color distinction for a color blind person.

In this way we aim to reduce the dangers of driving and change the fact that in a certain way the safety depends largely on the colors of the signals at the traffic lights, as well as to make faster the response to the changes of these and improve, at the same time, the flow of traffic.

2. OBJECTIVES

2.1 GENERAL OBJECTIVES

Make the reaction to traffic light changes be faster.

Improve traffic flow.

2.2 PARTICULAR OBJECTIVES

Making traffic lights more easily perceived by people with the condition of color blindness, through the application of different shapes.

3. DELIMITATION

The study will be made to a group of color blind people taken as a sample in the city of Los Mochis.

4. METHODOLOGY

Proposal of improvement on the traffic light symbology of vehicular traffic.

Redesign:

Move forward - Arrow facing north

Caution - equilateral triangle (universal)

Stop - Hexagon (reference to stop signals)

5. RESULTS

It is expected to increase the speed of reaction to the visual signals in a vehicle traffic light in people with color blindness through the use of different shapes for their faster perception. Create a more inclusive and conscious society towards people with some visual disability. Increase of the reaction time of the habitual users of traffic lights. To improve the level of the flow of vehicles in the streets.

6. DISCUSSION/CONCLUSIONS

Conventional traffic lights make the reaction time of people with some type of visual disability very difficult because the symbology they handle does not allow a fast and precise distinction of the signal that is being given to the user. Therefore it is necessary to implement the scientific method to develop a better design of these, and take into account the needs of people with some type of visual disability.

7. RECOMMENDATIONS

Implement this design at traffic lights in the city, primarily in those areas where there is usually so much traffic and consequently more danger.

8. REFERENCES

Camós J. (2008) http://www.circulaseguro.com/el-daltonismo-combinado-con-la-conduccion/

Clínica Baviera (2014) http://www.clinicabaviera.com/blog/salud-visual/tipos-de-daltonismo/

El Blog de la Salud (2014) http://www.elblogdelasalud.es/como-ven-los-daltonicos-los-colores/

El Universal (2008) http://archivo.eluniversal.com.mx/articulos/46010.html

http://www.vanguardia.com.mx/daltonismounaenfermedadmasculina-1345289.html

http://html.rincondelvago.com/daltonismo.html

Menéndez D. (2014) https://www.google.com.mx/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#

Miriam (2010) http://daltonismogrupo19.blogspot.mx/

Munaiz C. (2012) Semper D. (2013) http://www.aeromental.com/2013/05/14/como-ven-el-mundo-los-daltonicos/

Tellez A. (2012) https://sites.google.com/site/ergonomiaangelinatellez/unidad-ii-tableros-y-controles

ERGONOMIC ANALYSIS OF THE WORK IN EMPLOYEES OF A CONVENTIONAL CAR WASH COMPANY

Karla Hernandez, Daniel MartÍnez, Aide Maldonado-Macías

Department of Industrial Engineering and Manufacturing
University Autonomous of Ciudad Juarez
450 Del Charro Avenue
Juarez, Chihuahua. 32310
Corresponding author's e-mail: amaldona@uacj.mx;

Resumen: El siguiente proyecto es el resultado de un caso de estudio realizado por alumnos de la Universidad Autónoma de Ciudad Juárez a una empresa de lavado de autos, ubicada en un centro comercial de la ciudad. El proyecto resalta la importancia de la ergonomía en los lugares de trabajo y el cómo puede colaborar en el rendimiento de los trabajadores. La investigación se documentó a través de encuestas al dueño y los empleados acerca de sus actividades, horarios, turnos de trabajo, equipo con el que cuentan, promedio de autos lavados diariamente, así como las molestias o posibles accidentes sufridos en su experiencia laboral. Posteriormente, se llevaron a cabo videograbaciones en la estación de trabajo utilizando distintos ángulos para analizar las diversas posturas y movimientos. El análisis del trabajo fue realizado utilizando el software GOMPLAYER ® para generar fotogramas de las posturas de trabajo más frecuentes y riesgosas, mismas que fueron útiles para proceder a determinar el riesgo de la tarea. El método RULA (Rapid Upper Limb Assessment) fue aplicado, se aplicó antropometría para proponer nuevas dimensiones de trabajo en el rediseño de área de trabajo, la reubicación del equipo y el diseño de herramientas que promuevan posturas de trabajo más ergonómicas y seguras.

Palabras clave: Anthropometria, Factores de riesgo, posturas, Lesiones musculoesqueleticas, RULA.

Abstract: The following project is the result of a case study carried out by students of the University Autonomous of Ciudad Juarez to a car wash company. This project promotes the importance of ergonomics in the workplace and how it can help worker's performance. This research was documented through surveys to the owner and some employees about their activities, schedules, working hours, equipment with which they count, average cars washed daily, as well as the musculoskeletal complaints and accidents during work. Subsequently, video recordings were made at the workstation using different angles to analyze the postures and movements. Work analysis was made using the GOMPLAYER ®, video frames were useful to determine the most frequent and awkward postures. After carrying out this activity, the RULA method was applied, anthropometry principles were applied to determine

new workplace dimensions such as working heights, equipment location that help promote more ergonomic and safe work postures.

Keywords: Anthropometry, risk factors, postures, musculoskeletal disorders, RULA.

Contribution to Ergonomics: This article is important because it helps to realize that ergonomics not only applies in large companies, but also in small companies. Although it can be a seemingly simple work, it has aspects that can be studied to improve the working postures of the employees, as well as their performance.

1. INTRODUCTION

1.1 Problem statement

This car washing operation was carried out by around 10-20 workers in a car wash company. The work content involves outdoor heavy physical activity and awkward postures. The workers can wash about 10 to 12 cars daily. A large variety of car models are washed with little rest time between each car.

The problems or risk factors that were considered for this operation were awkward postures mainly of upper limbs because workers must wash or dry the cars on a standing work posture. Another factor to consider was the repetitiveness, because this operation is carried out every day, including weekends. Rapid movements were observed as well. Finally, we find the effects outdoors temperature, since this city register very hot temperatures during summer over 45 Celsius degrees and very cold temperatures in winter usually -10 Celsius degrees. All these factors combined can cause discomfort or musculoskeletal disorders among workers.

1.2 Objectives

The objectives of the research are to analyze the work, to apply anthropometry and Ergonomics principles and propose changes in the method and operation of this workplace.

1.3 Justification

The benefits of this project are increase knowledge about ergonomic risks in this workplace. Usually, the company registers lost days of work because of discomfort and injuries of employees and this project helps promote changes in the workstation, method or operation. In addition, it is common that employees gave up their work because of the risk involved and hard work conditions. Ergonomics analysis and interventions can help diminish these problems in the company.

1.4 Delimitations

This project focuses only on those workers who manually wash cars and perform this tasks as a profession. Usually the worker uses only water and wax. The plan is to continue with the same material, but implementing new equipment which is within the possibilities of the company no automations possibilities were considered. The project also focuses on the methods of a Carwash Company workers located in Juarez City.

2. LITERATURE REVIEW

In this section, it the main theoretical concepts are present:

2.1 Ergonomics

According to the International Ergonomics Association, is "the scientific discipline related to the understanding of interactions among humans and other elements of a system, as well as the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance" (Engineering Colombian School, 2011)

Ergonomics aims to improve workspaces and environments to minimize risk of injury or harm. So as technologies change, so too does the need to ensure that the tools we access for work, rest and play are designed for our body's requirements. Also, this discipline aims to create safe, comfortable and productive workspaces by bringing human abilities and limitations into the design of a workspace, including the individual's body size, strength, skill, speed, sensory abilities (vision, hearing), and even attitudes (Dohrmann Consulting, 2014)

2.2 Anthropometry

More than seven decades ago anthropometry was the only technique available for quantifying body size and proportions. As early as 1921, equations for predicting body fat were developed from measurements of body length, width, circumference, and skinfold thickness. Anthropometry is a simple reliable method for quantifying body size and proportions by measuring body length, width, circumference, and skinfold thickness (Wang, Thornton, Kolesnik, & Pierson, 1993)

According to the Industrial Engineering school of the Colombian University (2011), Anthropometry comes from Greek: Anthropos (human) and Metric (measurement). Is the discipline which describes quantitative measures of the human body differences and studying the dimensions considered to reference the anatomical structures i.e. that helps us to describe the physical characteristics of a person or group of persons, and serves as a tool to ergonomics in order to adapt the environment to people.

2.3 RULA Method

The RULA method was developed in 1993 by McAtamney and Corlett, of the University of Nottingham (Institute for Occupational Ergonomics), with the objective of evaluating the exposure of workers to risk factors that cause a high load postural and which can cause disorders in the upper limbs of the body. For the evaluation of risk are considered the method adopted position, the duration and frequency of this and the forces exerted when it is held.

The development of RULA occurred in three phases. The first was the development of the method for recording the working posture, the second was the development of the scoring system, and the third was the development of the scale of action levels which provide a guide to the level of risk and need for action to conduct more detailed assessments (Mcatamney & Corlett, n.d.).

2.4 Musculoskeletal disorders (MSDs)

An estimated 553,000 workers in 2014 and 201515 suffered from musculoskeletal disorders caused or made worse by their current or past work. Musculoskeletal disorders (MSDs) are conditions that affect the nerves, tendons, muscles and supporting structures, such as the discs in your back. They result from one or more of these tissues having to work harder than they're designed to (IOSH, 2017).

Also, workers in many different industries and occupations can be exposed to risk factors at work, such as lifting heavy items, bending, reaching overhead, pushing and pulling heavy loads, working in awkward body postures and performing the same or similar tasks repetitively. Exposure to these known risk factors for MSDs increases a worker's risk of injury.

Work-related MSDs can be prevented. Ergonomics --- fitting a job to a person --- helps lessen muscle fatigue, increases productivity and reduces the number and severity of work-related MSDs. (OSHA, 2017).

3. METHODOLOGY

The methodology involves two stages that are explained in the following paragraphs.

3.1 Application of Anthropometry

3.1.1 Analysis of video

Firstly, after video recording the process of washing a car and have selected the one where movements and postures can be observed more clearly; we made the analysis of 11 minutes of video using “Gomplayer version 2.3.14.5270” program. 200 frames were generated and classified according to the worker’s movements and postures. At the end, 9 elements of the task were obtained these are: load, rest, rinse, squeeze, low car wash, top car wash, low car drying, cloth drying and top car drying.

With these 9 elements, a video analysis table was created to represent the posture, the representative photo frame, number of frames found in the same posture by element of the work with their correspondent frequency and accumulative frequency. Postures that occupied more than 10% of frequency of the video recorded time were considered for further postural and anthropometric analysis.

3.1.2 Definition of relevant body dimensions for design, anthropometric principles and appropriate percentiles.

Based on the data from the previous video analysis table, the most frequent working postures registered were low and top car washing, low and top car drying.

The next step was to determine those relevant anthropometric dimension for the redesign of the method or operation. Those elements of the work were defined by a representative photo frame where the posture was clear and easy to study. Once this was done among 4 elements of task, it was continued with the creation of a new analysis table showing the photo frame, activity, posture, relevant anthropometric dimension, anthropometric principle, proper percentiles and tolerances and finally the desired dimension was obtained for the redesign of the workplace.

3.2. Application of Ergonomics

3.2.1 Risk Factors for Musculoskeletal Disorders

The most important risk factors of these task are: repetitive and/or heavy lifting, bending and twisting, repeating an action too frequently, uncomfortable working position, vibration and climate (unfortunately this factor we can`t control it), as well as, musculoskeletal disorders, that this conditions provoke after realizing them for a long period.

3.2.2 Application of RULA method

The postures chosen for further analysis were: when the worker is performing the tasks of lower and upper washing of a car, and upper or lower drying in a car. We chose 5 postures of each section of the elements of the task). And RULA method was applied for each one of them, this little section was obtained by means of analyzing in detail each part of the photo of the posture and adding the data to the RULA Software, which gave us the scores and their level of risk with their actions to be taken. It should be mentioned that most of the photos showed scores greater than 5 which means moderate risk and review it.

3.2.3 Identification of musculoskeletal disorders

According to the postures and movements and the frequency of them, those musculoskeletal disorders that potentially can affect the employees were identified. These were: wrist tendonitis, De Quervain's tenosynovitis, Carpal Tunnel Syndrome and thoracic outlet syndrome.

3.2.4 Redesign of the workplace

Finally, thanks to all the collected information and after analyzing them, it was started a redesign process of the workplace but due to the project focuses in a outdoor car washing operation, the project proposed some designed tools or equipment to be used by employees.

4. RESULTS

4.1 Application of Anthropometry

4.1.1 Table of Video Analysis

Based in the analysis of the initial classification about elements of the task it was found that a total of 4 postures had a frequency greater than 10%. These work elements were: low car wash with 21%, top car wash with 26%, low car drying 17%, and top car drying with 13%. Table 1 shows the results of this step.

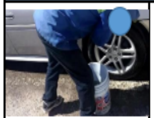
Table 1. Analysis Table.

Description	Photo	Number of Photo	Qty of Photos	Percentage	Cumulative
Rest		14,22,44,47,114,119,135,190	8	8%	7%
Squeeze		30, 115, 116, 117, 118, 152, 154, 155	8	8%	16%
Bottom Washing		16, 25, 7, 50, 52, 60, 71, 72,76, 79, 88, 90, 91, 93, 94, 95, 100, 103, 104, 109, 113	21	21%	37%
Top Washing		1,6, 7, 8, 9,10, 34, 36,37, 42, 43,45, 46, 49, 59, 65, 66, 70, 81, 82, 84, 96, 98, 120, 121	25	25%	62%
Rinse		86, 197	2	2%	64%
Bottom Drying		131,136, 137, 139, 141, 142, 146, 147, 175, 176, 181, 183, 184, 185,186, 187, 196	17	17%	81%
Top Drying		122, 123, 124, 125, 126, 127, 128, 129, 133, 164, 166, 169, 171	13	13%	94%
Load Bucket		67, 192	2	2%	96%
Drying (cloth)		31, 111, 156, 157	4	4%	100%

4.1.2 Table of relevant anthropometric dimensions, anthropometric principles and percentiles

A new analysis is shown in Table 2 for applying anthropometry wad designed. Each element of the task was analyzed. Relevant anthropometric dimensions were knee height and elbow height. In addition, in the next column the most affected body's part by the realization of the movements which were back and arm and finally was obtained each principal anthropometric principle and the calculation of the desired dimensions which ranged from 56.5 cm to 117.5 cm with the added tolerances.

Table 2. Table of body dimensions, anthropometric principles and percentiles

Frame		Posture	Body part	Principle	Percentile	Tolerances	Dimension	Recommended Dimension
	Bottom washing	Knee height	Back	Design for the ends	95% Men	0.5 cm.	55.3cm	53.8cm
	Top washing	Elbow Height	Arm	Design for the ends	5% Women	0.5 cm.	106.5cm	107cm
	Bottom drying	Knee height	Back	Design for the ends	95% Men	0.5 cm.	55.3cm	53.8cm
	Take bucket	Shoulder height / Knee height	Arm / Shoulder	Design for a range	95% Men 5% Women	0.5 cm.	149.7cm	150.2cm
	Top drying	Elbow Height	Arm	Design for the ends	95% Men	0.5 cm.	113.5cm	114cm

4.1 Application of Ergonomics

4.1.3 Application of RULA program

In this part, it was obtained that the 4 postures that were analyzed got a final score of 6 for the case of low car wash (column 1), a 5 for the activity of top wash (column 2), a 6 in low car drying (column 3) and 6 for the activities of top car drying (columns 5 & 6). For all this scores the conclusion that the program gave us is that they are moderate risk and be need investigated and change them soon (see Figure 3).

,

	Upper Arm	Lower Arm	Wrist	Wrist Twist	Posture A	Muscle Use A	Force/ Load A	Final A	Neck	Trunk	Legs	Posture B	Muscle Use B	Force/ Load B	Final B	Final Score
1	3	2	3	1	4	0	0	4	3	5	2	7	0	0	7	6
2	3	2	1	1	2	1	0	3	3	3	2	5	1	0	6	5
3	3	2	2	2	3	1	0	4	3	5	2	7	1	0	8	6
4	3	2	2	1	3	1	0	4	3	3	2	5	1	0	6	6
5	0	2	1	1	3	1	1	5	2	2	2	3	1	1	5	6
6																
7																
8																
9																
10																

Figure 3. General Results of RULA

4.1.3 New equipment and tools for the workplace

This project shows that workers are exposed to a working conditions with risk to suffer musculoskeletal disorders due to many factors, mainly in washing and drying bottom/top of the vehicles, it is for this reason that a new workplace was designed, but due to these operations would be used in a free area where certain factors as weather can't be controlled, we focus only on the equipment for workers.

In first instance, consist in a cart which it works with battery and has a pressure hose, allowing that spend less water than a bucket, so the operator would not sudden movements or stressful positions. It provides a reach better and easier in the top and bottom sides of the vehicle. The cart size must have a considerable height, so the operator can place the cleaning equipment you need and haven't to make the effort to do so. We rely on height of the elbow. As women don't operate in this work, we decided to use a 95% percentile for men, being the size of 1.163 meters. In terms of extend of the hose, it must be long enough to spray well both small and large vehicles, should have a range of at least 3 meters, taking into account that the average height of a large vehicle is 2.20 meter approximately (see Figure 4).

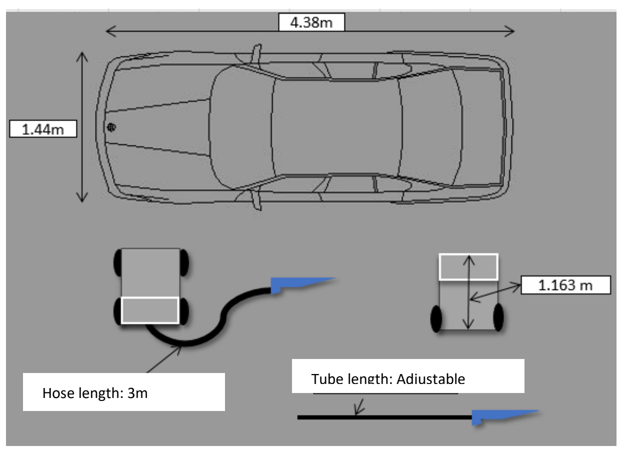


Figure 4. New Workstation

5. CONCLUSIONS AND RECOMENDATIONS

It is concluded that knowledge of Ergonomics helps companies and workers to be aware of ergonomics risks of working conditions.

This project was a good experience for us, because we applied ergonomic and anthropometric methods to analyze the work and working postures. Initially, the project was difficult to make it because the workers didn't want to be recorded, but finally the permits were given and we were able to analyze the work. If this is implemented in more companies, could help workers become more efficient, ergonomic and with less risk of injury.

In terms of the recommendations, outdoor work must be better done until the Sun is at its peak it would be ideal (in time of heat) and vice versa in cold weather.

In addition to those workers already were in the project they were satisfied with the redesign the use of the new hose, water gun, and a cart.

6. REFERENCES

Dohrmann Consulting. (2014). *What is Ergonomics?* Consulted on March 10, 2017, from http://www.ergonomics.com.au/what-is-ergonomics/

Engineering Colombian School (2011). *Ergonomics. Workstation design.* Colombia. Consulted on October 14, 2016. From http://www.escuelaing.edu.co/uploads/laboratorios/8312_ergonomia_de_pie.pdf

Faculty of Engineering. (2011). *Anthropometric.* Colombia. Consulted on October 14, 2016
from http://www.escuelaing.edu.co/uploads/laboratorios/2956_antropometria.pdf

Mcatamney, L., & Corlett, E. N. (n.d.). *RULA: a survey method for the . investigation of world-related upper limb disorders. Applied Ergonomics (*2), 91–99. Consulted on Mach 10, 2016 from http://ftp.demec.ufpr.br/disciplinas/TM802/RULA_original 1993.pdf

Neese Consulting Inc (2000). *RULA SOFTWARE.* Practical Ergonomics. Consulted on October 16, 2016.

OSHA. (2017). Safety and Health Topics.*Ergonomics*. Occupational Safety and Health Administration. Consulted on March, 10, 2017, from https://www.osha.gov/SLTC/ergonomics/

Polytechnic University of Valencia (2016). *RULA Method. Evaluation of the postural load.* Spain. Consulted on March 31, 2016 from http://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

Wang, J., Thornton, J. C., Kolesnik, S., & Pierson, R. N. (1993). *Anthropometry in Body Composition an Overview*. Applied Ergonomics, 24, 91–99. Consulted on March 10, 2016. http://www.ufrgs.br/locomotion/Agenda/apresentacoes/Wang_AnthropometryOverview_2000.pdf

HAND TOOL TO DEFECATE PROPERLY

José Alfredo Leyva Astorga, Alberto Ramírez Leyva, David Gonzalo Guerrero Delgado, Luis Fernando Gerardo Manzanarez, Ilich Eduardo Franco Anaya.

Industrial Engineering department
M.I.E. Engineer and Professor
Institute Technologic of Los Mochis
Los Mochis, Sinaloa
jalajala64@hotmail.com

Resumen: En el área occidental se va al baño de una forma que puede decirse incorrecta o anti-natural, esto porque al momento de sentarse en una posición de noventa grados a evacuar la materia fecal, el recto queda doblado en cierta forma, lo cual hace que la persona ejerza una mayor fuerza para lograr evacuar, lo que ocasiona que se dejen residuos en el intestino.

Es por eso que en el presente estudio, se centra en proponer una herramienta especial para que las personas de diferentes alturas puedan defecar en una correcta posición aproximándose a treinta y cinco grados, lo que trae consigo el poder evacuar toda la materia fecal así como evitar diferentes enfermedades como cáncer de colon. Hemorroides, estreñimiento, entre otros.

Abstract: The western area goes to the bathroom in a wrong or unnatural way. This because when a person sit in a ninety degrees position to evacuate, the rectum is bent in a way that makes the person need for a greater force for evacuation, which causes waste left in the intestine.

That's why this study focuses on proposing a special tool for people of different heights to defecate in a correct position approaching thirty-five degrees, which brings the benefit of evacuating all fecal matter and avoid various diseases such as colon cancer, hemorrhoids, constipation, among others.

1. INTRODUCTION.

Hand tools are devices that assist the work, and characterized by amplifying or reducing some of the functions owned by the hand, increasing the functionality thereof; either by increasing the strength, accuracy, surface, generating more torsional power, impact and increased resistance to temperature and so on.

In this study a hand tool is developed, which it's main goal is helping the human to defecate properly; making an emphasis in the American continent because Asians already have the culture of defecating to 35 °.

1.1 JUSTIFICATION.

The purpose of this study is of vital importance for humans, since bowel movement is a daily necessity that must done. The result of various studies is that it's not being done in the right way, and causes serious health problems inadvertently. That's why it is convenient to carry out and make the people know about this investigation. Because with the use of this prototype when defecating, a variety of health benefits are obtained, preventing a simple stomachache, to a serious illness such as colon cancer.

This study would be a great importance for society, because it is a tool that all people of all ages could use. The results would be reflected with satisfaction since the begging and over time. So people can reduce stomach problems, some diseases and obesity, which is a serious problem for our country Mexico, which is the first in childhood obesity in the world.

1.2. GENERAL PURPOSE.

Develop a prototype to help the human to defecate in a correct, comfortable and natural position being.

1.2.1. SPECIFIC OBJECTIVES.

- Avoid diseases by wrong postures while defecating such as colon cancer, constipation, hemorrhoids, appendicitis, etc.
- Reduce obesity in America.
- Design the prototype of an inclusive way, so people of all ages would be able to use it.
- Facilitate the evacuation of stool.

1.3. DELIMITATION.

This study is aimed to all people in general, regardless of age and sex.

1.4. THEORETICAL FRAME.

Squatting is the best excretion position.

Take a look at the nature and verify **that all animals squat to defecate**. Even our closest ancestors, primates, squat with their knees against their chest to "do their needs." What perhaps you overlook, is that in other cultures has been using this method and **defecating on this natural posture, especially in Asia, Africa and the Middle East.**

Only in the industrialized West, where modern toilet was invented, **people are used to "sit" to defecate as it does to eat**. It is no wonder that the entire Western suffer from chronic constipation, hemorrhoids and other problems due to the fact bowel movement in a sitting position. While modern toilets can save your legs the force needed to squat, **for your intestines is equivalent to an instrument of torture**, and the problems it can cause compensate the comfort that provides.

When sitting on the toilet, the lower end of the descending colon is doubled, **which requires considerable muscular effort to move the bowels**. The intensity of this effort can pop or obstruct the tiny capillaries that feed the anal sphincter, resulting in subsequent bleeding. When crouching, **the colon is naturally aligned with the rectum and anus** that opens completely and effortlessly. This way the evacuation occurs naturally, unstressed. Daniel Reid (2014).

Are you going properly to the bathroom? Meet the sitting posture. All human beings, without exception, have some things in common, one of which is that regardless of our nationality, sex or tastes are all go to the bathroom.

The Stanford University revealed in a study that the best position to go to the bathroom is squatting. This position relaxes muscles and creates the perfect angle to facilitate the evacuation.

According to Dr. Henry L. Bockus in his Gastroenterology book explains: "Squatting position is ideal to defecate, with bent muscle on the abdomen. Thus decreases the ability of the abdominal cavity and increases intra-abdominal pressure, which favors the expulsion ".

In this regard, the French doctor Frederic Saldmann, in his book The best medicine is you explains: "Think of a garden hose filled with water half bent: it's hard for the water to run. It is exactly what happens when sitting. When the person crouches down, the angle opens, the crease disappears and the water can be drained easily.

1.5 METHODOLOGY.

1.5.1 Work Design.

Current research about tools to defecate properly are based on ergonomic design, which facilitates the work that is done with them, and reduces potential disease risks when using it.

The few existing tools, use a fixed and stable design, on which they handle the same height, which favors only part of the population as are people with an average anthropometry. Below is a tool that served as a reference for the development of what we call "Art Studio".

The ergonomic tool to defecate Squatty Potty is an example of an alternative of a fixed design.

Prototype or tool

1.5.2 Prototype Formulation or tool.

The tool design was made considering the people anthropometry, which was obtained through several applied and documented measurements in a anthropometric schedule, that was adapted to this project. The tool was designed with a hydraulic piston to adapt itself to different heights, in order to be used by people of different age, height, and abilities, this means, it was designed thinking on the need of every person.

2. RESULTS.

With the design of this prototype and tool has achieved progress and innovation in the way the stool is evacuated, benefiting users, reducing illness and difficulties when going to the bathroom. Next, the statistic results are shown having taken the results from the measurements and images of the pilot prototype.

ARITHMETIC AVERAGE	**45,11666667**	**40**	**41,09166667**	**36,04166667**	**27,75833333**	**10,06666667**
MAXIMUM	**55**	**40**	**51**	**55**	**33**	**12**
MINIMUM	**40**	**40**	**34**	**28**	**23**	**8**
STANDARD DEVIATION	**3,021445292**	**0**	**2,93055716**	**3,486819922**	**2,203876773**	**1,010310987**
PERCENTILE	**P5=41**	**P5=40**	**P5=36**	**P5=30**	**P5=24**	**P5=8**
	P50=45	**P50=40**	**P50=41**	**P50=35**	**P50=28**	**P50=10**
	P95=50	**P95=40**	**P95=46**	**P95=42**	**P95=31**	**P95=12**

Source: Own Elaboration (2016).

3. CONCLUSIONS.

The hand tools represent a small investment considering the great benefits that can be obtained in ergonomically speaking in a fast and effective way, that´s why we choose to do this project, given that is known, to defecate is a very important human need, in order for the body to evacuate all that is not needed and it can work properly, that is the reason that we chose to follow through with this project.
Just one year ago, we only had an idea and basic theories, now; we have a prototype designed accordingly to the measurements that the anthropometric results showed us.

4. BIBLIOGRAPHY.

El tao de la salud, el sexo y la larga vida (en papel), Daniel Reid Urano (2014), Uranus pubñishing, 512 pages.

Gastroenterology, Henry L. Bockus (1985), Saunders editorial, 4730 pages.

El mejor medicamento eres tú, Frédéric Saldmann (2014), Aguilar editoril, 336 pages.

DESIGN OF EQUIPMENT FOR FURNACE SMELTING OF ALUMINUM CANS

Rigoberto Zamora Alarcón[1], Ana María Castañeda[2], Eddna Teresa Valenzuela Martínez[3], Mario Abel Padilla Navarro[4], Leobelinda Valdez [5]

[1]Universidad Autónoma de Baja California
Blvd. Benito Juárez S/N CP 21280 Mexicali, B.C.
zamora@uabc.edu.mx

[2-3]Universidad Autónoma de Baja California
Blvd. Benito Juárez S/N CP 21280 Mexicali, B.C.

[4] Advisor of companies

[5] Medicine of the work

Resumen: Los alumnos de ingeniería mecánica de la facultad de ingeniería, desde diciembre de 2015, diseñan, construyen y utilizan hornos para fundición de latas de aluminio.

Los hornos tenían exposición a humos de fundición de aluminio y posturas con riesgos al preparar, operar y cargar el crisol lleno de aluminio fundido. A los operadores se les aplicaron entrevistas, medidas antropométricas, evaluación de postura y manipulación de cargas con métodos ergonómicos. A las estaciones de trabajo se realizaron mediciones de condiciones ambientales de trabajo conforme a normas mexicanas.

Se rediseñaron accesorios y equipos del horno, basados en principios de ergonomía, lo cual permitió posturas de operación y manipulación confortables, disminuir condiciones de operación inseguras y exposiciones a gases de fundición de aluminio. Como resultados se logró aumentar la producción debido a que se diseñaron estaciones de trabajo bajo el principio ergonómico.

Palabras clave: Diseño de accesorios para hornos, fundición de latas de aluminio, humos de fundición de aluminio.

Abstract: Mechanical engineering students of Engineering Faculty, since December 2015, design, build and use furnaces for melting aluminum cans.

The ovens had exposure to aluminum melting fumes and risky postures when preparing, operating and loading the crucible filled with molten aluminum.

Operators were interviewed, anthropometric measures, posture evaluation and load manipulation using ergonomic methods. Measurements of environmental working conditions were carried out to the work stations in accordance with Mexican regulations

Accessories and equipment of the oven were redesigned, based on ergonomic principles, which allowed for comfortable operation and handling postures, reduce unsafe operating conditions and exposures to aluminum melting gases. As a result, it was possible to increase production due to the design of workstations under the ergonomic principle

Key words: Design accessories for furnaces, smelting of aluminum cans, aluminum smelter fumes

Contribution to ergonomics: Efficiency can be increased in the production of cast aluminum, to design an operation on ergonomic conditions.

1. INTRODUCTION

Mechanical engineering students of Engineering Faculty, since December 2015, design, build and use furnaces for melting aluminum cans.

The ovens had exposure to aluminum melting fumes and risky postures when preparing, operating and loading the crucible filled with molten aluminum.
Interviews, anthropometric measurements, measurement of working environmental conditions were evaluated stance and handling of loads.

To reduce and eliminate conditions of operation, were designed and redesigned accessories and equipment of the oven, based on principles of ergonomics which allowed positions for comfortable operation and handling that allowed increased production of cast aluminum.

2. OBJECTIVE

Design auxiliary equipment to operate furnaces and manipulate cast aluminum cans, through ergonomic approaches, to reduce risk positions, improve working conditions and facilitate the production

3. METHODOLOGY

Assessment of environmental conditions of operation in compliance with Mexican regulations NOM-10 (STPS,2014) y NOM 85 (SEMARNAT, 2011), with RULA, Suzanne Rodgers and OKRA methods were evaluated positions of furnace operation, was evaluated the handling of loads of melted material, anthropometric measurements were performed to operators, applied process reengineering and design of workstation

Anthropometry and dimensions of equipment

Table 1, shows the anthropometric measurements of furnace operators (Avila, 2007), to design the respective dimensions in the oven design. (Becker.J), (*Lista de comprobación ergonómica*, 2001).

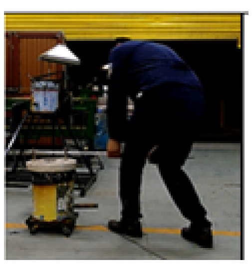
Table 1 Anthropometry of furnace operators

Descripción Antropométrica		Percentiles (mm)		
		P_{05}	P_{50}	P_{95}
2	Estatura	1665	1730	1794
3	Altura de ojo	1540	1619	1699
4	Altura de hombro	1345	1416	1487
5	Altura de codo flexionado	1044	1107	1169
7	Altura a la rodilla	487	515	542
8	Alcance de brazo frontal	698	777	857
10	Profundidad de tórax	188	266	344
15	Anchura codo -codo	333	375	416
16	Anchura de la mano	89	100	112
17	Longitud de la mano	169	181	192
18	Longitud de la palma de la mano	89	97	105
20	Longitud de pie (zapato)	219	269	318
21	Anchura de pie (zapato)	101	108	114
33	Perímetro de la cabeza	531	566	600
34	Anchura de la cabeza	148	155	163
35	Profundidad de la cabeza	181	196	212

Ergonomic analysis methods

RULA method. Table 2 shows the results of the first oven designed by students, with a final score 7 RULA and a level of risk 2, which required an analysis and immediate change in its design, to open and close the oven and take the Crucible

Table 2. RULA method for analysis of open and close oven

METODO RULA. Abrir y cerrar Horno			
	GRUPO A. Análisis brazo, antebrazo y muñeca		GRUPO B. Análisis del cuello, tronco y pierna
Puntuación de Brazo (1-6)	3	Puntuación del cuello (1-6)	4
Puntuación de antebrazo (1-3)	2	Puntuación del tronco (1-6)	4
Puntuación de la muñeca 1-4)	4	Puntuación de las piernas(1-2)	2
Puntuación giro de muñeca (1-62)	1	Puntuación del tipo de actividad muscular (Grupo B) (0-1)	0
Tipo actividad muscular (Grupo A) (0-1)	1	Puntuación de carga/Fuerza (Grupo B) (0-3)	1
Puntuación carga/Fuerza (Grupo A) (0-3)	1		
NIVELES DE RIESGO Y ACTUACIÓN			
Puntuación Final RULA (1-7)	**7**		
Nivel de Riesgo (0-4)	**4**		
Actuación	**Se requiere análisis y cambios de manera inmediata**		

Suzanne Rodgers method. Table 3 shows the result of the first furnace designed by students, with assessments ranging from 9 high, to moderate only in neck with 6, open and close the oven. However taking the Crucible, shows low assessment with a score of 3 and 4.

OCRA method. Table 4, shows the result of the first furnace designed by students, with an index of risk and valuation of 14, for both hands when opening and closing the oven, which is not acceptable level light, risk assessment scale marks from 11.1 to 14.

Table 4, also shows the result when taking the Crucible, with indexes of risk and assessment of 23 for right hand and left hand 19, are not acceptable in high level and medium respectively

Table 3. SUE Rodgers method to open and close oven, and take crucible with aluminium

Table 2 Table 4

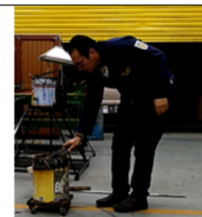
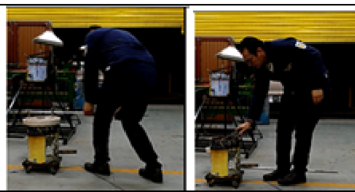
MÉTODO SUE RODGERS. Tapar y destapar Horno						Tomar crisol				
	Esfuerzo	Duración	Por minuto	Puntaje	Evaluación	Esfuerzo	Duración	Por minuto	Puntaje	
Cuello	2	2	2	6	Moderado	2	1	1	3	Bajo
Hombro	3	2	2	9	Alto	3	1	1	4	Bajo
Espalda	3	2	2	9	Alto	3	1	1	4	Bajo
Brazo y Codo	3	2	2	9	Alto	3	1	1	4	Bajo
Muñeca, mano, dedo	3	2	2	9	Alto	3	1	1	4	Bajo
Piernas y Tobillos	3	2	1	9	Alto	3	1	1	4	Bajo

Table 4. OCRA method for analysis of open - close the oven and take Crucible

METODO OCRA.	Abrir y cerrar horno		Tomar crisol aluminio	
	Derecha	Izquierda	Derecha	Izquierda
Tiempo de recuperación insuficiente	10	10	10	10
Frecuencia de movimientos	4.5	4.5	2.5	2.5
Aplicación de Fuerza	10	4	24	16
Hombro	1	24	2	24
Codo	0	8	2	8
Muñeca	2	2	2	2
Mano-dedos	2	4	8	4
Estereotipo	1.5	1.5	1.5	1.5
Posturas Forzadas	3.5	25.5	9.5	95.5
Factores de riesgo complementario	0	0	0	0
Factores duración	0.5	0.93	0.5	0.5
Índice de Riesgo y Valoración	Der.	Izq.	Der.	Izq.
Índice de Riesgo	**14** No aceptable nivel leve	**14** No aceptable nivel leve	**23** No aceptable nivel Alto	**19** No aceptable nivel medio
Escala de valoración del riesgo	11.1-14 No aceptable nivel leve	11.1-14 No aceptable nivel leve	≥ 22,5 No aceptable nivel alto	14.1-22.5 No aceptable nivel medio

4. RESULTS

1. The figure 1, shows dimensions of oven designed, as Anthropometry of operators and handling of gases (Lista de comprobación ergonómica, 2001), (Ávila, 2007).

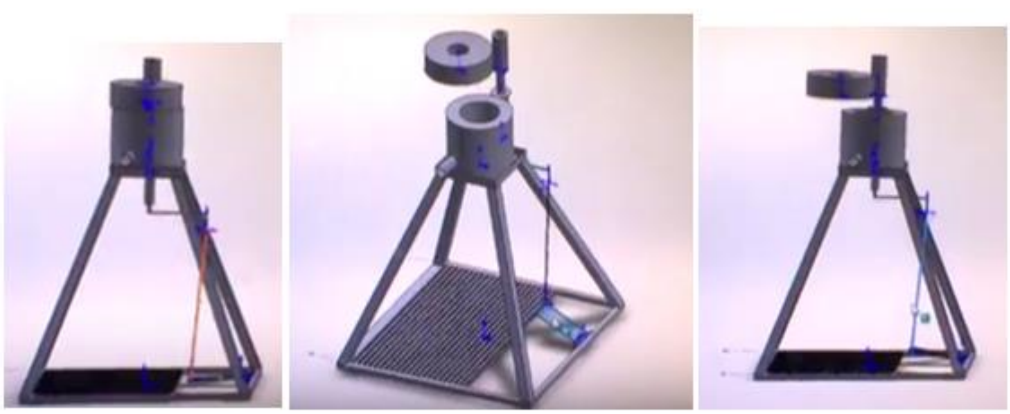


Figura1 Dimensiones Horno

2. Tables 5, 6, 7 and 8 show the results before and after design in each of the methods of evaluation, which range from 50% to 80% in final rates
3. The tables show improvements in positions of operation and cargo handling in neck, back, shoulder and arms, with design of Figure 1 oven, as shown in the attached pictures to tables 6, 7 and 8
4. Decreased exposure to aluminum smelter gases, replace pump as shown in the photographs of the tables 6, 7 and 8
5. Decreased unsafe conditions, to open and close oven, as well as to the crucible with molten aluminum
6. Increase the production of cast aluminum, to reduce time to open and close oven, take crucible in a more comfortable position, in both actions previously caused poisoning in operator, inhaling fumes from the molten metal directly

Table 5. RULA method for analysis of result of improvement in open and close oven

METODO RULA. Abrir y cerrar Horno			
GRUPO A. Análisis brazo, antebrazo y muñeca	Antes	Después	Mejora
Puntuación de Brazo (1-6)	3	1	33.3 %
Puntuación de antebrazo (1-3)	2	1	33.3 %
Puntuación de la muñeca 1-4)	4	1	75 %
Puntuación giro de muñeca (1-6)	1	1	0 %
Tipo actividad muscular (Grupo A) (0-1)	1	0	50%
Puntuación carga/Fuerza (Grupo A) (0-3)	1	0	33.3 %
GRUPO B. Análisis del cuello, tronco y pierna	Antes	Después	Mejora
Puntuación del cuello (1-6)	4	2	50 %
Puntuación del tronco (1-6)	4	1	75 %
Puntuación de las piernas(1-2)	2	2	0 %
Puntuación del tipo de actividad muscular (Grupo B) (0-1)	0	0	0 %
Puntuación de carga/Fuerza (Grupo B) (0-3)	1	0	33.3 %
NIVELES DE RIESGO Y ACTUACIÓN	Antes	Después	Mejora
Puntuación Final RULA (1-7)	**7**	**3**	**57 %**
Nivel de Riesgo (0-4)	**4**	**2**	**50 %**
Actuación que requiere	**Cambio inmediato**	**Evaluar detalladamente y Posibles cambios**	

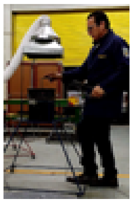
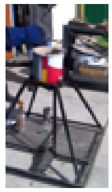
Table 6. SUE Rodgers for analysis of the result of improvement in open and close oven

Tapar y destapar Horno										
	Antes				Después					Mejora
	Esfuerzo	Duración	Frecuencia	Puntaje	Esfuerzo	Duración	Frecuencia	Puntaje	Evaluado	
Cuello	2	2	2	6	1	1	1	1	Bajo	50%
Hombro	3	2	2	9	1	1	2	1	Bajo	80%
Espalda	3	2	2	9	1	1	1	1	Bajo	80%
Brazo y Codo	3	2	2	9	1	1	2	1	Bajo	80%
Muñeca, mano, dedo	3	2	2	9	1	1	2	1	Bajo	80%
Piernas y Tobillos	3	2	1	9	1	1	2	1	Bajo	80%

Table 7. SUE Rodgers for analysis of the result of improvement in taking crucible

Tomar crisol con aluminio										
	Antes				Después					Mejora
	Esfuerzo	Duración	Frecuencia	Puntaje	Esfuerzo	Duración	Frecuencia	Puntaje	Evaluado	
Cuello	2	1	1	3	1	1	1	1	Bajo	20%
Hombro	3	1	1	4	1	1	1	1	Bajo	30%
Espalda	3	1	1	4	1	1	1	1	Bajo	30%
Brazo y Codo	3	1	1	4	2	1	1	3	Bajo	10%
Muñeca, mano, dedo	3	1	1	4	3	1	1	4	Bajo	0%
Piernas y Tobillos	3	1	1	4	1	1	1	1	Bajo	30%

Table 8. OCRA method for analysis of result of improvement in open and close oven

Abrir y cerrar Horno  	**Antes**		**Despuès**			
	Derecha	Izquierda	Derecha	Izquierda	**Mejora**	
Tiempo recuperación insuficiente	10	10	10	10	0%	0%
Frecuencia de movimientos	4.5	4.5	0	0	450%	450%
Aplicación de Fuerza	10	10	2	0	80 %	100%
Hombro	1	1	1	1	0%	0%
Codo	0	0	0	0	0%	0%
Muñeca	2	2	2	0	0%	200%
Mano-dedos	2	2	2	0	0	200%
Estereotipo	1.5	1.5	0	0	150	150
Posturas Forzadas	3.5	3.5	**2**	**1**	**43**	**71.4**
Factores de riesgo complementario	0	0	**0**	**0**	**0**	**0**
Factores duración	0.5	0.5	**0.5**	**0.5**	**0**	**0**
Indice de Riesgo y Valoración	Derecha	Izquierda	Derecha	Izquierda	Der.	Izq.
Indice de Riesgo	**14** No aceptable nivel leve	**14** No aceptable nivel leve	**7** Aceptable	**5.5** Aceptable	**50%**	**60.7%**
Escala de valoración del riesgo	11.1-14	No aceptable nivel leve	Hasta-7.5	Aceptable		

5. CONCLUSION

Once evaluated physical ergonomic factors in cast aluminum kilns, missing accessories were to improve the conditions of operation

1. Base oven has been designed to achieve the principles of neutral positions of work at elbow level, allowing for better comfort
2. Actuator has been designed with foot-operated mechanism, to open oven while you are handling the Crucible, which remove having to load the initial design cover
3. Design table of discharge at the level of the process of extraction, arms and back just below elbow
4. Design system of extraction of gases of casting of aluminum, which allowed approach is to take and load Crucible, with arms loaded more near body
5. Intermediate base between melting pot and coal oven, has been designed to eliminate coal in each wash preparation
6. Could increases the production stations working with ergonomic principles in designing

6. REFERENCES

Ávila, R., Prado L. y González E. (2007), *Dimensiones antropométricas de población latinoamericana*, Universidad de Guadalajara

Becker J. *Plan Integral para el desarrollo del proceso ergonómico de la industria*.

ERGON *Lista de comprobación ergonómica* (2001).- *Ergonomic Checkpoints*, Soluciones prácticas y de sencilla aplicación para mejorar las seguridad, la salud y las condiciones de trabajo, Oficina Internacional del Trabajo – Asociación Internacional de Ergonomía

SEMARNAT, (2011). *NOM-85-SEMARNAT-2011*, Contaminación atmosférica – Niveles máximos permisibles de emisión de los equipos de de combustión de calentamiento indirecto y su medición.

STPS, (2014). NORMA OFICIAL MEXICANA NOM-10-STPS-2014, Agentes químicos contaminantes del ambiente laboral- Reconocimiento, evaluación y control.

ERGONOMIC EVALUATION OF ORTHOPEDIC MECHANISM FOR PATIENT CARE

Luis G., Bermúdez[1], Araceli, Vázquez[2], Ubaldo, Gil[1], Leonardo, Córdoba[1] and Hugo, Silva[1]

. [1]*Industrial engineer*
Interdisciplinary Professional Unit Engineering Campus Guanajuato
Av. Mineral de Valenciana No. 200
Fracc. Industrial Puerto Interior, Silao de la Victoria, Guanajuato. C.P. 36275.
lgbermudez@ipn.mx

[2]*Engineering in Logistics and Transport*
Polytechnic University of the Bicentennial
Silao-Romita Km 2
Col. San Juan de los Durán
Silao de la Victoria, Guanajuato, C.P. 36283.

Resumen: En 2010 el porcentaje de la población nacional con discapacidad motriz ocupó el 58.3%, seguida de la discapacidad visual con 27.2%. Se calcula que la incidencia anual de paraplejia provocada por lesiones medulares en México es de 18.1 por millón de habitantes y ocurre con más frecuencia en hombres en edad productiva (16 a 35años de edad). Esta situación nacional se agrava ya que los servicios de atención hospitalaria y cuidados del paciente son insuficientes, además de presentar efectos colaterales en los profesionales de la salud como enfermedades y accidentes ocupacionales en el manejo y traslado de pacientes. Las lesiones musculo-esqueléticas que presentan los fisioterapeutas no sólo se debe a que un gran número de profesionales no practica asiduamente los cuidados ergonómicos que conoce, sino que hay otros factores como los diseños inadecuados de los lugares de trabajo, la falta de ayudas mecánicas y equipos, y una deficiente gestión de los factores organizativos del trabajo (distribución de descansos, horarios, rotación de tareas…) que influyen en su aparición. Así mismo, el incremento en el número de pacientes a tratar por los servicios de fisioterapia ha originado un aumento en el ritmo de trabajo que ha multiplicado los movimientos repetitivos, actividades físicas intensas y sobreesfuerzos realizados por el personal.

El estudio de la presente investigación comprendió el diseño ergonómico de un mecanismo ortopédico para el aseo de pacientes con capacidad de carga hasta 170 kg, facilitando el aseo del paciente al hacerlo girar 180 grados sobre su asiento, ajuste de altura entre 50 y 95 cm y cabecera ajustable. El estudio primeramente, contempló la traducción de las necesidades de los pacientes a especificaciones de diseño mediante la metodología Blitz QFD, en una segunda etapa, se realizó el estudio antropométrico con 80 pacientes de la tercera edad y/o con discapacidad motriz, el diseño consideró el percentil 90 de la población medida. En la tercera etapa se simuló la operación de la silla ortopédica con el software SolidWorks. Posteriormente se evaluó la manipulación manual de cargas mediante el método GINSHT con la finalidad de evitar trastornos músculo-esqueléticos que afectan a la espalda. El estudio de BIOMECÁNICA se empleó en la evaluación de posturas y esfuerzos puntuales de corta duración, así como esfuerzos estáticos y esfuerzos que se repiten con una frecuencia inferior a una vez cada 5 minutos. Finalmente con el método OWAS se valora la carga física derivada de las posturas adoptadas por el terapeuta o enfermero durante la actividad de baño.

Palabras clave: Mecanismo ortopédico, NISHT, OWAST y QFD.

Abstract: In 2010, the percentage of the national population with motor disabilities occupied 58.3%, followed by visual impairment with 27.2%. The annual incidence of paraplegia caused by spinal cord injury in Mexico is estimated at 18.1 per million inhabitants and occurs more frequently in men of productive age (16 to 35 years of age). This national situation is aggravated since the services of hospital care and patient care are insufficient, in addition to presenting side effects on health professionals such as occupational accidents and diseases in the handling and transfer of patients. The musculoskeletal injuries presented by physiotherapists are not only due to the fact that a large number of professionals do not regularly practice the ergonomic care they know, but that there are other factors such as inadequate workplace designs, lack of mechanical aids and Teams, and a poor management of the organizational factors of work (distribution of breaks, schedules, rotation of tasks ...) that influence their appearance. Likewise, the increase in the number of patients to be treated by physiotherapy services has led to an increase in the work rate that has multiplied repetitive movements, intense physical activities and over-exertion performed by the staff.

The study of the present investigation included the ergonomic design of an orthopedic mechanism for the hygiene of patients with load capacity up to 170 kg, facilitating the patient's toilet by turning it 180 degrees on its seat, height adjustment between 50 and 95 cm and Adjustable headboard. The study first contemplated the translation of the patients' needs to design specifications using the Blitz QFD methodology; in a second stage, the anthropometric study was performed with 80 elderly patients and / or with motor disability, the design considered The 90th percentile of the population measured. In the third stage the operation of the orthopedic chair with the software SolidWorks was simulated. Subsequently, the manual manipulation of loads was evaluated using the GINSHT method in order to avoid musculoskeletal disorders that affect the back. The study of BIOMECHANIC was used in the evaluation of postures and punctual efforts of short duration, as well as static efforts and efforts that are repeated with a frequency less than once every 5 minutes. Finally, the OWAS method evaluates the physical load derived from the postures adopted by the therapist or nurse during the bathing activity.

Keywords: Orthopedic Mechanism, NISHT, OWAST and QFD

Contribution to Ergonomics: The analysis of the design shows the application of ergonomic analysis methods to validate the prototype in the area of physical therapy and improve working conditions.

1. INTRODUCTION

In 2016 the research project "Orthopedic Mechanism for Patient Care" is developed, with the aim of improving the management and bathing activity of patients with motor disabilities. Since currently the mechanisms and implements commonly used in such activities lack considerations such as facilitating the patient's toilet by turning it 180 degrees on its seat, adjustment of height and inclination, adjustable headrest, support in feet, safety belt, in addition to retract And mating on wall. So it is decided to design and manufacture with ergonomic criteria the equipment mentioned.

Alternately, we work on the development of a technology-based company, in the manufacturing sector oriented to the design and manufacture of equipment for orthopedic use such as shower chairs and transfer cranes, contributing to the reduction of occupational diseases by the management of patients ; As well as greater autonomy for the patient. The project develops technological solutions focused on meeting the needs of patients with motor disabilities such as: Diplejía, Paraplejia, Cuadriplejia or tetraplejia, Hemiplejia and Monoplejía.

The project intends to market an orthopedic device for the cleaning of patients with load capacity up to 170 kg, capable of facilitating the patient's hygiene through its ergonomic design with international quality characteristics, as well as benefits of at least 20% in reducing costs Operation and maintenance by incorporating first generation composites.

Currently, 3 people are expected at the pilot level and in the medium term, they expect to generate sources of paid employment in the region for vulnerable groups in our society, such as single mothers, mothers, elderly people and others.

Among the alternatives to solve the problem is the ergonomic design of the work station applied to equipment, furniture and tools (chairs, stretchers, stools, material carts, scissors ...), as well as spaces (compartments, Areas of passage, gymnasium ...) and to the environmental environment (lighting, ventilation, noise and temperature), favoring the comfort in the work positions and avoiding the overheads during the execution of the tasks.

Patient transfer and handling teams consider it comfortable to achieve, with the aim of avoiding unnecessary forced postures: stretching the arms too much, lifting them over the shoulders, twisting the trunk, and so on. It is advisable that the height of the equipment oscillate between 50 and 95 centimeters so that it can adapt to the work plan of the physiotherapist, according to its height, and avoid generating postures of flexion of neck, trunk and arms. Have supports to support the arms, legs or feet of patients. These elements are very useful for physiotherapists because they allow them to act on the foot for example, without the need for the worker to support it.

Therefore, the proposed mechanism helps to meet the needs of patients with motor disabilities such as: Diplegia, paraplegia, quadriplegia or tetraplegia, hemiplegia and monoplegia by means of an orthopedic shower chair, helping disabled patients and / or the elderly to perform Shower activity properly. The orthopedic mechanism for patient hygiene has a load capacity up to 170 kg, capable of facilitating the patient's toilet by turning it 180 degrees on its seat, height adjustment and inclination, adjustable headrest, support in feet, seatbelt, in addition To retract and engage on the wall.

It has an ergonomic product, with international quality features, plus benefits of at least 20% in reducing operating and maintenance costs by incorporating first generation composites.

2. GENERAL OBJECTIVE

Design and manufacture an orthopedic device for patient care that allows adequate performance of the shower and improves the quality of life of patients with motor disabilities.

3. SPECIFIC OBJECTIVES

1. Design an orthopedic device for patient hygiene using the Blitz QFD methodology with a maximum load capacity of 170 kg, facilitating the patient's toilet by turning it 180 degrees on its seat, height adjustment between 50 and 95 cm and adjustable headrest.

2. To develop the anthropometric study with 80 elderly patients and / or with motor disabilities in order to characterize the study population and to establish design criteria with the 90th percentile of the population measured.

3. Simulate design with SolidWorks software.

4. Evaluate the manual manipulation of loads using the GINSHT, BIOMECHANIC and OWAS methods.

4. METHODOLOGY

In the first stage, through the Blitz QFD methodology, the client's voice (therapists, patients and relatives) was translated to design the components of the orthopedic mechanism for the patient's grooming. The sample size was 120 patients with mobility and displacement problems, the survey included 15 questions and 2 replicates to know the needs of the client.

In the second stage, the anthropometric study was performed with 80 elderly patients and / or with motor disability, with the intention of characterizing the study population. With this information the orthopedic chair was designed considering the 90th percentile of the population measured, hygienic techniques in the management of the patient, applicable normativity; As well as security systems for proper operation.

In the third stage, the operation of the crane was simulated using the SolidWorks software and the stress analysis was performed on the structure using finite elements (ANSYS).

The manual manipulation of loads is then evaluated using the GINSHT method in order to avoid musculoskeletal disorders that affect the back. The study of BIOMECHANIC was used in the evaluation of postures and punctual efforts of short duration, as well as static efforts and efforts that are repeated with a frequency less than once every 5 minutes. Finally, the OWAS method evaluates the physical load derived from the postures adopted by the therapist or nurse during the bathing activity.

5 RESULTS AND DISCUSSIONS.

5.1 Obtain the voice of the client.

First, a Customer Segmentation Table (TSC) was developed to identify clients of the orthopedic chair under different scenarios.

5.2 Structure customer needs.

At this stage, the actual needs of clients were extracted from the verbalizations by a second review by a group of therapists from the Irapuato DIF.

5.3 Analyze and prioritize Customer Needs.

The dependency ratios between needs were determined as shown in Table 1

Table 1. Needs dependency relationships

																	IMPORTANCIA (1–5)	V. COMPETITIVA 1	2	3	4	5
Costo	Disponivilidad	Bajo precio	★	★	★	★	Δ	Δ	Δ	Δ	Δ	●	★	●	●	●	1		A		B	
		Diferentes precios	Δ	★	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	●	★	Δ	●	2		A	B		
Diseño	Innovador.	Que sea electrico	★	★	★	★	Δ	Δ	Δ	●	●	Δ	Δ	Δ	Δ	Δ	2	AB				
		Que sea práctica	★	●	●	★	Δ	Δ	Δ	●	●	Δ	Δ	●	Δ	Δ	3		AB			
		Que sea segura	●	Δ	Δ	Δ	★	Δ	Δ	●	Δ	Δ	Δ	Δ	Δ	Δ	3		AB			
		Área para lavado anal	Δ	Δ	Δ	Δ	Δ	★	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	4		A			B
		Diversas posiciones del paciente	Δ	Δ	Δ	Δ	Δ	Δ	★	Δ	Δ	Δ	●	●	Δ	●	3			A		B
	Ergonomico	Buen diseño del Arnés	★	Δ	Δ	Δ	★	Δ	Δ	★	Δ	Δ	★	●	Δ	Δ	4		AB			
		Buen diseño (descanza brazos) Que permita bañar al paciente	Δ	Δ	Δ	Δ	★	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	4		AB			
		Que el usuario no se lastime al subir al paciente	Δ	●	★	●	★	Δ	Δ	●	Δ	Δ	Δ	Δ	Δ	Δ	5	AB				
		Que esté a la altura del terapeúta	●	Δ	Δ	Δ	Δ	Δ	Δ	Δ	★	Δ	Δ	Δ	Δ	Δ	3		AB			
		Evitar que el paciente se lastime	Δ	●	★	●	Δ	Δ	Δ	●	●	●	Δ	Δ	Δ	Δ	5	AB				
	Fácil manejo.	Pueda plegar	Δ	●	Δ	Δ	Δ	Δ	★	Δ	Δ	★	Δ	●	Δ	Δ	2		A			B
		Facil de maniobrar	Δ	●	★	Δ	Δ	●	●	★	Δ	★	Δ	Δ	Δ	●	2		AB			
Material	Propiedades	Resistente	★	★	★	★	●	●	★	Δ	Δ	Δ	★	Δ	★	★	3		AB			
		Ligero	★	★	★	★	Δ	Δ	Δ	Δ	Δ	Δ	★	★	★	Δ	3	A		B		
		Durable	★	●	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	★	★	★	★	5		AB			

5.4 Anthropometric study

Once the clients or users of the chair were identified, the anthropometric study was performed in patients with lower limbs disability. The study population was characterized by age, gender and disease. The design considered the 90th percentile of the population measured, applicable regulations and safety criteria in their systems for proper operation. A group of 120 patients with mobility and displacement problems was interviewed in the Irapuato DIF, the survey consisted of 15 open questions to know the needs of the client. The questions were asked twice (2 replicates) to ensure that the patient was clear about what he was wondering, later the verbalizations were recorded electronically.

The characteristics of the study population are presented below:

1. 120 patients of the DIF-Irapuato
2. Age between 31 and 74 years
3. Size 1644 to 1746 mm
4. Weight 66.8 to 120 kg
5. 90% men and 10% women
6. 80% diabetics
7. Middle-low socio-economic level

Body mass index from 24.4 to 31.7

Conditions: Amputation of limbs, loss of mobility, quadriplegia, Paraplegia, Marrow fracture, Pelvic
fracture and spinal cord injury T9 and T10.

5.5 Measurement conditions

Measurements were made at the Irapuato DIF for people with disabilities, with adequate safety, lighting and cleaning conditions. The patients were measured in 2 positions: In the recumbent position, the patients were placed in a flat horizontal bed, without shoes with the head facing the front in the Frankfort plane, relaxed shoulders and both at the same height, extended arms On the sides of the body, hands resting on the bed; The heels united and the tips of the feet separated 45 degrees between both. In the sedentary posture, the patients were placed in their wheelchair, with the trunk erect preserving the normal curvature of the spine, head oriented to the Frankfort plane; Relaxed shoulders and horizontal line; Arms flaccid on both sides of the body and hands resting on the first third of the thighs; The thighs forming a right angle with the trunk and with the popliteal zone separated, a few centimeters from the edge of the seat; Legs forming a 90 degree angle with thighs; Adjusting the height of the chair; Feet completely resting on the saddle supports trying to keep the trunk-thigh-leg and foot alignment. Measurements were performed between 2 people, the therapist assisted in placing the patient in the appropriate positions to take the measurements.

5.6 Design of the prototype

Finally the dimensions of the chair in different profiles are shown, as well as the anthropometric measurements obtained.

It can be observed that in the images of the anthropometric study advance they show three measurements which are supposed to be the corresponding measurements at the percentiles 5, 50 and 95 respectively, of which the 50th percentile will be taken as reference for comparison with the measurements Of the chair, this in order to take into account the average of the measurements of the anthropometric study.

5.6 Design of the prototype

Finally the dimensions of the chair in different profiles are shown, as well as the anthropometric measurements obtained.

It can be observed that in the images of the anthropometric study advance they show three measurements which are supposed to be the corresponding measurements at the percentiles 5, 50 and 95 respectively, of which the 50th percentile will be taken as reference for comparison with the measurements Of the chair, this in order to take into account the average of the measurements of the anthropometric study.

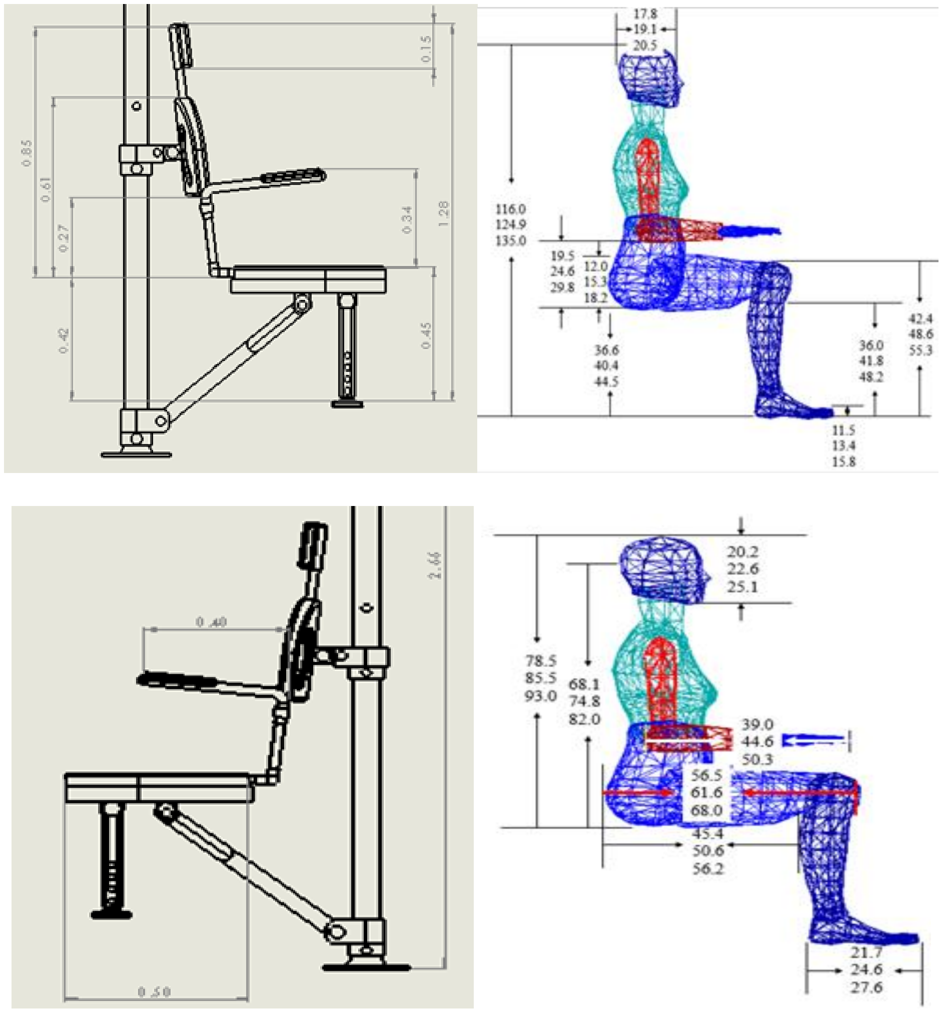


Fig.2. Views of the orthopedic chair vs anthropometric measures

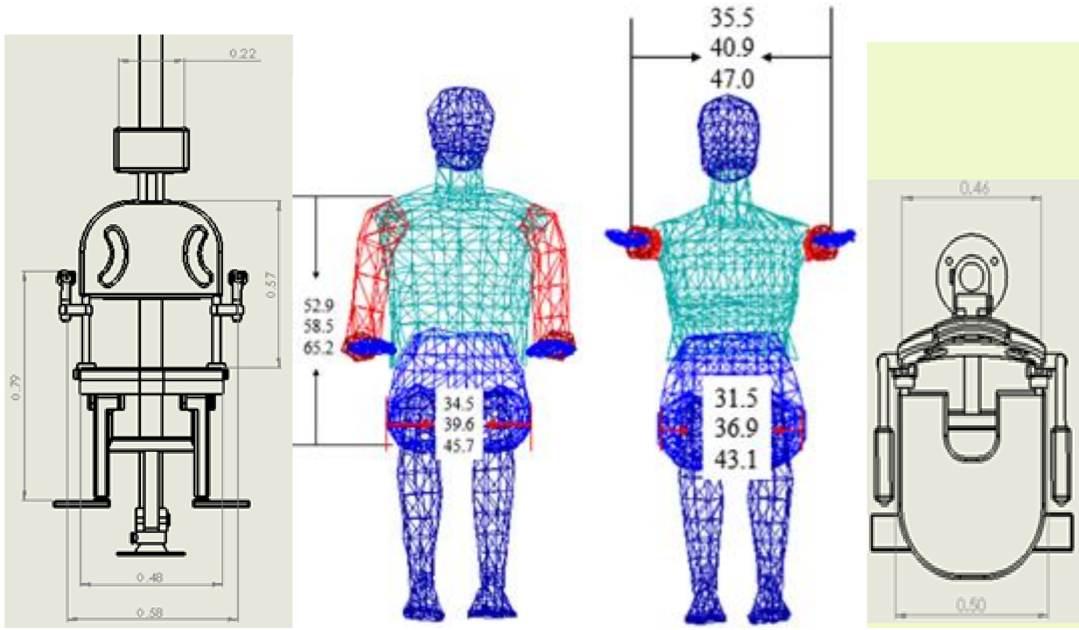


Fig.3. Views of the orthopedic chair vs anthropometric measurements.

Next, a comparative table of the dimensions of the orthopedic shower chair with respect to the measurements of the anthropometric study is shown, taking into account certain dimensions that are prioritized to guarantee the ergonomics of the model of the orthopedic shower chair (the dimensions are in meters).

Table 2.Anthropometric Measurement

Medida	**Silla**	**Estudio**	**Diferencia**
Altura del asiento a los pies	0.450	0.418	0.032
Altura del asiento trasero a los pies	0.420	0.404	0.016
Altura Espalda baja	0.270	0.153	0.117
Altura del antebrazo	0.340	0.246	0.094
Altura de la cabeza a los pies	1.280	1.249	0.031
Altura del respaldo	0.570	0.585	-0.015
Altura del asiento a la cabecera	0.850	0.855	-0.005
Longitud de la cabeza	0.150	0.226	-0.076
Longitud de antebrazo	0.400	0.446	-0.046
Longitud de asiento	0.500	0.506	-0.006
Amplitud de asiento	0.480	0.396	0.084
Amplitud de brazos	0.500	0.409	0.091
Ancho de la cabeza	0.220	0.143	0.077
Ancho del respaldo	0.460	0.312	0.148

As can be seen the difference between the dimensions taken is relatively small in most of the measures that were taken into account, although it could be said that from 0.10 to 0.15 meters the difference is already remarkable, this can be justified in That the dimensions of the chair in some measures have clearance, that is, the dimension of the chair is greater than the size of the body, this is due to variations that may exist in the dimensions of the patient's body, since each patient is Unique in terms of body dimensions, that is why it is worked that the dimensions of the chair are attached to the standard dimensions that were obtained from the anthropometric study, ensuring that the proposed model of the chair is ergonomically acceptable for patients from the Mexican territory with a Age range from 17 to 54 years old and up.

The orthopedic shower chair as a technological development patented, maintains superior quality with respect to commercial products, since it contemplates load capacity up to 170 kg, able to facilitate the patient's cleanliness since the therapist can make it rotate safely 180 degrees on its Seat, height and tilt adjustment providing comfort for the patient, rests safety arms, seat belt, adjustable headrest, feet support. The back has holes to prevent water accumulation, in addition to retraction and mating on the wall. It has an ergonomic product, with international quality features, plus benefits of at least 20% in reducing operating and maintenance costs by incorporating first generation composites.

OWAS (Ovako Working Analysis System)

To apply the method of OWAS are marked a series of steps to follow, below is shown a table where these steps will be answered.

Application of the Method	
Steps	Orthopedic Chair
1. Determine whether the task is divided into phases	Simple Evaluation
2. Set the total observation time	4 minutes
3. Determine frequency of observation.	Every 15 seconds
4. Record postures.	6 different positions
5. Coding Positions	4-digit code based on tables
6. Calculate risk category of each posture	Based on the estimated code, in tables
7. Calculate the percentage of relative frequency of each position	How many times each position is repeated
8. Calculate risk category based on relative frequency	With help of established tables

Postures evaluated.

Ergonautas Results

Nº	Espalda	Brazos	Piernas	Carga	Frec.	Frec.Rel.(%)	Riesgo	
1	1	3	2	1	1	14,29	1	x
2	3	3	2	1	2	28,57	1	x
3	2	2	2	1	1	14,29	2	x
4	2	1	4	1	1	14,29	3	x
5	2	1	2	1	1	14,29	2	x
6	2	2	3	1	1	14,29	2	x

GINSHT

Resultados generales

Peso Real	Peso Teórico Recomendado	Peso Aceptable
6 Kg	11 Kg	7,05 Kg
Peso real manipulado en el puesto	Peso máximo recomendado para la carga en función de la zona de manipulación, altura y separación respecto del cuerpo, en condiciones ideales de manipulación de cargas.	Peso máximo recomendado considerando las condiciones en que se produce el levantamiento. Es el resultado de corregir el peso teórico considerando las características del puesto analizado y la población a proteger.

Improvement in the method of management of finished product, reduction of work risk as a consequence of the improvement of the posture in the activity. Among the results of the work, we have the specifications and tolerances of each of the components of the orthopedic shower chair, as a result of the translation of the client's voice when using Blitz QFD methodology.

The anthropometric study helped characterize the elderly and disabled population that presents mobility and displacement difficulties in the city of Irapuato, Mexico.

By simulating the operation and assembly of each component of the orthopedic chair with solidWorks, ergonomic design errors were identified prior to manufacturing, helping to reduce time and cost.

The evaluation of ergonomic risks when using the shower chair, allowed to validate the feasibility of the prototype for commercialization.

The project favors the formation of research and technological development boards; As well as strengthens the research projects developed by UPIIG-IPN.

5. REFERENCES

González, B. & Tamayo, F. (2012.). Blitz QFD: Un Vistazo Relámpago al Poder del QFD. *Asociación Latinoamericana de QFD.*

Hertzberg, H. (1968). The conference on standardización of Anthropometric techniques and Terminology. *Ameer J Physical Anthropol*, Vol. 28, pp 1-15.

Gallego, T. (2007.). Bases Teóricas y Fundamentos de la Fisioterapia, *Editorial Médica Panamericana*, 350 p., Madrid, España.

Wilkinson, W., Salazar, M. y asociados (1992). Occupational injuries: a study of health care workers at a northwestern health science center and teaching hospital. *Aaohn Journal*; Vol. 40(6), pp 287-93.

Glover, W., McGregor, A. & Sullivan, C., (2005). Work related musculoskeletal disorders amongst therapists in physically demanding roles: qualitative analysis of risk factors and strategies for prevention. *BMC Musculoskelet Disorders*, Vol. 2011, pp 12-24.

González, R. & González, A. (2012). Cuadriplejia total secundaria a micetoma cervicodorsal. *Revista de Especialidades Médico-Quirúrgicas*, Vol. 17(2), pp. 137-140.

http://www.ergonautas.upv.es/

http://www.lacaja.com.ar/lacaja/ART/files/content/ManErgonomia2.pdf

https://books.google.com.mx/books?hl=es&lr=&id=Jr4FIRQnVqQC&oi=fnd&pg=PP1&dq=Introduction+to+Ergonomics&ots=QnDd8kw7YY&sig=1ueQjt2JYWEvazfRM4INE6TyuiI#v=onepage&q=Introduction%20to%20Ergonomics&f=false

ERGONOMY IN THE DESIGN OF INDUSTRIAL TECHNOLOGICAL PROCESSES

Luis Enrique Soto Muciño, Raúl Reyes Reynoso, and Ramón Elizarrarás Baena

Instituto Politécnico Nacional, IPN.
Escuela Superior de ingeniería Mecánica y Eléctrica. ESIME, Unidad Azcapotzalco.
Ciudad de México. Av. de Las Granjas 682, 02250.
lsotom607@gmail.com

RESUMEN: La existencia humana está inmersa entre lo natural y lo artificial, porque evolucionamos transformando el entorno natural a través de elementos tecnológicos como artefactos, procesos de trabajo, materiales y diseño de puestos de trabajo no solo seguros y saludables, sino también funcionales, que han modificado el ambiente y Han dado como resultado un universo artificial. En este trabajo se presenta la importancia de la ergonomía en el diseño de procesos tecnológicos de trabajo, en los que interactúan los seres humanos, a través de un enfoque sistémico. Según Monterroza (2011), los seres humanos forman la compleja relación social, técnica y artefactual que ha esculpido las características más sobresalientes: lenguaje, moralidad, valores, creencias, racionalidad y la misma técnica y tecnología. Según Soto-Muciño (2016) un modelo que permite hacer operativa la noción de sistema tecnológico, es lo que se denomina práctica tecnológica, se define la práctica tecnológica, basada en la interacción de las siguientes categorías: patrones organizacionales, planificación, administración, culturales Aspectos, valores, códigos éticos y aspectos específicamente técnicos como habilidades, conocimientos, máquinas y equipos en general.

Palabras clave: Ergonomía, diseño, ingeniería, sistema.

ABSTRACT: Human existence is immersed between the natural and the artificial, because we evolve transforming the natural environment through technological elements such as artifacts, work processes, materials and designing jobs not only safe and healthy, but also functional, which have modified the environment and have resulted in an artificial universe. In this paper, the importance of ergonomics in the design of technological work processes, in which human beings interact, is presented through a systemic approach. According to Monterroza (2011) human beings form the complex social relationship, technical and artifactual that have carved out the most outstanding characteristics: language, morality, values, beliefs, rationality and the same technique and technology. According to Soto-Muciño (2016) a model that allows to make operative the notion of technological system, is what is called technological practice, technological practice is defined, based on the interaction of the following categories: organizational patterns, planning, administration, cultural aspects, values, ethical codes, and specifically technical aspects such as skills, knowledge, machines and equipment in general.

Keywords: ergonomics, design, engineering, system.

1. INTRODUCTION

Globalization has brought the constant need of companies to keep on competitive status, this competitiveness forces business organization to reduce their operating costs to a minimum, seeking to consolidate their operations more efficient and at the same time have optimal levels of quality and productivity with the purpose of keeping on the market. This pretension of competitiveness causes that companies are focused on results mainly and they are away from an orientation towards the human factor that interacts with the technological means of work in a company, which, according to Montano (2007) has given rise to inconsistent and abusive labor interactions. The relationship between the design of technological processes and productive ergonomics establishes a material culture designed to solve the needs and solve the problems that they face in the development of technological systems. Unfortunately, it is not commonly done and technological processes work in companies that do not fulfill the function for which they were projected, or even require the operator to adapt when there is no other possibility of operation.

2. INDUSTRIAL DESIGN

The word Industrial refers to the production system according to Gay and Samar (2007) of goods that, replacing the craftsmanship, was born with the Industrial Revolution, a historical process that developed in England in the late eighteenth and early nineteenth centuries, marking the beginning of mass production. In this respect, and as an exception, we can point out an antecedent, the books, which we can consider the first series production, but which for a long time was artisanal.

The word Design refers to the systematic preconception of form and other characteristics of the product, taking into account the social, technological, aesthetic, psychological, anatomical, physiological, etc., it means the creation of a model of it (plans, prescriptions, etc.), with all the details, before its realization. Blanco (1990) mentioned that should be clarified that when speaking of industrial design is generally used indiscriminately the concept of design, since it refers, on the one hand to the product made, it means the object of design and, on the other hand, the idea of design, ranging from the program to the intentions and needs of users. For his part Ricard (1982) design does not treat form by form, but defines it according to the utility that it has to make possible, it does not try to adorn the new technological artifacts, or make up the traditional objects, but aims to equip them with that peculiar configuration which will enable them to improve their useful function, that is to say:

their service and their relationship with the man, the form is the means by which the useful function of the material becomes possible.

3. SYSTEMIC APPROACH FOR THE DEVELOPMENT OF MECHANICAL PROJECTS

A project of technological development in a business organization has different purposes, one of them is that users or operators of these processes, interact with them in the best way, ergonomically, through functional controls. Due to its multi-causality and complexity characteristics that are present today, it is necessary to use systemic tools that facilitate and enhance the development of this type of technological solutions from the same industrial engineering context. In this sense, one of the main objectives pursued by organizations is to develop artefactual systems, according to the processes with the functions required for their implementation based on knowledge, skills, techniques and tools, that are at the forefront and that at the allowing them to develop complex technological devices, structures or processes. This is where the systemic approach has important contributions.

Rosell-Puig and Mas-Garcia (2003) state: "The content of a design must be structured with a systemic approach or set of related elements that constitutes a certain integral formation, with new characteristics not implicit in the components that they form it ". Applying the above to the engineering in man-machine systems, these characteristics are observed in their multidisciplinary form to synergistically combine knowledge, to analyze the relationship with the environment, for design, simulation and manufacture of models, including for the planning, generation and management of technological projects, which represent, as a whole, elements that are part of the process for obtaining a solution. In addition, the systemic approach contributes to the answer to the dichotomy that exists between the design of a project and the engineering design, integrating them into a single entity facilitating their understanding and realization. Technology can be defined as the systematic application of scientific knowledge to productive activities. In other words, it is the set of knowledge used in the production and commercialization of goods and services, materialized in machines and equipment and information about them (Valencia-Giraldo, 2004, p.160). The component elements of a system are integrated as a single unit, which interact through logical relationship channels in order to achieve a common goal. With respect to a complex system, it is characterized by the number of component elements and logical relations that make it up, that is, the greater the number of component elements in the system, the more complex it will be. This is the main reason why a system of this type presents a great dynamics in its internal transformation process, due to the high sum of interrelations between its high sum of interrelations between its components, as well as of the several states that it could present for his emerging collective behavior.

The integrated schematization of an open system, a closed system and a complex system is shown in Figure 1, where we can see the way in which they are represented, the difference that exists based on the relation they have with Its environment, and finally its behavior in terms of the number of elements-components and interrelations that simply represents its own complexity.

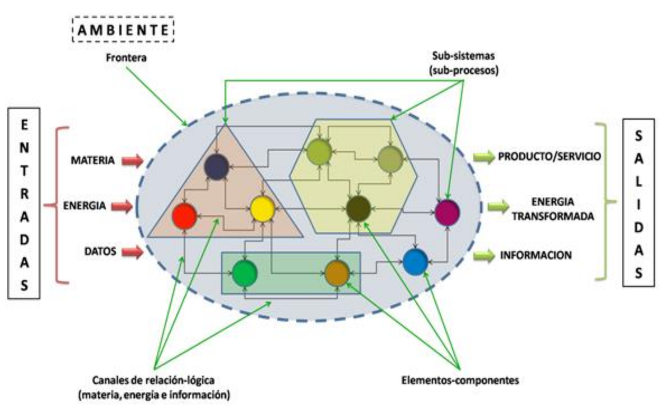
FIGURE 1. SYSTEM STRUCTURE OPEN, CLOSED AND COMPLEX.

Source: Reyes at. (2015).

The boundary of a system is established by its boundary, which may be physical or not. Outside of the system boundary is its environment. The environment is the environment that surrounds the system, it represents the environment where it is immersed. The environment is a source of resources and threats. This is also known as the environment or context (Ramírez, 2002, p.29).

Reyes et al, (2015) from the environment comes the inputs of a system. Inputs are usually represented by matter, energy and data. As a result of the logical interaction that exists between the component elements of a system, a process of transformation takes place within it, where the inputs of the system are transformed or actively involved in the process of transformation necessary to achieve the objective or purpose for which the system was designed (teleological attribute)

FIGURE 2. GENERAL STRUCTURE OF A SYSTEM.



Source: Reyes at. (2015).

A technological development, being a complex system, must be approached with suitable approaches, knowledge, methodologies and techniques to deal with this complexity. For this, the application of the General Theory of Systems (TGS) is very useful. The TGS is a theory with a unitary vision of the world, it has the purpose of modeling objects, natural or artificial, simple or complex in a systematic and scientific way of approximation and representation of reality, mainly related to forms of work, organizations and Interdisciplinary processes. TGS provides research capability to the systems approach. It investigates the concepts, methods and knowledge pertaining to the fields and systems thinking. In this context, the terms systems approach and applied general systems theory are used as synonyms (Van Gigch, 1993, p.50).

4. ERGONOMY IN THE PRODUCTION PROCESS

Ergonomics is currently a topic that deserves special attention in companies, mainly from managerial levels to operators, where not only must the worker be given the tools necessary for the development of his activities, but also analyze the conditions in which he works. The interaction with its machinery and tools; The environment, including factors such as temperature, noise, vibration; their ability to carry out a task. The postures and movements he performs; Labor relations; The mental burden, as well as their emotional and economic situation; Among others (Mondelo, Gregori, and Barrau, 1999).

This is why, to date, various studies and research concerning ergonomics have been developed, not to mention that its origin dates back to 1857, when the term was first used in the book Compendium of Ergonomics or science Of work based on truths taken from the nature of Wojciech Jastrzebowki (Mondelo et al., 1999). The traditional definition of the term ergonomics, typically refers to the study of the human body, equipment used and workplace environment, now also includes the interaction between the human body, objects and work environment (Tiraboschi et al, 2002). According to Gillette (2001) ergonomics is the science of designing work environments to ensure safety and efficiency, and notes that the new ergonomic standards try to prevent cumulative traumatic disorders. The International Labor Organization defines ergonomics as the application of human biological sciences to achieve the optimal and reciprocal adaptation of man and his work, whose benefits are measured in terms of human efficiency and well-being (Llaneza, 2004). Occupational ergonomics is the art and science of designing work according to each worker to achieve the optimum level of productivity, economic efficiency and minimum risk of injury (Manuelle, 2000).

In this article we propose the following conceptualization:

• The ergonomics in the design of technological processes, studies the relationship of people and the way of use in a productive process, for the adaptation of their characteristics in the workplace and the study of their own capacities of the operator or user.

Productive versus counterproductive behavior is included and produced according to Smith (2003) in response to a negative reaction to someone or something in the person's work environment. Anthropometry is the application to humans of physical-scientific methods for the development of design standards, specific requirements and for the evaluation of engineering designs, scale models and manufactured products, in order to ensure the adequacy of all them to the characteristics of the users (Llaneza, 2004). For López et al. (2012) it is important to emphasize that the anthropometric characteristics of the technology design

5. ERGONOMIC METHODOLOGY

Reyes (2016) component of a system can also be called sub-systems, in turn the subsystems are also composed of component elements of different hierarchical order. The boundary of a system is established by its boundary, which may be physical or not. Outside of the system boundary is its environment. The environment is the environment that surrounds the system, it represents the environment where it is immersed. The environment is a source of resources and threats. It is also known as the environment or context (Ramírez, 2002, p.29). From the environment or environment come the inputs of a system. Inputs are usually represented by matter, energy, and data.

FIGURE 3. TECHNOLOGY FOR THE DEVELOPMENT OF THE ORGANIZATION

Source: Soto-Muciño (2016).

According to Rescalvo and de la Fuente (2016), they argue that the conception of the place of human labor action is to conceive or form in the mind the idea of a certain job. Taking into account the characteristics that must be gathered, a priori, in relation to the people who will occupy it and the type of tasks that are going to perform. In short, it is a matter of projecting the idea of a certain job and making it a reality. CEPYME (2007) one of the most widespread models of analysis in the field of ergonomics is system-based. From this perspective the relationships between people, their environment and objects are relations between different subsystems. The system is spoken of:

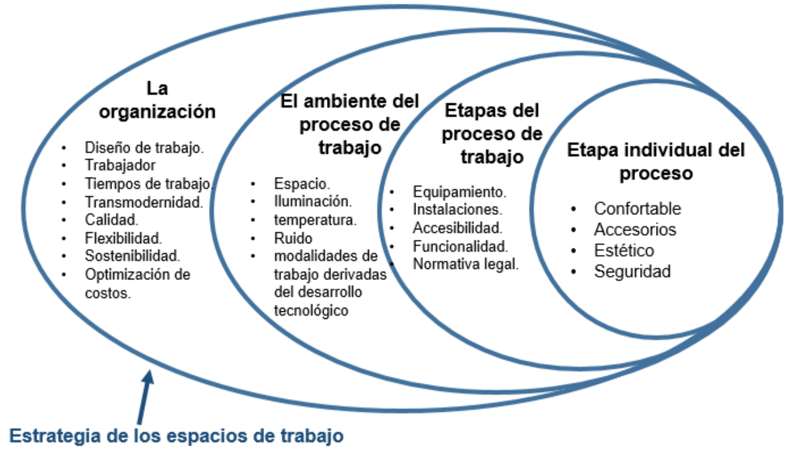
MAN - MACHINE - SURROUNDINGS

The conception of a job is based on three basic points: knowledge of ergonomics, production and quality needs of the final product, and the integration of ergonomics into the structure of the organization. The systemic approach based on a discipline known as general systems theory, a term first used by the biologist L. Von Bertalanffy in 1954 to refer to the quantitative description of natural systems. The central concept of the theory is that of "system". A system is a part of reality that can be isolated from the rest and has internal rules of operation.

6. METHOD FOR TECHNOLOGICAL DESIGN

According to Villareal (2015) Based on the analysis carried out in the ergonomic methodology stage, the following points should be made very clear and resolved: Environmental factors: these are the ones that analyze the physical, natural and artificial characteristics in a defined physical space, that can be any natural or artificial space where the user carries out its activities; That is, the user is analyzed first and then the criticism and evaluation of the environment in which he is immersed and from which he receives continuous stimuli is performed. The data of this factor have origin mainly in the exact sciences. The objective factors: they are those that analyze the formal characteristics of the objects, defined through the industrial design process, and are based on the parameters dictated by the previous factors. Functional factors.

FIGURE 4. THE ERGONOMIC PROCESS IN THE BUSINESS ORGANIZATION

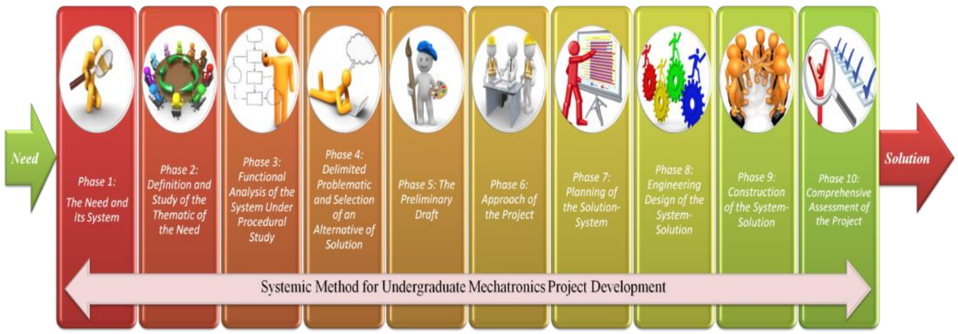


Source: Soto-Muciño

These are those that are related to the activity for which the product is destined and the function performed by the man with it. Human factors: they can be understood from several aspects: I. The factor dedicated to the analysis of the structure, composition and functioning of the human body. II. The one that analyzes the corporal dimensions of the man. III. The one that considers the capacities, limitations and psychic and mental reactions of the human being. IV. He who studies man as a social being, his cultural, social, economic and ideological characteristics. Dussel (2015) mentions that transmodernity is cultural exteriority and, it is not a mere uncontaminated and eternal substantive "identity" that has evolved before modernity itself, it is an identity in the sense of process and growth, but always As an alternative exteriority (of the environment), of the different, that can develop and adapt, according to the circumstances of a business organization.

A necessity has obligatory characteristics of what is really requested, is not based on simple desires that lack hard elements that justify them. A hard element is official information of government instances, organizations, societies, consortiums, etc., which make it public as it is useful for many purposes. A hard element supports the veracity and importance of a particular approach. Therefore, in the approach of a project, mainly in relation to the problematic and the justification, they must integrate hard elements that support them. The hard elements allow to establish the authenticity and magnitude of the need, and consequently the important thing that its solution represents. According to Reyes (2016) proposes a systemic method for the development of mechatronics projects, ie. This systemic method integrates ten phases to develop a technological solution to respond mainly to complex and multi-causal problems. In the particular case of the science that is studied and applied in engineering is called engineering science, it is composed of basic sciences and applied sciences, which in summary, are the subjects that are studied during the training of students .

FIGURE 5. PHASES OF THE SYSTEMIC METHOD FOR MECHANICAL PROJECTS



Source: Reyes-Reynoso (2016).

Among these can be identified those related to the laws of motion, the structure of matter, the behavior of fluids, the conversion of energy, among others. From here we can derive the concept of engineering, which is a profession that studies and applies the science of engineering, for the development of solutions that partially or completely satisfy a particular problem. However, the solutions that are obtained through engineering are called technology. Technology is the set of elements (knowledge, skills, techniques, tools, systems in general, etc.) that allow man to obtain solutions to their needs, these solutions are also considered as technology, since these will surely be Used to obtain some solution to another need. Therefore, an engineering project is a unique cyclical technological process that integrates planning, resource allocation and the development of a series of coordinated and controlled activities where the knowledge of engineering sciences is constantly applied to generate technology. Figure 5 shows the ten phases of the method for the development of mechatronic projects in which ergonomics is contemplated.

Reyes (2016) the methodology is a process that focuses on the development of methods to carry out some productive activity. Therefore, the systemic method proposed here is the result of the development of a methodology. Having established the conceptual system to support the understanding of the phases of the systemic method for the development of mechatronics projects, the following ten phases are presented:

1) The need for the project and its system.
2) Definition and study of the thematic of necessity.
3) Procedural functional analysis of the system being studied.
4) Problem delimited and selection of an alternative solution.
5) The preliminary draft.
6) The approach and teleology of the project.

7) Planning the solution system
8) Engineering design of the system-solution.
9) Construction of the solution system.
10) The integral evaluation of the project.

Therefore, Ergonomics contributes to the scientific knowledge that studies the biological, psychological and social capacities that are factors that are related to the work and the machinery that interacts with the human being or the equipment (artefactual systems) that manipulates, and to the Improving the interrelation of these, improves the abilities of individuals by establishing developments capable of making productive processes more functional, secure, and always seeking the optimization of the organization's resources. Repair of a specification, this is done with the purpose of establishing those requirements that must be fulfilled in the proposed solution. Particularly in the industrial field, it is very common that the solutions developed must meet certain requirements already established by the user, such as compliance with standards and standards, energy requirements to be used, certain technology and protocols are specified.

Communication, materials, safety and environmental measures, among others. In this case, when it is an academic project, it is important that the work team establishes its own specification, except for the problems that come directly from an industrial case where, as already mentioned, the user is the one who establishes it. Model of the Concept, this is done with the purpose of facilitating the manipulation of the selected solution alternative. The type of model to be used will be the student's decision with his / her work team, it will be the one that matches the characteristics, specifications and needs of the project. The concept model can be mathematical, three-dimensional drawing, diagramming, virtual (software), a combination of models, among others. In reality, the concept model normally precedes a general sketch. In this regard, Spencer (2009) argues that the most original ideas or mechanical inventions are recorded for the first time in the form of a sketch or sketch. Sketches help designers organize their ideas and remember what was created before. The sketch also serves to show others what the designer has in mind.

7. ORGANIZATIONAL CHANGE AND THE USE OF TECHNOLOGY

The organizational change according to Giddens (2000) indicates that an organization is "a large group of individuals related by a certain set of relations of authority", that is to say, that they are composed of a numerous group of people that is structured, of form Impersonal in order to achieve a specific goal or objectives. In his case Ordóñez (2006) expresses that a clear understanding of the incorporation of the technology in an organization will cause that the resistances to the change diminish, and if there was no such resistance, the same knowledge of this one will help to its better use and as a consequence, the balance will be positive for all the actors involved in this process. One factor that explains such resistance is ignorance, rejection, it is not in relation to the technology itself, an explanation, it is the ignorance of why, and what will improve its application of technology in a given process, before there is a lack of knowledge, the participants in the work process, feel threatened and displaced by technology.

Martínez and Torres (2012) mention that it is important to recognize that organizational culture is the product of a dialectical relationship between the values that define the organization and the individuals who participate in it. Often change is influenced by a majority of factors, which is better recognized in one environment than in another, but predominantly the organization is the one that defines the guidelines and their addressing. Although the organization outlines the beliefs it wants to project, through its mission, vision and values, it necessarily has an impact on employees. Kast and Rosenzweig (1983) mention that the technologies in the organization are based on the knowledge, equipment and other techniques of the process, that are used for the accomplishment of the work tasks, are affected, the type of inputs of the organization and the Products obtained from the system. Today, organizations have been influenced by technological growth. The way in which organizations adapt to technological change, and have a significant impact, on the subsystems of the organization itself. The development of the organization is closely related, with technological changes.

CONCLUSION

Currently in the ergonomics praxology in the technological design of the productive processes, this is based on fundamental objectives that are: Process planning, process, human interaction, staff activity or task, modification of the process after use, and the reduction of staff effort. So that the human being that interacts with a technological process is in the best conditions of operation, in any activity that takes place within the organization (company). Since an ergonomic product, or with a greater level of flexibility of its operation (is that is better adapted to the needs of the user, in a given process, and that the action for which it is designed can be performed with efficiency and comfort) Allowing the operator to improve his working conditions and maintain a physical and mental balance. The categories and their importance, which are contemplated in the design of technological processes, in which human beings interact, through functional elements, involving three components; In the organizational aspect, to which we must add, the cultural and the technical, which concern the application of scientific or organized knowledge, practices, through orderly systems, including people, and They form the organizations, as living (dynamic) organisms and machines (artefactual elements), which is what Pacey calls technological practice.

REFERENCE

Gay A. y Samar L., (2007). *El diseño industrial en la historia. Tecnológico*.
Blanco, R., (1990). *"Ética, estética y diseño industrial*". *Revista Tipográfica.* Año 4, N° 10.

CEPIME. (2013). *Guía orientada para la aplicación de procedimientos ergonómicos en empresas industriales.* Departamento de economía y empleo.

E.P.A.R., (2014). *Método para el establecimiento de criterios de diseño de ingeniería*. Apuntes de la materia de diseño de conjuntos de la carrera de ingeniería en robótica industrial. Soto-Muciño L.E..

Dabat, A., (1993). *El mundo y las naciones*, UNAM-CRIM, Cuernavaca Morelos; capítulo 7: las etapas del capitalismo y su dimensión espacial.

Dabat, A., (1994). *Capitalismo mundial y capitalismos nacionales*, México, Fondo de cultura económica.

Dussel E., (2015). *Filosofías del sur*. Descolonización y transmodernidad. Akal / inter pares.

Figueiredo, N. (2004). *Aprendizaje tecnológico e innovación industrial en economías emergentes*: una breve contribución para o desarrollo de implementación de estudios empíricos y estrategias en Brasil. En: Revista Brasileña de Innovación, 3 (2): 323-361.

Giddens, Anthony. (2000). *Sociología*. (3ª ed.) Madrid, Alianza.

Giddens, Anthony. (2002). *Consecuencias de la modernidad*. Madrid: Alianza.

Gillette B., (2001). *Ergonomics can help prevent injuries, boost productivity*. Mississippi Business Journal, January 29- february 04, 14.

Gich, J. van (1993). *Teoría general de sistemas*. México: Trillas.

Kerr S. y Keer E. B., (1972). *Why Your Employes Resist Perfectli Rational Changes*. Hospital Financial Management.

Kuznets, S. (1973). *Crecimiento económico moderno*, Aguilar, Madrid.

Martín-Carbajal Ma. de la L. y Carlos Garrocho-Rangel C., (2016). *Competitividad, aprendizaje tecnológico y sistemas de calidad entre los procesadores de aguacate de Uruapan, Michoacán*. Paradigma Económico.

MEN. (2008). *Ser competente en tecnología*: Una necesidad para el desarrollo. Ministerio de Educación Nacional. República de Colombia. ISBN 978-958-691-296-9.

National Research Council, (2002). *Technically speaking:* why all americans need to know more about technology.

Nelson R. y Winter S. (1977). "*In Search of a Useful Theory of innovation*", Research Policy, Vol. 6, No. 1, pp. 36-76.

Llaneza, A. (2004). *Ergonomía y Psicosociología aplicada*, cuarta edicion. Valladolid: Editorial Lex Nova.

López V. G., Marín M. E. y Alcalá M. C., (2012). *Ergonomía y Productividad*: variables que se relacionan con la competitividad de las plantas maquiladoras. Año 5, Vol. III, N° 9. ISSN.

ONU., (2015). *Agencias participes en el Grupo de Trabajo de Naciones Unidas para la Agenda de Desarrollo*.

Ordoñez J., (2006). *El desarrollo tecnológico, una perspectiva social y humanista*. Congreso Iberoamericano de Ciencia, Tecnología, Sociedad e Innovación.

Ramírez, L.A., (2002). Teoría de sistemas. http://www.virtual.unal.

Reyes, R. (2016). Metodología Sistémica para el Desarrollo de Proyectos Mecatrónicos Terminales (Tesis de Doctorado). Instituto Politécnico Nacional, México.

Reyes R. R., Rojas R. J. A., Campos S. I. E., Soto M. L. E. y Elizarraras B. R. (2015). El enfoque sistémico aplicado a la enseñanza en el desarrollo de proyectos académicos de ingeniería mecatrónica. Pensamiento Crítico. Año 2, Número 1, ISSN 23958162.

Ricard, A. (1982). Diseño ¿Por qué? Barcelona, Ed. Gustavo Gili, p. 170-171.

Robbins S. P. y Coulter M. (2000). Administración. México.

Rosell-Puig, W. y Más-García, M. (2003). El enfoque sistémico en el contenido de la enseñanza. Educación Médica Superior, 17(2).

Smith, R. (2003). *Growing an ergonomics culture in manufacturing*. Journal Engineering Manufacture, 217 part B, July 1, 1027-1030.

Soto-Muciño L. E., (2016). *Análisis socioeconómico de la producción de miel en el municipio de Álamo, Veracruz. Una propuesta para el desarrollo competitivo de la actividad apícola*. (tesis doctoral). Universidad del Distrito Federal.

DESIGN OF A SYSTEM OF DEVELOPMENT OF SYNESTHESIA COLOR-SOUND FOR CHILDREN USING A TOY

Francisco Platas López, Samantha Ponce Jandette

Universidad Autónoma del Estado de México
Zumpango, Estado de México.
Diseño Industrial
fplatasl@uaemex.mx

Resumen: El siguiente estudio explora, en una primera aproximación, el diseño de juguetes con formas tridimensionales para promover la estimulación con los niños. La comunicación háptica se relaciona con las formas de interacción táctil (no verbal) entre los seres humanos y el diseño háptico como un diseño que interactúa con un usuario a través del sentido del tacto. La investigación proporciona elementos para apoyar la interacción entre el diseño háptico y los juguetes ergonómicos que proporcionan una estimulación significativamente mayor en el desarrollo de los niños. El diseño de este tipo de juguetes propicia una mejora de la percepción asociando los colores con los sonidos gracias a la capacidad de la sinestesia mejorando su calidad de vida.

Palabras clave: Ergonomía para niños, juguetes, diseño háptico, sinestesia

Abstract: The following study explores, in a first approximation, the design of toys with three-dimensional shapes to promote stimulation with children. Haptic communication is related to the forms of tactile (non-verbal) interaction between humans and the haptic design as a design that interacts with a user through the sense of touch. The research provides elements to support the interaction between haptic design and ergonomic toys that provide significantly greater stimulation in the development of children. The design of this type of toys propitiates an improvement of perception associating the colors with sounds thanks to the capacity of synesthesia improving its quality of life.

Keywords: Ergonomics of children, toys, haptic design, synesthesia.

Introduction

The interaction between ergonomics, synesthesia and haptic aspects have been treated in the literature generating proposals that revalue the integration of different areas of the design. Raj, et al (2000) in Human Factors and Ergonomics Society Annual Meeting Proceedings that "Results show that tactile signals can be used to improve performance in space tasks." For their part, in the Proceedings of the Annual Meeting of Human Factors and Ergonomics Society, there are works that contribute "details an evaluation of a tactile system that was created to improve the navigation of a complex route" (Dorneich, 2006). Thus, "the designer will use their knowledge of user interfaces and ergonomics to create a comfortable sensory experience"

(Alfaro 2015). The work of these results in children has been scarcer, although it has been shown that musical stimulation in children even affects brain development. Schlaug et al. (2009) in their text Training-Induced Neuroplasticity in Young Children, points out that "but differences emerged after an average of 29 months of observation in the high-practicing group in the previous midbody of the CC (which connects premotor and supplementary motor areas of the two hemispheres).

Total weekly music exposure predicted degree of change in this subregion of the CC as well as improvement on a motor-sequencing task. Our results show that it is intense musical experience / practice, not preexisting differences, that is responsible for the larger previous CC area found in professional adult musicians ". (Schlaug, 2009).

Based on this background, we proceeded to design a system for the development of sound-color synesthesia for children using a toy. Considering as a general objective to develop a prototype of a toy using a related design for children, to develop their ability to Synesthesia, will allow you to know and detect different colors and basic shapes that are in your environment through the stimulation of the senses of hearing and touch. For the purposes of the research, it was necessary to identify and analyze the anthropometric and ergonomic characteristics of children between 4 and 6 years, as well as the concept of synesthesia to be taken into account during the making of a toy for children.

METHODOLOGY.

The methodology was based on previous studies, which examine ergonomics, modeling games, haptic and everyday design. The methodological approach provided the children with the opportunity to help them prepare for the artistic task and stimulate their senses.

The methodological aspects of the research are presented. It shows the methodological perspective that has been considered, the strategy of inquiry and the methodological design of the different phases of the research developed. The methodology consists of a series of necessary operations, arranged in a logical order, dictated by experience. Its purpose is to achieve its maximum result with the minimum effort. It is not absolute and definitive, it can be modified if other values are found that improve the process.

1. Documentary research: In this phase of the research, the main concepts were investigated, such as synesthesia, haptic design, child blindness and toy design, exploring all the conditions and limitations of research to satisfy the needs of what is going to be done.

2. Data collection: In this phase, we gather the information about the existing products from what already exists. Questions like "is there anyone who has done it before?

3. Analysis of results: we analyzed the products on the market in this case toys for people with visually deficiency, making comparisons and we made a conclusion in basis of the investigation, both of the competition as the thematic. The analysis of all the data collected can provide suggestions on what is not to be done in the project to be carried out and that can guide us towards other research of other

materials, other technologies, other costs. They answer the questions "How did you do it?" "What can I learn from that?"

4. Prototype Design: Brainstorming, experimentation, freedom, with different tools such as software or handwriting, word relationships with shapes and colors. The question is answered: How can all this be conjugated in a correct way. These experiments can extract samples, tests, information, which can lead to the construction of models demonstrating new uses for certain objectives. These new uses can help solve sub problems, which in turn will contribute to the overall solution. In this way, we will obtain a model of what may eventually be the solution of the problem.

Generation of the haptic ergonomic toy design for blind children.

The use of ergonomic proposals in their interaction with anthropometry allowed the design of a toy to be more easily and economically developed. Accuracy is very important and proper instruments should be available, as well as inconsistencies between the measurements of one or different examiners.

Various measures can be taken to evaluate the size, proportions and body composition. According to Lino Carmenate Milian's "Manual of Anthropometric Measures", the most frequently used dimensions in practice and study with children are the following.

Figure 1. Child standing dimensions.

1. Weight.

2. Body height:

Height to shoulder.

Height to elbow.

Height to hip.

Height to gluteus.

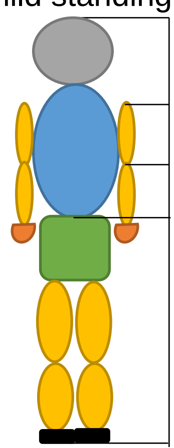


Figure 2. Child sitting dimensions.

3. Sitting subject height:

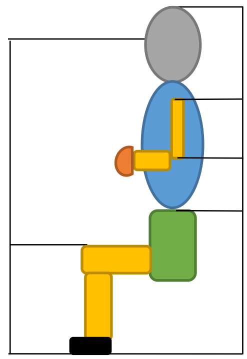
Height to eye.

Height to shoulder.

Elbow height

Height to gluteus.

Height to the knee.



The anthropometric and functional characteristics of the person are important determinants of the ergonomic conditions; therefore, anthropometric studies should refer to specific populations. These population characteristics are fundamental to establish normative databases that allow the appropriate decision to making in relation to the parameters for the design.

The anthropometric and functional characteristics of the person are important determinants of the ergonomic conditions; therefore, anthropometric studies should refer to specific populations. These population characteristics are fundamental to establish normative databases that allow the appropriate decision to making in relation to the parameters for the design.

The adjustment to the child's age is one of the most important criteria; the form and ergonomics of the game must respond to the manipulation capacity of the child to whom we offer it.

Must adapt to the size of your hand (a fit with giant pieces that you cannot grasp with your hands will not be able to fulfill its function), must have dimensions that adjust to its height, if it requires the use of the toy, a weight that be bearable by the child.

This research focused on anthropometric measurements specifically of the hands of children from four to six years as it is the making of a toy.

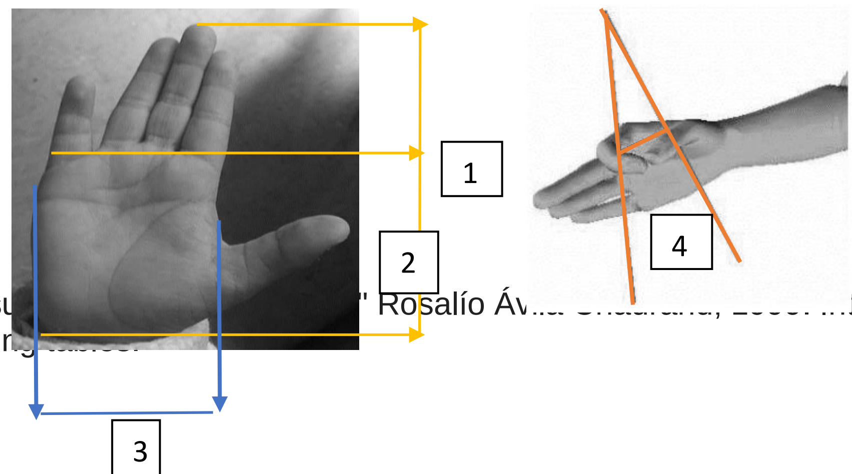
(1) Hand length: Vertical distance from the base of the hand (first fold of the wrist) to the tip (pulp) of the third finger (middle).

(2) Hand palm length: Vertical distance from the base of the hand (first fold of the wrist) to the base of the third finger (middle).

(3) Hand palm width: Horizontal distance from the lateral border (hypotenary region) on the fifth finger (pinky) to the lateral border of the second finger (index) at the level of the knuckle (toar region). Line through the ends of the metacarpal bones

(4) Handle diameter: Inner diameter that can be grasped with the thumb and middle finger at the widest level of a cone.

Figure 3. Anthropometric measures of the hand of children between 4 and 6 years old.



The measu... " Rosalío Áv... ...terpreted in the followi...

Table 1. 4 and 5 years old female sex.

	DIMENSIONS			PERCENTILES					PERCENTILES		
		X	D.E	5	50	95	X	D.E	5	50	95
1	Hand length	115	7	103	115	127	122	6	112	121	132
2	Length of palm	66	4	59	65	73	69	5	61	69	77
3	hand Palm width	52	4	45	53	59	55	4	48	55	62
4	Diameter grip	25	2	21	25	28	26	3	21	26	31

Table 2. 4 and 5 years male children.

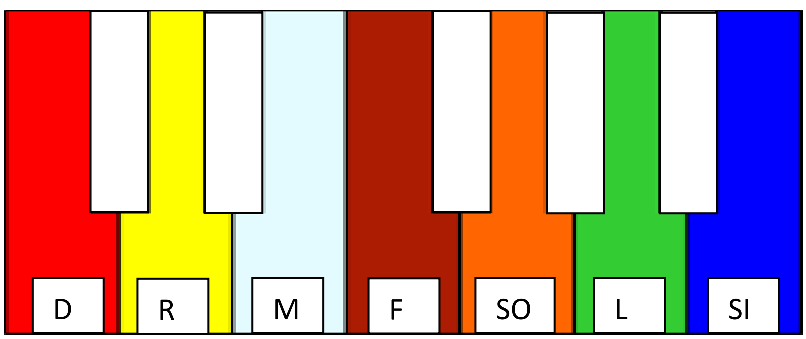
	DIMENSIONES			PERCENTILES					PERCENTILES		
		X	D.E	5	50	95	X	D.E	5	50	95
1	Longitud mano	116	7	105	116	128	121	7	109	121	133
2	Longitud de la palma mano	67	5	59	66	75	69	5	61	70	77

3	Anchura de palma de mano	54	4	47	53	61	57	4	50	57	64
4	Diameter grip	24	2	21	24	27	26	2	23	26	29

In relation to the haptic and synesthetic aspects for children, it was based on the proposals of studies of Aleksandr Scriabin. Scriabin was one of the most innovative composers in the history of music; he was a recognized personage who invented the chromatic keyboard. When he started studying music, he agreed with Sergei Rachmaninov. Both shared, apart from the profession of composer, the capacity of synesthesia. Scriabin understood musical creation as a harmony of colors before a musical harmony, that is to say, above the sounds; the colors are the elements that structure the composition. According to this conception designed in 1911 together with Alexander Mozer, an organ that projected colors on the stage depending on the harmonic regions that crossed the score.

In his case, they could perceive the sounds in the form of colors and associate to each sound a chromatic value, thanks to his synesthetic ability he was strongly influenced in his musical work "Prometeo". Its main virtue was to associate each hue with a certain color, raises its association between notes and colors on its chromatic keyboard.

Figure 4. Scriabin color scale according to the musical note on a keyboard.



Knowing the color map of the composer and pianist Alexander Scriabin (figure) and associating the frequencies of the notes obtained by a piano to a color determined by the map. In this way when playing simple melodies you get a certain pattern of colors that follows the rhythm of it. It was the pianist who assigned colors to the notes which is an instrument that emits a very pleasant auditory signal for the human ear, a certain pattern of colors as shown in the figure.

PROPOSAL.

For the realization of the project it was important to define and identify all of the aforementioned, to take into account the importance of toys for children as the most natural way for them to learn is through touch and sound generating important learning for their development, As well as the importance of knowing the colors in childhood.

The sound toy design was inspired by a three-dimensional mandala, they can interact in a more direct and fun way with the tool, this means that the children do not feel afraid to touch or throw it and that can use both hands for their better learning by Braille language through touch. Not only generating the stimulus of that sense, but also the hearing, speeding up the memory as they can manipulate it as they wish in search of colors and sounds.

Specifically he took the design of a mandala called "Merkaba", platonic polyhedrons and Wentzel Jamnitzer figures.

- The Platonic polyhedrons: The faces that make up a platonic solid are regular polygons. (Figure 5)

- Wenzel Jamnitzer 1568: presidency of Arithmetic, Geometry, Perspective and Architecture, derived directly from the regular polyhedra making each of them twenty-three different variations. (Figure 6)

Figure 5. Perspective of regular bodies, 1568.

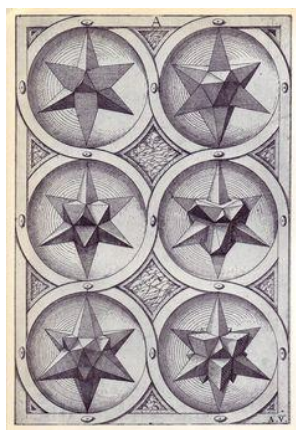
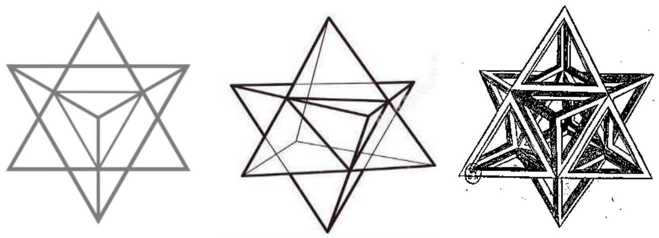


Figure 6. Platonic Polyhedra

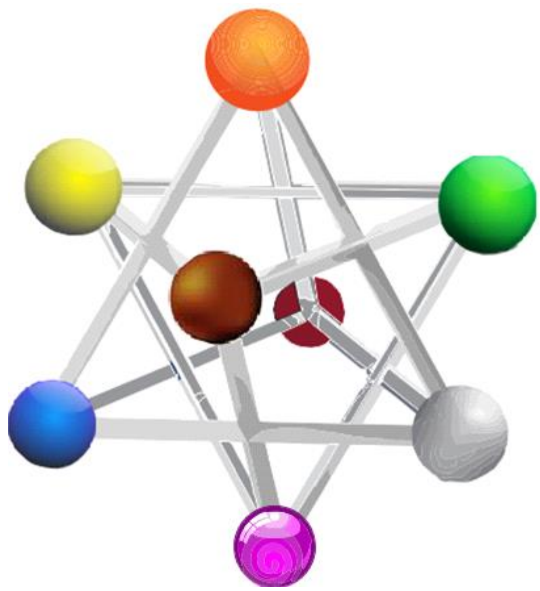
The merkaba are two interlaced pyramids, in the isometric form, composed of three tetrahedral superimposed on one another. When you look at it or you draw it, it looks as if it were one represented in the following way.

Figure 7. Merkaba



Coming to a proposal represented as follows:

Figure 8. Final proposal.



Forming eight peaks, which complete 7 colors:

Primary colors:

- Green
- Blue
- Red

Colors according to the chromatic scale of Aleksandr Skriabin:

- Do - Red
- Re - Yellow
- Mi - White
- Fa - Coffee
- Sol - Orange

- La - green
- Si – Blue

As I mentioned the mandala called "merkaba" has eight peaks for seven colors with its corresponding musical note, the eighth peak would represent the combination of two colors and two musical notes generating a secondary color:

• Do + Si = Red + Blue = Magenta

The child will be able to mix colors, he or she will learn about which secondary colors formed based on the primaries, which can also feel and listen to what color corresponds to each note to form secondary colors.
The design concept that emerges then is:

• Identify colors through a sound toy: the tool allows you to play and identify colors with sound, specifically the main musical notes, stimulating your ability to synesthesia.

The child will have contact with the sound spheres to generate a certain note "We do not pretend to be musicians, but they are capable of improvising, listening and feeling pleasure with music, and for this it is It is necessary to give musical importance the importance it requires and to take into account the objectives towards which the activity is to be directed "(Bernal, J. and Calvo, 2000).

The development of sound perception should follow these steps:
• Listen >>> Identify >>> Hold >>> Play
Contemplating this process as follows
• Hear >>> Listen
• Listen >>> Percibir
• Perceive >>> Feel
• Feel >>> Imagine
(Bernal, J. and Calvo, M. 2000).

CONCLUSIONS.

Ergonomics aims to generate better procedures to perform certain tasks. In this case, ergonomics applied to toys will provide us with information to design a three-dimensional sound toy under the principles of mandalas as this affects the growth in brain functions before the stimulation of children of 5 years, as a result of sounds And music (Schlaug, 2009).

Among the future challenges is to carry out a homogenization in relation to synaesthetic criteria. As an example, it should be noted that, for a synaesthetic, the note C could trigger the perception of red color but if we ask why Do sounds red, the subject could not give a specific and causal reason for that relationship, rather than the immediate perception Of both associated stimuli.

Jacques Lusseyran recounts his synesthesia: "DO white entrance of sounds possible beginnings and confident cheerful, RE turbulent fire yellow gold leap from every birth, Mi insolent and mimosa green and yellow lamp, FA red dress." (Lusseyran, 2000). A future challenge is the classification and further development of the types of sensors that are available and that can detect information easily. This opens up a new field of knowledge called design through digital synaesthesia. In that sense "in the far future vision of Digital Synesthesia, this interface will let user choose which sensor they want to be active and where they wish to experience this feedback. This way, users will be able to turn artificial senses on and off depending on the activity "(Alfaro, 2015).

REFERENCES

Alfaro Bernate, S. E. (2015). *Digital Synesthesia: using mobile technology and sensory substitution to interact with our world* (Doctoral dissertation, Massachusetts Institute of Technology).

Bernal, J. y Calvo, M.L. (2000). Didáctica de la Música. La Expresión Musical en la Educación Infantil. Málaga: Aljibe

Carmenate, 2014. Manual de medidas antropométricas. SALTRA, Costa Rica.

Dorneich, M. C., P. M. Ververs, S. D. Whitlow, and S. Mathan. 2006. "Evaluation of a Tactile Navigation Cueing System and Real-Time Assessment of Cognitive State." *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 50 (24) (October 1): 2600–2604. http://pro.sagepub.com/content/50/24/2600.abstract.

Raj, A. K., S. J. Kass, and J. F. Perry. 2000. "Vibrotactile Displays for Improving Spatial Awareness." *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 44 (1) (July 1): 181–184. http://pro.sagepub.com/content/44/1/181.abstract.

LUSSEYRAN, Jacques, Et la lumière fut, París, Editions du Félin, 2005 [ed. cast.: Y la luz se hizo, trad. Miguel Fraguas.]

Schlaug, G., Forgeard, M., Zhu, L., Norton, A., Norton, A., & Winner, E. (2009). Training-induced Neuroplasticity in Young Children. *Annals of the New York Academy of Sciences*, *1169*(1), 205-208.

STUDY OF A DEGENERATIVE MUSCLE SKELETAL DISEASE IN THE HANDS OF WORKERS IN A PLASTIC BOTTLES FACTORY

Ricardo Muñíz, Martinez

Escuela Nacional de Antropología e Historia
Zapote s/n, esquina con Periférico sur,
Colonia Isidro Fabela, Delegación Tlalpan,
C.P. 14030 Cd. México, México.
Corresponding author's e-mail: ricardo.muniz@enah.edu.mx,
ricardomunizmum@gmail.com

Resumen: La antropología física es una disciplina académica con más de 100 años de práctica, pero en las últimas décadas ha visto un crecimiento en áreas que no se creían pertinentes investigar por su particular especialización, así que esta investigación sobre el padecimiento musculo esquelético, busca este eslabón desde la visión antropofisica y la ergonomía.

Es un tema de alta importancia ya que los trastornos observados en las manos llegan a tal gravedad que puede inmoviliza totalmente el dedo pulgar, con la consecuencia final del despido de la persona de su fuente laboral o su incapacidad total, incluso para llevar a cabo actividades no laborales.

Para demostrar como la antropología física puede incursionar y encontrar soluciones a problemáticas especificas, se efectuó en una fábrica la investigación, en donde la frecuencia de este padecimiento era relativamente alto, más de 30 casos anuales, así que mediante la gestión con la administración se llevo a cabo un estudio cualitativo – descriptivo, con la participación de 70 trabajadoras, todas de un mismo turno, con edades entre los 20 y 50 años, para lograr encontrar las casusas probables que dan origen a esta situación.

Este modelo de investigación requirió del diseño de un mecanismo de 10 pasos para que la investigación fluyera de manera deductiva, partiendo de bloques generales a la particulares de la problemática musculo esquelética de los trabajadores, mediante la utilización de técnicas tradicionales y otras novedosas adecuaciones de ingenierías, permitieron lograr el conocimiento general que provee la antropología física y la medicina proveen un eje solido de partida.

El impacto obtenido fue asilar de manea sistemática las casusas probables y aplicar a cada una la situación. Así en este estudio se analizo la relación de la morfología de la mano, su movimiento y la forma en que fue ejecutado un trabajo en particular, denominado rebabeo, como resultado de la investigación se llego a determinar la causa principal probable que genera el desarrollo del padecimiento, de tal manera que se propuso una mecánica que permitiera evitar los movimientos que actualmente dañan el tendón, causando la tendinitis en las manos de las trabajadoras.

El resultado obtenido fue benéfico para las trabajadoras de esta fábrica ya que del tener un promedio de 10 casos anuales registrados, a un año de haber concluido la investigación se tienen 3 anuales, además de poder demostrar que el protocolo puede ser aplicado en otras fábricas o actividades para solucionar problemas similares.

Palabras Clave: Antropometría, Ergonomía, Artralgias.

Abstract: Physical anthropology is an academic discipline with more than 100 years of practice, but in the last decades it has seen a growth in areas that were not considered pertinent to investigate for its particular specialization, so this research on the skeletal muscle disease, looks for this link from the anthrop physical view and the ergonomics.

It is an issue of high importance as the disorders observed in the hands reach such severity that it can completely immobilize the thumb, with the final consequence of dismissing the person from their work source or their total inability; even to carry out activities not work.

To demonstrate how physical anthropology can penetrate and find solutions to specific problems, a research was carried out in a factory, where the frequency of this disease was relatively high, more than 30 cases per year, so through management with the administration took A qualitative - descriptive study, with the participation of 70 workers, all of the same shift, with ages between 20 and 50 years, to find the probable causes that give rise to this situation.

This research model required the design of a 10-step mechanism for research to flow in a deductive way, starting from general blocks to the particular skeletal muscle problem of the workers, through the use of traditional techniques and other novel engineering adjustments , Allowed to achieve the general knowledge that provides physical anthropology and medicine provide a solid starting axis.

The impact was systematically ascertained the probable causes and apply to each one the situation. In this study we analyzed the relationship of the hand morphology, its movement and the way in which a particular work was carried out, known as *rebabeo*, as a result of the investigation, it was determined the main probable cause that generates the development of the disease, In such a way that a mechanism was proposed that would allow to avoid the movements that currently damage the tendon, causing the tendinitis in the hands of the workers.

The result obtained was beneficial for the workers of this factory since of having an average of 10 annual cases registered; to a year of having concluded the investigation they have 3 annuals, in addition to being able to demonstrate that the protocol can be applied in other factories or Activities to solve similar problems.

Keywords: Antropometría, Ergonomía, Artralgias.

Relevance to Ergonomics: The impact of knowing how a condition affects an important part of the human body is very important for the person who suffers it and for the employers, in this case, since in the medium and long term the medical consequences can be high risk. In this study, a novel protocol was analyzed, in which research techniques of physical anthropology and other disciplines were integrated, the relation of the morphology of the hand, its movement and the way in which a particular work is executed, Known as rebabbing, as a result of the investigation, the main probable cause of the development of the disease was determined, so that a mechanism was proposed to avoid the movements that currently damage the tendon, causing tendonitis in the hands of Workers. The result obtained was beneficial for the workers of this factory since of having an average of 10 registered annual cases, to a year of having concluded the investigation they have 3 annuals.

1. Introduction.

Skeletal muscle disease (SMD) is a silent disease that affects the general population Arroyo, (2007), so studying it is not an easy task to do, and to find the causes that develop it, you should have a population in which Have symptoms of this disease, as is the case of a working population, took advantage of the opportunity that a factory manufactures to do the research with person, since for several years these have very clear symptoms and in some cases merited The surgical intervention to correct it, although without concrete results, since it is still present in the mentioned population, DGPyDT (2011). This factory has a continuous process and 100% manual repetitive operations, which they call "*rebabeo*". Therefore, the investigation task was taken 18 months, from obtaining the CEO authorization till write the report.

2. Objectives.

The general objective of this research was to be able to find the causes that stimulate the disease, as well as to propose some probable actions of improvement that diminish or delay for a long time its appearance among the workers, through the description, identification and analysis of the conditions that to establish, through a case study, the tangible elements that allow to implement in the medium term a comprehensive program of corrective actions on the execution of this daily activity and thus be able to reduce the frequency of the SMD to medium term.

3. Delimitation.

The relationship between physical anthropology and ergonomics has been given through anthropometric studies with ergonomic criteria mainly, in addition to that the majority of the works are of the descriptive-interpretative type according to Lara (2007), Faulhaber (1971), therefore there are Points of coincidence in which the research activity can be transferred with the other academic disciplines, such as medicine and engineering, so a review of these was made.

Physical anthropology has tackled this problem from the perspective of health disease, an aspect related to the wear and tear of the human being through the work he performs, seeks to improve conditions and work environment through the application of norms like ISO (2003) and legal frameworks, which does not reach to deepen the origin of the problems, as mentioned by Montoya (2010) in his research with hospital workers. It is worth mentioning that the work of Laurel (1985), Wisner, (1988), and Ramirez (1991) establish a watershed for physical anthropology to investigate diseases as a cause that has the consequence of the worker's health attrition by the preponderant activities that they do.

4. Methodology.

In order to approach this problem, it was determined by means of a quantitative research model, through which the history of the problem was constructed, with the contribution of the collected records with specific techniques. The aforementioned problem can be described as to how the skeletal muscle disease present in the hands of workers in a plastic packaging factory develops by the way the operation is performed rather than by the cutting tool employed. The proposed research model generally considers working on these points: 1.- Make direct observation, 2.- Document the work site, 3.- Make an anthropometric record, 4.- Visual document the process (still photography and video), 5.- Analyze the population of workers, 6.- Design work guides with the proposed solution.(Zinchenko, 1993).

These elements were formed in a mechanism of 10 steps for the investigation to flow in a deductive way, starting from general blocks to the particular problems of skeletal muscle workers. The general knowledge provided by physical anthropology and medicine provides a solid starting point. We considered the social factor as the next phase concentrating on the historical and social background of the working population and factory (see figure 1).

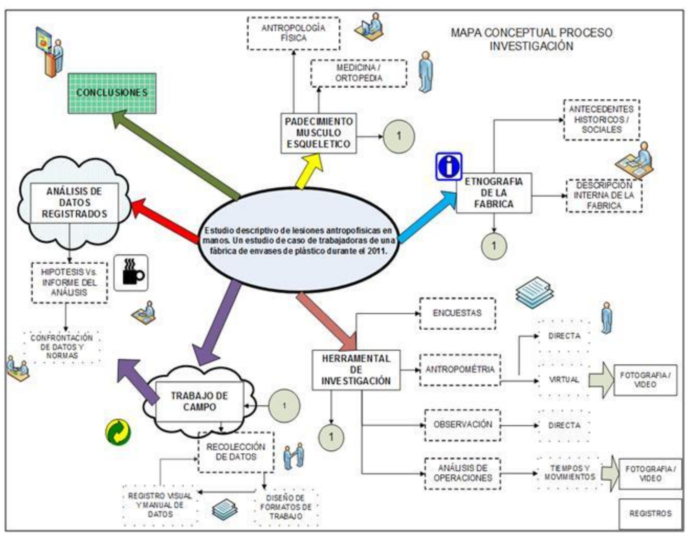


Figure 1: Research Model Proposed. Source Work shop PRAT /

In order to achieve this, it was necessary to select some techniques and tools that facilitate the recording and collection of data, including: surveys, anthropometry, site observation and operations analysis, mainly, and make the method arrangement describe in the figure 2. (Barnes, 1952, Roebuck, 1975, Wisner 1988, Louhevaara, 1992, Tilley, 1993, Kroemer, 1994, Saengchaiya, 2004, Malina, 2006, Villanueva, 2010)

The materials used in this research were mainly factory workers, a Martin anthropometer, the physical space of the factory and a digital compact digital camera, this one with a quality of 12 mega pixels, Yañez, (2009).

The group of workers, Operators-Packers, was formed with 70 people. This group has weekly rotating shifts and two rest days, which are from Monday to Friday, and mainly clean the plastic cans that are manufactured by injection in the plant.

This analysis was done using video recording the workers and comparing the movements, based on the format to group each of them, the corresponding records were made, the results will be discussed later (Barnes, 1952).

94 photographs were obtained showing the workers in a lateral and frontal position. And 49 were obtained from the right hand, in the computer the application NIH was used to determine the dimensions, and these data were captured in a spreadsheet, the results were tabulated to know the corresponding differences, (See figure 2), the author Muñiz, (2015) describe all the research process to analyses the different data recording and motion videos.

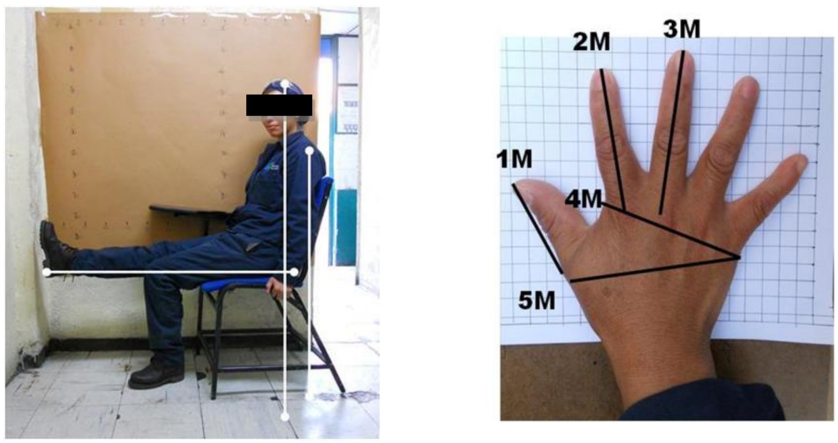
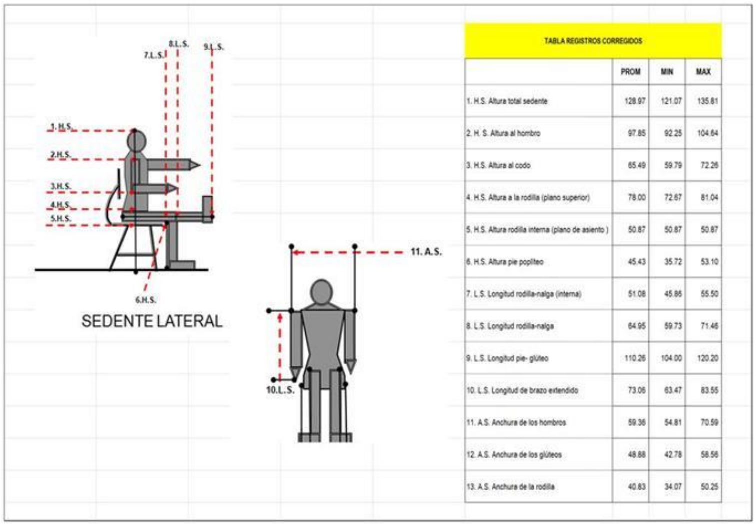


Figure 2: Worker anthropometry with photography. Source RMM,

Based on these it was determined that the dimension of the person is not a factor that promotes the development of a SMD in the hands, (see figure 3). On another hand the correct positions on the hand in each step is a determining grow factor for the SMD, as we can see in the Arroyo and et al work, based in the anatomy of the hand, Rouviere (2005).



	PROM	MIN	MAX
1. H.S. Altura total sedente	128.97	121.07	135.81
2. H. S. Altura al hombro	97.85	92.25	104.64
3. H.S. Altura al codo	65.49	59.79	72.26
4. H.S. Altura a la rodilla (plano superior)	78.00	72.67	81.04
5. H.S. Altura rodilla interna (plano de asiento)	50.87	50.87	50.87
6. H.S. Altura pie popliteo	45.43	35.72	53.10
7. L.S. Longitud rodilla-nalga (interna)	51.08	45.86	55.50
8. L.S. Longitud rodilla-nalga	64.95	59.73	71.46
9. L.S. Longitud pie- glúteo	110.26	104.00	120.20
10. L.S. Longitud de brazo extendido	73.06	63.47	83.55
11. A.S. Anchura de los hombros	59.36	54.81	70.59
12. A.S. Anchura de los glúteos	48.88	42.78	58.56
13. A.S. Anchura de la rodilla	40.83	34.07	50.25

Figure 3: Anthropometry Data Abstract. Source RMM

5. Results:

Through this research model, a positive result could be obtained by achieving a significant reduction in the number and frequency of cumulative SMD cases, since before of the 10 cases per year, In the course of 2014 only three were recorded, because was used a training method with visual aids to reduce the bad wrist movement on the daily action, (see figure 4).

It was also observed that the proposed methodology (see figure 1), helps to make the research process agile and timely as to what and how to collect the records and build the information that was required at each stage of the investigation, that was required to give due attention to the problem of SMD solving the health problem since the root cause.

Figure 4: Visual Aids to Train New Workers: Source RMM

Even though the outcome of the research was positive, there are several issues that merit a review. One of these is related to virtual anthropometry, since a technique based on digital photography analysis and an analysis application, by which the anthropometric dimension selected for this research was determined, it was seen that although facilitated the field work of recording the human dimensions, it is recommended to use it for group of more than 100 people to have a better results.

It is also recommended that the control scale be clearer in order to make more accurate calculations, as well as the signals to locate the chair or support equipment to keep them more visibly, since this will avoid errors of reading and / or appreciation when used in The NIH[1] application.

This is mentioned because it is probable that this is the cause of the differences between the virtual and the direct registration that was taken to 10% of the population of workers, which is very great, for the cases in which the dimensions are essential for the Research, in this case it was determined that the size of the body and hands are not a precursor to the SMD.

Regarding the methodology that was designed for the investigation, it did not have changes during the execution, which leads to think that the design corresponded to solve the needs of the problem, in such a way that could be reproduced by other investigators without problem some.

7. References.

Arroyo, J., Delgado, P., & Abad, J. (2007). Tratamiento quirúrgico de la tenosinovitis estenosante de De Quervain. Patología del Aparato Locomotor.

Barnes, R. M. (1952). Motion and Time Study. New York: John Wiley & Sons, Inc.

DGPyDT. (2011). Indicadores Estadísticos del sector, 2002 - 2011. México DF: Secretaría de Turismo del Distrito Federal.

Faulhaber, J. (1971). Las posibilidades de aplicación de la antropología física en México. Anales de Antropología IIA UNAM, 57 - 68.

ISO, Organization (2003). MS ISO 7250: 2003 Basic human body measurements for technological design (ISO 7250: 1996, IDT). Berna. ISO Department of Standard, Malasia.

Kroemer, K. H.-E. (1994). Ergonomics: How to design for Easy & Efficiency. (W. F. Mize, Ed.) New Jersey, EUA: Prentice Hall Inc.

Lara, M. A. (2007). Tendencias de investigación ergonómica entre antropólogos físicos a partir de sus tesis de licenciatura. (UNAM, Ed.) Estudios de Antropología Biológica., XIII, 41-55.

Laurel, A. C. (1985). El desgaste obrero en México. México DF. ERA.

Louhevaara, V. T. (1992). OWAS, A Method for the Evaluation of Postural Load During Work (1ra ed., Vol. 11). Helsinki, Finland: IOH.

Malina, M. R. (2006). Antropometría, Illinois, Chicago, USA: PubliCE Standard.

Montoya, M. (2010). Lesiones Ostero musculares en Trabajadores de un Hospital Mexicano y la Ocurrencia del Ausentismo. Ciencia y Enfermería., XVI (2), 35-46.

[1] NIH: Ssoftware NIH Image 1.61 (http://rsb.info.nih.gov/nih-image/)

Muñíz M. R. (2015) Estudio de un padecimiento músculo esquelético degenerativo en las manos de trabajadoras de una fábrica de envases de plástico. México, Tesis Licenciatura Escuela Nacional de Antropología e Historia.

Ramírez, C. C. (1991). Ergonomía y Productividad. México: Limusa.

Roebuck, J. K. (1975). Engineering Anthropometry Methods, New York: John Wiley & Sons.

Rouviere, H. D. (2005). Anatomía Humana (11 ed.). Barcelona, España: Elsevier Masson.

Saengchaiya, N. B. (Jan-Mar de 2004). Anthropometry of Thai Female Industrial Workers, The Journal of KMITNB, 14(1), 16-19.

Tilley.Alvin. (1993). The Measure of Man and Woman (Human Factors in Design) New York: Henry Dreyfuss Associates.

Villanueva, S. M. (2010). Morfología facial, estudios en población mexicana a través de fotografías digitales. México: IIA, UNAM.

Wisner, A. (1988). Ergonomía y Condiciones de Trabajo. Buenos Aires, Argentina: Humanitas.

Yáñez, M. J. (4 de Junio de 2009). Antropometría: Mediciones a partir de una cámara fotográfica. CONCYTEG (48), 724-730.

Zinchenko, V. M. (1979). Fundamentals of Ergonomics. Moscow: Progress Publisher.

DIAGNOSIS OF ERGONOMICS SUBJECT IN INDUSTRIAL DESIGN PROGRAM AT SCHOOL OF HIGHER STUDIES ARAGÓN-NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO.

Ma. Fernanda Gutiérrez Torres

Department of Industrial Design
School of Higher Studies Aragon
National Autonomous University of Mexico
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: Este artículo trata de la revisión de las asignaturas del área de Ergonomía dentro del marco de la modificación de contenidos del Plan de Estudios de la Licenciatura en Diseño Industrial de la Facultad de Estudios Superiores Aragón UNAM con el fin de describirlas y analizarlas para proponer los cambios pertinentes, basados en los avances de la disciplina así como las actualizaciones de la tecnología y de la pedagogía para lograr una mejora cualitativa en la enseñanza del diseño en la cual la Ergonomía tiene un gran potencial por aportar.

Palabras clave: ergonomía, diseño industrial, educación.

Abstract: This article deals with the review of the subjects of Ergonomics in Industrial Design program at School of Higher Studies Aragon UNAM, with the purpose of presenting a brief description and analysis in order to propose suitable changes, based on discipline improvements, technological and pedagogical updates and looking forwards to high quality design education where ergonomics has a great potential to contribute.

Key words: ergonomics, industrial design, education.

Relevance to Ergonomics: This paper could impact design programs because it would provide data about applied research; knowledge and professional skills relevant to ergonomics program that would help teachers and students use and spread the results. These actions would help to enhance contributions and generate a useful database for academic purpose and other projects.

1. INTRODUCTION

Industrial Design program is being reviewed thoroughly in order to update subjects. This paper introduces the assessment of ergonomics topics and its conclusions.

Industrial design has found in Ergonomics a solid basis to propose creative and innovative solutions to problems related with human factors. Ergonomic methods help a lot in problem solving, because it focuses on systems in which humans interact with objects –“things”-, machines and physical environment, other people and culture. (Dul et al., 2012). As an example, we can talk about products where we can find ergonomics as the core of the design, as it is evident in “Aeron” work office chair. The designers “combined a deep knowledge of human-centered design with innovative never-before-seen technology to deliver a chair unlike any other”. (Herman Miller products, 2017).

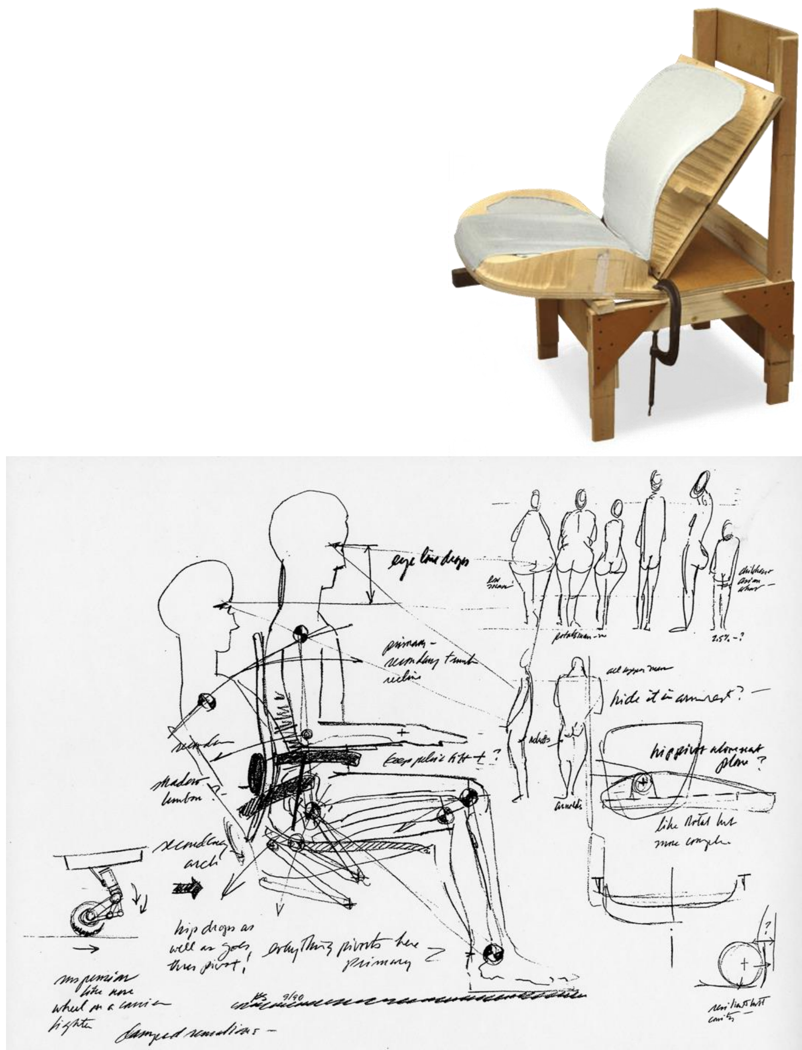


Figure 1. Simulator and drawings of Aeron design by Bill Stumpf and Don Chadwick. (1994).

In the decade of the eighties, Ergonomics was considered as a very important issue that contributed and enabled industrial design undergraduates in multiple ways. As time passed, interest in ergonomics decreased, because there are few opportunities to apply it in industrial design practice projects due to different reasons as lack of interest, money, time or information. Also professional practice has changed because some influential and successful designers have focused only in developing skills and abilities to product styling as promoted in different Mexican and international magazines, museums, stores, etc.

Figure 2. Centipede bench by Hector Esrawe.

On the other hand, educational institutions as UNAM and some designers are convinced that design should be committed to contribute to build a better world. This is the reason why we are working to propose that ergonomics should continue to be part of design courses. This is an academic research within the process of reviewing Industrial Design Program of FES Aragon.

2. OBJECTIVE

Analyze ergonomics subjects focusing on the use and application of design knowledge, skills and approaches in order to apply findings in the new industrial design program.

3. METHODOLOGY

- Describe and analyze current topics of the three subjects: Introduction to Ergonomics (third semester), Ergonomics (fifth semester) and Selected Ergonomics Themes (optional subject, 7th to 10th semesters).
- Describe and analyze the use and application of ergonomics in industrial design projects published in the UNAM Digital Library.

- Classify data based on general issues as physical and cognitive ergonomics, contribution to design and evaluation tasks, jobs, environments and overall systems, compatible with the needs, abilities and limitations of people. (IEA, 2017).
- Compare national and international ergonomic courses of different schools and universities.
- Classify approaches based on ergonomics.
- Be acquainted with the avant-garde and professional interest issues through publications as well as attendance at the discipline's congresses.
- Be part of the committee responsible of working in the new program and its relation with industrial design process.
- Spread the results.

4. RESULTS

Table 1. Description of Third Semester Subject

Subject: **Introduction to Ergonomics**
Semester Third
Type Theoretical and practical
3 hours/week
Educational Objective:
Define Ergonomics basis, history, evolution, structure and terminology. Importance of being a multidisciplinary discipline and its close relationship with Industrial Design, emphasizing the attention on humans as the part of the man-machine system.

Lessons:

1. Background and definitions.
2. Ergonomics and anthropometry.
3. Ergonomics research
4. Ergonomic diagrams
5. Ergonomics and Industrial Design
6. Cultural diversity and ergonomics.

Table 2. Description of Fifth Semester Subject

Subject: **Ergonomics**
Semester Fifth
Type Theoretical and practical

Educational Objective:
Define Anatomical, Physiological and Human Hygiene of organs, apparatus and systems; emphasizing the importance that this knowledge can contribute to the design process.

Lessons:
1. Background and definitions.
2. Relationship between Ergonomics and Anatomical, Physiological and morphological knowledge.
3. The Skin. Protection and heat transfer.
4. The skeleton. Body structure and protection.
5. Muscles and movement.
6. Nervous system. Control and response to the world around us.
7. Sight definition, the power or faculty of seeing; perception of objects; vision.
8. Ears and hearing. Sound and noise.

Table 3. Description of 7th semester Subject

Subject	**Selected Ergonomics Themes**
Semester	**7th -10th semesters**
Type	Elective course. Theoretical and practical

Educational Objective:
Define important concepts in man-man and man-object systems emphasizing communication, especially between people (information, message, communication) and between man-machine system, underlining the application of these concepts in design projects.

Lessons:
1. Man-man communication. Information, communication, graphic elements.
2. Machine-man system/instrument boards: visual, auditory and tactile.
3. Man-machine system/controls.
4. Ergonomic research

4.1. Analysis.

Both objectives from third and fifth semesters could be considered as adequate as far as students can acquire the basis of the discipline and its relationship with industrial design. Nevertheless, the purpose of applying the concepts and anthropometric data related to ergonomic diagrams is not so easy because of the students' lack of skills to illustrate human proportions and correlation while using a product.

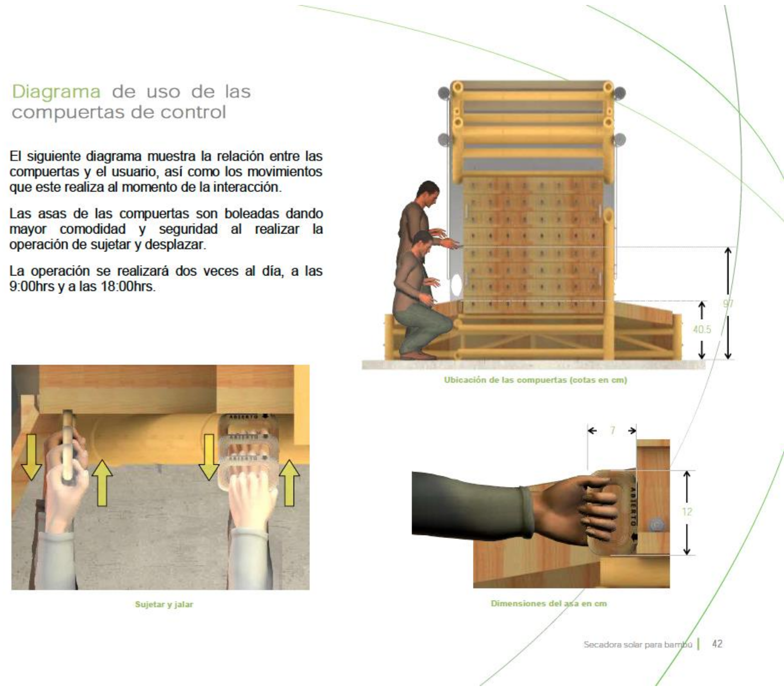


Figure 3. Illustration of a diagram of man-machine *interaction* system. (Aquino, O., 2011).

The third program and part of the second are closely related to Cognitive Ergonomics, even though it is not explicit in those terms of mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training (IEA, 2017).

4.2. Recommendations.

Objectives and contents must be updated, in order to include concepts recognized nowadays in Applied Ergonomics to solve Industrial Design problems as user, usability, user-centered design, experience, product/service users, work environment, for example.

We suggest unifying in a single course all the contents of 3rd and 5th semesters, a significant curricular modification, so students would be able to develop knowledge and skills regarding Physical Ergonomics regarding anthropometric, anatomical, physiological and biomechanical characteristics as they relate to physical activity and fitting objects/products/tasks and systems. (IEA, 2017). And the most important issue is to understand user as center of the system and have a deeper understanding of the people we are designing for. It is important for design thinkers to empathise with the people they're designing for to understand their needs, thoughts, emotions and motivations (The Interaction Design Foundation ApS DK, 2017). Identify children and adults' needs, ageing process, expectant mothers, small and big persons, disabled and elderly (Kroemer, 2006).

Do not forget it is very important to learn about users through testing with prototypes, models or simulators.

There is something that has not be discussed in this paper, the importance of the elective courses like “Furniture Design”, “Museography” and POP design, and creation and production of exhibitions and scenography, where specialized knowledge and skills must be developed. In these subjects Ergonomics should be part of the design practice

Absolutely the references must be studied carefully, include Mexican anthropometric data, usability, emotion, pleasure and so many topics. However, the changes must be studied carefully trying to avoid superfluous and trivial issues, outstanding cultural diversity

The pedagogic matters should be studied carefully so learning ergonomic subjects must be closely related to design solving problems and students interests.

5. DISCUSSION/CONCLUSIONS

Ergonomics must be improved and strengthened in different ways, so students have a better experience, a higher motivation and satisfaction, concerning the importance of this discipline in all their projects.

We have found that at the end of the undergraduate programs students choose theses related to health, better fixing products for disabled children or adults, well being of families better competitiveness and the need for innovation, without omitting sustainability and social responsibility, same issues as published in the International Ergonomics Association Home Page in *A strategy for human factors/ergonomics: developing the discipline and profession.* (Dul, J. et al, 2012).

6. REFERENCES

Aquino, O. (2011). *Secadora solar para bambú.* Tesis profesional. México: Facultad de Estudios Superiores Aragón, UNAM.

Cross, N. (2011). *Design thinking.* New York: Berg Publishers.

Dul, J. et al. (2012). A Strategy of Human Factors/Ergonomics: Developing the Discipline and Profession. In *Ergonomics.* Vol. 55. No. 4. April 2012. 377-395. London: Taylor and Francis. http://www.tandfonline.com/doi/abs/10.1080/00140139.2012.661087

Esrawe, Hector: https://www.google.com.mx/search?q=hector+esrawe+design&espv=2&tbm=isch&imgil=El_2s_W5lPMydM%253A%253BaLhEhaQFsoo7sM%253Bhttp. Retrieved: April 1st 2017.

Herman Miller Home Page: http://www.hermanmiller.com/products/seating/performance-work-chairs/aeron-remastered.html#/. Retrieved: April 1st , 2017.

International Ergonomics Association Home Page: http://www.iea.cc/whats/index.html. Retrieved: April 1st 2017.

Kelly, T. (2005). *The ten faces of innovation.* USA: Doubleday a Division of Random House.

Kroemer, K.H.E. (2006). *"Extra-Ordinary" Ergonomics.* Boca Raton, FL.: CRC Press Book.

Loughborough University Home Page: http://www.lboro.ac.uk/study/undergraduate/courses/user-centred-design/ Retrieved: April 1st, 2017.

Plan de Estudios de la Licenciatura en Diseño Industrial. (2002). México: Facultad de Estudios Superiores Aragón, UNAM.

The Interaction Design Foundation ApS DK, 2017) Home Page: https://www.interaction-design.org/literature/article/stage-1-in-the-design-thinking-process-empathise.

ADMINISTRATIVE WORKERS AND FIELD IN THE MINING INDUSTRY: AN EVALUATION OF PHYSICAL FATIGUE AND POSSIBLE CTD'S.

Jesus Anayanci Roman Ruiz[1], Alberto Ramirez Leyva[2], Oscar Manuel Roman Ruiz[3]

[1,3] Continuous Improvement Department
the area of machinery and Maintenance
Noche Buena Mine
Caborca City, Sonora State
Corresponding author's e-mail: anayanci.roman@construplan.com.mx

[2] Technological Institute of the Los Mochis
Industrial Engineer Depart
Juan de Dios Batiz Street and Belizario Dominguez
Fracc "El Parque"
Los Mochis City, Sinaloa

Resumen: En diversos sectores productivos, se ha extendido el uso de horarios nocturnos y largas jornadas laborales, lo que ha aumentado las probabilidades de errores y accidentes. Uno de los efectos más significativos es la fatiga, una respuesta normal del cuerpo frente a la falta de horas de sueño, que se manifiesta en cansancio físico y mental profundo que impacta negativamente en las personas, reduciendo su capacidad de estar alerta y la calidad de su desempeño laboral (Barreda O). La repetitividad del trabajo como la concentración necesaria para ejecutar la tarea, monotonía de movimientos corporales semejantes, la posición que debe asumir el trabajador para ejecutar la operación, el cansancio muscular y finalmente el estado general de salud del trabajador físico mental, dieta, descanso, estabilidad emotiva; además la duración del turno de trabajo es posiblemente causa de fatiga, porque no es lo mismo trabajar una jornada de 8 horas continuas a 12 hora continuas o más. La fatiga en diversas ocasiones podría presentarse e ir en aumento con respecto al tiempo debido al gasto de energía del trabajador (Niebel 1990).Las diversas causas de presentar fatiga en los trabajadores son: Laborales (turnos mayores a horas, días consecutivos de trabajo sin descansos adecuados, naturaleza de la tarea, y condiciones del lugar de trabajo, como el calor/frio, el ruido, la humedad, el polvo, la vibración, iluminación) .No-laborales (trastornos del sueño, responsabilidades y conflictos familiares, compromisos sociales, hábitos de alimentación no saludables, sedentarismo, tabaquismo y otros), los que impactan en el tiempo destinado a dormir y/o en la calidad de dicho sueño. Las consecuencias de manera inmediata:

Las personas fatigadas ven disminuidas sus capacidades de concentración. Molestias en diversas partes del cuerpo. Disminuyen sus tiempos de respuesta, su productividad y sus habilidades comunicativas. Alto grado de irritabilidad con lo que sus relaciones interpersonales sufren un deterioro que, en ocasiones, es

irreversible. Mayor probabilidad de error en sus tareas. Aumenta la posibilidad de sufrir un accidente. Las consecuencias a largo plazo: Aumentan los riesgos de enfermedades como la hipertensión arterial, el sobrepeso y la obesidad, la diabetes, el estrés y la depresión. La Organización para la Cooperación y el Desarrollo Económico (OCDE), México es el país miembro en el cual se trabaja más al año (dos mil 246 horas) y donde las personas se retiran a la edad más avanzada (73 años, en una nación cuyo promedio de vida es de 75).La calidad de vida de los trabajadores mexicanos se ve afectada por las extensas jornadas laborales, ya que México es el país donde los trabajadores laboran más horas al año, con 2,243, lo que representa 872 horas más que los que trabajan los alemanes (1,371 horas), dentro de los países miembros de la organización para la cooperación y el desarrollo económico (OCDE, 2016).

PALABRAS CLAVES: Lesiones, Productividad, Accidentes de trabajo.

Abstract. In several productive sectors, the common use of night schedules and long working days has been extended, which has increased the probability of errors and work accidents. One of the most significant effects is fatigue, a normal response of the body to the lack of sleep, manifested in deep physical and mental fatigue that negatively impacts people in general, reducing their ability to be alert and the quality of their work performance. The repetitiveness of work as the concentration necessary to perform the task, monotony of similar body movements, the position that the worker must assume to perform the operation, muscle fatigue and finally the general health of the physical mental worker, diet, rest, and emotional stability; In addition to this, the duration of the work shift possibly cause fatigue, because it is not the same to work for 8 hours straight than 12 hours or more. Fatigue, on various occasions could be presented by itself and have an increase due to the time of the worker's energy expenditure.

The various causes of worker fatigue are: Labor (long hour shifts, consecutive working days without adequate breaks, nature of the task, and workplace conditions such as heat / cold, noise, humidity, dust, vibration, lighting). Non-labor (sleeping disorders, family responsibilities and conflicts, social commitments, unhealthy eating habits, sedentary lifestyle, smoking and others) which impact on the time spent sleeping and / or the quality of sleep. Consequences Immediate results: People who are fatigued are less able to concentrate.

Discomfort in various parts of the body. They reduce their response times, their productivity and their communicative skills. High degree of irritability with which their interpersonal relationships suffer deterioration that, at times, is irreversible. Increase probability of error in their tasks. Increase the chance of an accident. Consequences Long term: They increase the risks of diseases such as hypertension, overweight and obesity, diabetes, stress and depression. The Organization for Economic Co-operation and Development (OECD), states that Mexico is the member country where the working time is carried out most a year (two thousand 246 hours) and where people retire at the advanced age (73 years, in a Nation whose average life is 75). The quality of life of Mexican workers is being affected by the long working hours, since Mexico is the country where workers work

more hours per year, with 2,243, which means 872 hours more than the German workers (1,371 Hours) within member countries of the Organization for Economic Cooperation and Development (OECD). Provide an overview regarding the effects of fatigue on workers of a mining company to provide preventive measures in order to minimize errors in its activities, work accidents and injuries.

KEYWORDS: Injuries, Productivity, work accidents.

1. INTRODUCTION

This is common in jobs that require a high physical and mental load, leading workers to the limit of their demands forcing themselves to work beyond their psychophysiological possibilities.

The accelerated pace of work nowadays, propitiates that the workers are subject to work under the pressure of time, in addition to an extensive work schedule; which causes, in the medium or long term, consequences in their performance to make errors or occupational accidents due to work fatigue. The result of this ends in bad repercussions for the personnel, the company and its surroundings by diminished performance, errors increase, demotivation, and loss of initiative.

2. OBJECTIVES

2.1 GENERAL OBJECTIVES

Know the level of fatigue of workers at the end of their work.

2.2 PARTICULAR OBJECTIVES

Identify the effects of fatigue on workers.
Identify potential CTD's.
Measures to be taken to reduce fatigue in workers.

3. DELIMITATION

The investigation was carried out in the company Planned Constructions, mine noche buena to personnel of the department of the area of machinery and equipment that carry out administrative and field activities. During their "eleven" work and when they employ extra times.

4. METHODOLOGY

Currently there are several methods to assess physical fatigue, in this work the fatigue be evaluated subjectively by 4 point scale of the Luke, Corlett & Bishop to understand and evaluate the degree of discomfort in different parts of the body. Yoshitake to understand “how do you feel”.

5. RESULTS

5.1 4 POINTS OF LUKE.

From the 9th day of work, the staff starts their day with a degree of “tired” fatigue to a degree of "very tired" fatigue by the end their work activities. See Figure 1. Luke’s 4 Points Fatigue Level Chart, With a tendency to increase the degree of fatigue in overtime see figure 2. Luke’s 4 Points Fatigue Level Chart.

5.2 YOSHITAKE

Related fatigue symptoms of Yoshitake’s Fatigue figure 3 in 11 days of work: tired body, tired sight and headache; with a tendency to increase the degree of fatigue in overtime see figure Yoshitake’s Fatigue figure 4.

5.3 CORLETT AND BISHOP

Difficulty for straight posture and pain the neck. And presence of discomfort or pain in the body: See figure 5. Corlett & Bishop Bars Chart: with high degree of discomfort in lower back, top back, head and feet, with medium degree of discomfort in half back.

There is presence of pain in workers in various parts of the body such as:
Pain in their feet at the end of the 8th working day.
Shoulder pain at the end of the 8th working day.
Headaches at the end of the 9th working day.
Neck pain at the end of the 9th working day.
High back pain at the end of the 9th working day.
Thigh pain at the end of the 9th working day.
Leg pain at the end of the 10th working day.
The presence of pain in the workers begins in the 8th day of work, becoming CTD's.

Fatigue can cause accidents, cause problems to the people’s health and generate a decrease in productivity. It is also manifested as a feeling of weakness and exhaustion accompanied by discomfort, even pain and inability to relax. Fatigue is a consequence of stress, workload, lack of rest, etc.

6. FIGURES AND TABLES

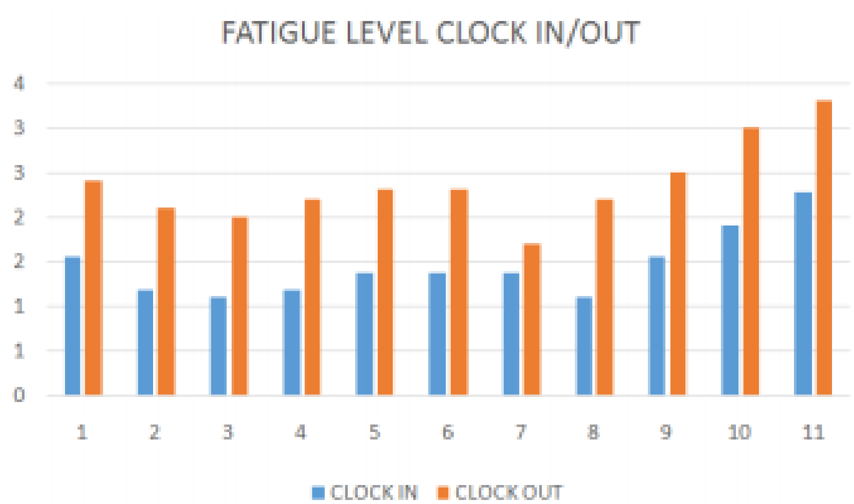


Figure 1. Luke's 4 Points Fatigue Level Chart
(1. Not tired,2. Tired, 3.very tired,4. Extremely tired)

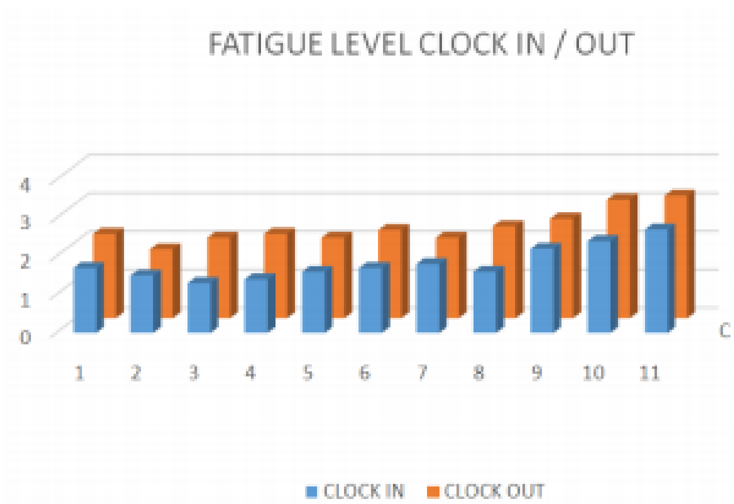


Figure 2. Luke's 4 Points Fatigue Level Chart
(1. Not tired, 2. Tired, 3.very tired, 4. Extremely tired)

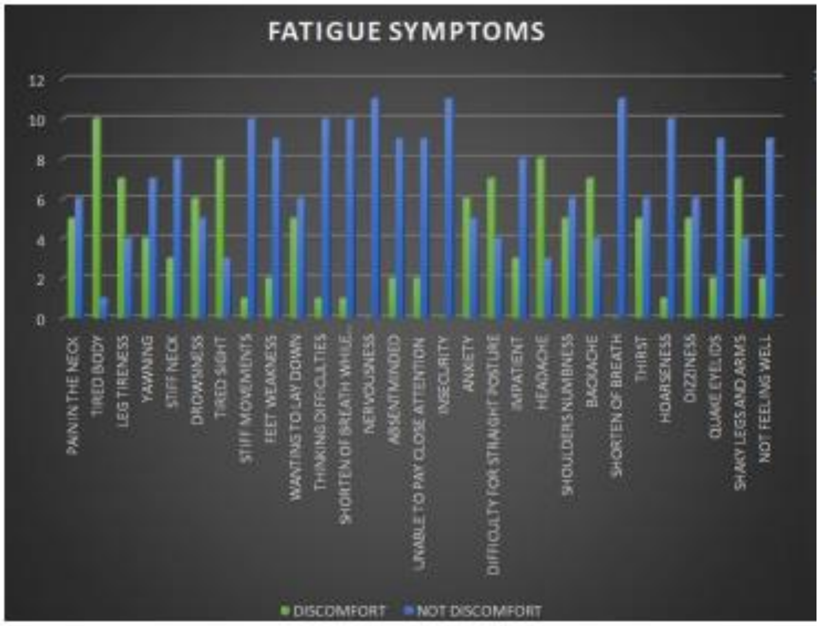


Figure 3. Yoshitake' Fatigue Charts

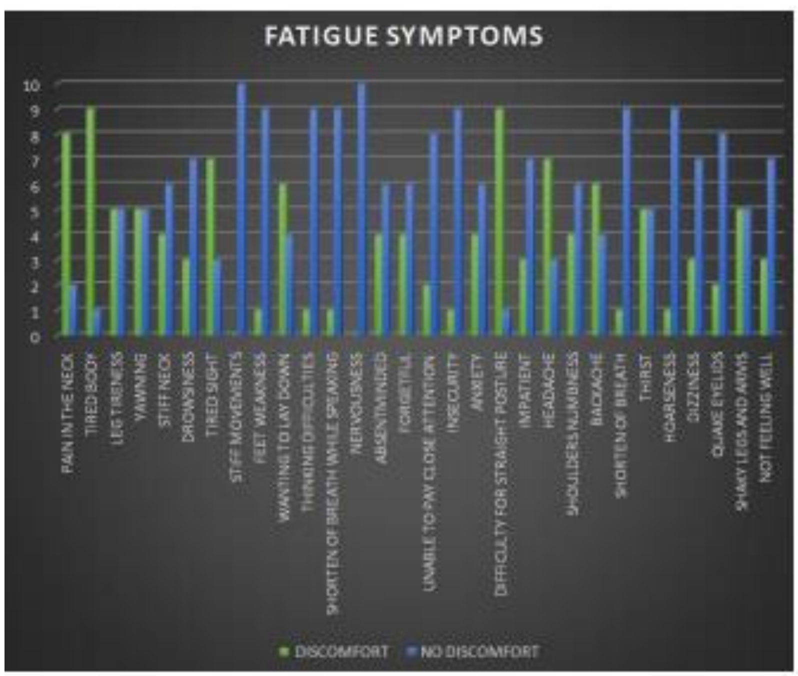


Figure 4. Yoshitake' Fatigue Charts

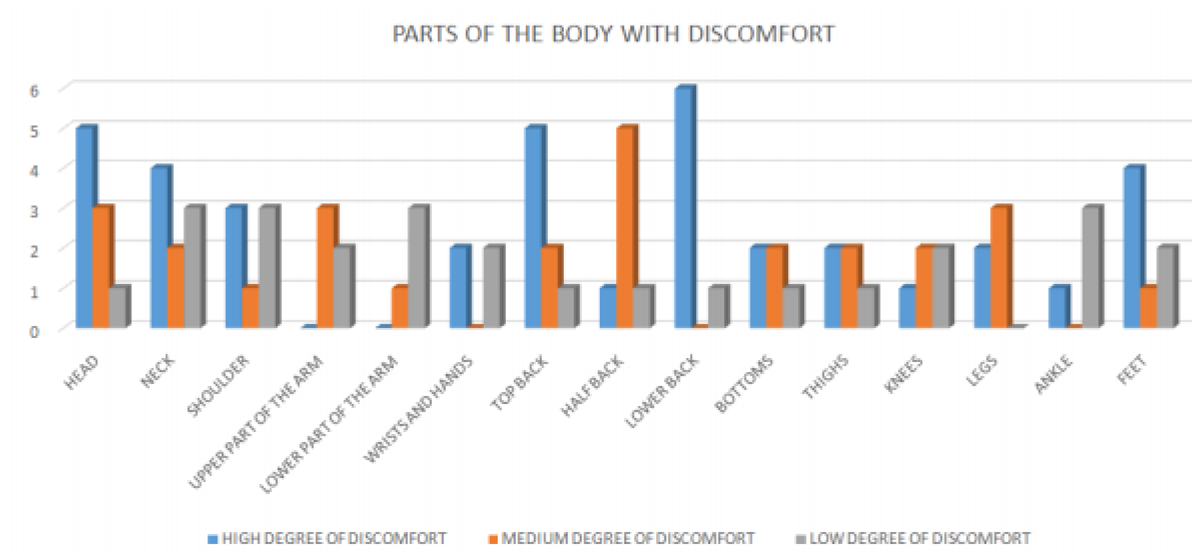


Figure 5. Corlett & Bishop Bars Chart

7. DISCUSSION/CONCLUSIONS

From the 9th day of work, the staff starts their day with a degree of “tired” fatigue to a degree of "very tired" fatigue by the end their work activities. There is presence of pain in workers in various parts of the body such as: Pain in their feet, Shoulder pain, Headaches, Neck pain, High back pain, Thigh pain and Leg pain. The presence of pain in the workers begins in the 8th day of work, becoming DTA'S.

8. RECOMMENDATIONS

Based on the applied surveys, to reduce the levels of fatigue in the workers it is proposed:

To have an ideal role 10 days of work x 4 days of rest. (Work role frequently applied in mines).

Evaluate jobs and suggest improvements that fit the job.

Avoid physical overload, monotony, poor posture and / or repetitive movements.

Do physical exercise of medium intensity, minimum three times a week, at least half an hour. Perform rotation / relay when task is exhausting, repetitive or routine.

Perform ergonomic exercises (stretching) before starting activities.

"Distribute breaks of 10-15 minutes at mid-morning and mid-afternoon, giving the possibility of consuming fruits, vegetables or nutritional supplements that increase the energy level."

9. REFERENCES

Acosta D. (2016) Autonomous University Of Baja California
http://www.angelfire.com/un2/ergonomia/dtas.html
Barreda O. (2012) http://www.emb.cl/hsec/articulo.mvc?xid=58&edi=3&xit=la-fatigalaboral-como-origen-de-accidentes
Hernandez R (2016) Articulo de investigación:
de El coordinador de Salud en el Trabajo de la Facultad de Medicina de la UNAM, http://www.gaceta.unam.mx/20161103/horarios-prolongados-de-trabajo-afectan-la-salud/
08 diciembre 2016
Masud and Fernandez (1990). investigacion sobre la determinación de fatiga física en trabajadoras de la industria textil del norte de Sinaloa de Ramirez A, Meza P. http://www.semac.org.mx/archivos/5-23.pdf
Mosquera J. (2016)
https://es.slideshare.net/colegiodemedicosdelguayas/ergonomia-y-pausas-activas
27 septiembre 2016
Niebel (1990)
http://www.izt.uam.mx/sotraem/Documentos/Documentos/Amet2003/templates/res/tema%209/GILBERTO%20ORRANTIA-ENRIQUE%20DE%20LA%20VEGA.pdf
http://www.insht.es/InshtWeb/Contenidos/Documentacion/TextosOnline/EnciclopediaOIT/tomo2/43.pdf
file:///C:/Users/cplan2016/Desktop/ARTICULOS%20DE%20FATIGA/GILBERTO%20ORRANTIA-ENRIQUE%20DE%20LA%20VEGA.pdf
Saavedra A. (Febrero 2015) jornadas laborales y salud del trabajador: factor de cuidado. http://www.construccionminera.cl/jornadas-laborales-y-salud-del-trabajador-factor-de-cuidado/
https://www.forbes.com.mx/de-todo-el-mundo-mexico-es-el-pais-donde-mas-horas-se-trabajan/
La Organización para la Cooperación y el Desarrollo Económico OCDE, (2016).
Estadísticas laborales IMSS (reportes estadísticos 2000-2011).
http://www.milenio.com/cultura/Estres-fatiga-cuadro_oficial_enfermedades_laborales-STPS_IMSS-trabajo_presion_0_732526753.html

LABOR FATIGUE IN ARMED DESKTOP WORKERS.

Alma Citlali Ramírez Flores, Isaac Infante Palomino, Jiasü Jiarü Benítez Marín, Román Juárez Becerril, Raquel Muñoz Hernández

División de Ingeniería Industrial y de Sistemas.
Universidad Politécnica del Valle de México.
Av. Mexiquense s/n, Col. Villa Esmeralda,
C.P. 54910, Tultitlán, Estado de México.
jael2222@hotmail.com

Resumen: En la investigación se desarrolló un estudio de trabajo en una empresa de escritorios del estado de México municipio de Tultitlan de Mariano Escobedo, específicamente en el proceso de empaque de escritorios, con el fin de identificar los factores de riesgo a la salud de los trabajadores, así como la evaluación del posible iesgo de adquirir enfermedades profesionales.

Se utilizaron diferentes metodologías con las cuales se evaluaron las posturas, fuerzas, y actividades musculares, así mismo, se realizó un estudio de condiciones antropométricas y de condiciones ambientales tales como: ruido, iluminación y temperatura. Como conclusión se mencionan algunos principios ergonómicos en el desempeño de la tarea y recomendaciones de equipo de protección personal para minimizar el riesgo de adquirir enfermedades profesionales.

Palabras clave: Ergonomía, estudio de trabajo, lesión, puesto de trabajo

Relevancia para la Ergonomía: Con la aplicación permanente del Método Rula, se puede considerar que la Ergonomía, es preventiva y correctiva, pero que también puede ser aplicada para controlar los procesos y evitar daños a la salud.

Abstract: In the investigation, a study was carried out in a desk company in the Mexican state of Tultitlan de Mariano Escobedo, specifically in the process of packaging desks, in order to identify risk factors for workers' health, As well as the evaluation of the possible risk of acquiring occupational diseases.

Different methodologies were used to evaluate muscular postures, forces, and activities. A study of anthropometric conditions and environmental conditions such as noise, illumination and temperature was also performed. In conclusion, some ergonomic principles in the performance of the task and recommendations of personal protection equipment are mentioned to minimize the risk of acquiring occupational diseases.

Keywords: Ergonomics, work study, injury, workplace.

Relevance to Ergonomic: With the permanent application of the Rula Method, it can be considered that Ergonomics is preventive and corrective, but can also be applied to control the processes and avoid damage to health.

1. INTRODUCTION

The company studied is dedicated to the design and manufacture of office furniture, for the present study was delimited to the area of wooden desks.

This line focuses its designs towards contemporary styles, rustic, minimalist and modernist classics with great exclusivity, made of wood.

As it is a material that requires phytosanitary inspections, prior to manufacture, the materials are pre-immunized in accordance with Mexican Official Standard NOM-144-SEMANART-2015, which establishes phytosanitary measures and the requirements of Brand internationally recognized for the wooden packaging.

Based on it, it is carried to the oven which remains on for 12 days, where the wood dries, but is allowed to stand three days with the wood inside, so the wood has a drying process in the oven for 15 days. The wood is removed from the furnace and passed to the radial machine, this cuts the raw wood to begin the machining process.

Cut the wood according to the size of the piece that is needed, cut a series of pieces for a certain amount of furniture, take out several pieces of various furniture at the time.

Within the machining process the assembly is carried out by means of the machine for the drilling and gouging. During the machining and figuration process, templates are drawn and the fumigating machine cuts a certain shape on the wood, from this process the frames of combers and all forms that have curves come out. The whole described process is carried out without the aid of loading equipment because the sawing area is limited in its process due to the lack of tools or elements that will technify its process and eliminate in a percentage the intervention of workers who avoid all The ergonomic problems caused by the handling of loads.

Figura 1. Temperaturas durante el año en la zona de producción.
***Fuente*:** Creación propia.

Accidents at work are frequent due to unsafe working conditions, which can lead to illness, temporary or permanent injuries and even death, and consequently reduce the efficiency, productivity of each worker and loss of production, Causing poor product quality and all of this generate sales losses for the company.

The staff is divided into two large areas: 22% do administrative work and 78% do productive work, so the percentage of workers who work in areas that have greater exposure to risk is very high, and not being Controlled by a system based on prevention, the likelihood of an occupational accident is high.

The working day depends on the demand for daily work; In general, the work shift starts at 7:00 and ends at 4:00 p.m., with 8 working hours a day, since one hour corresponds to the daily lunch of each worker. Although sometimes the operator works up to 12 hours depending on the demand, they remain until the order is concluded.

The physical infrastructure of the company has been built without a previous plan, but the distribution of work areas has been changing as the market grows.
Due to accidents caused by heavy loads, operators wear wool gloves to protect hands from blistering, but they are already very worn and broken, since there is no program to replace personal protective equipment and The company does not have training, training and induction staff. The flow of communication is not efficient in terms of occupational safety and health, due to the fact that there are no tools or means used to disseminate security issues or matters of business interest. (Llomovatte & Wischnevsky, 2007).

A task analysis has not been performed to assess possible occupational hazards and thus to be able to control them

2. OBJECTIVES

Analyze the conditions under which each activity is performed to identify possible risk of DTAs, per workstation and environmental conditions.

3. METHODOLOGY

3.1. Characteristics of the study.

Only production processes were evaluated in the packaging area of the desks, ie the manufacture or area of machines is not included.
The manufacturing company is made up of a team of collaborators differentiated into two large groups, which are what develop administrative activities and those that develop operational activities of the company, who are in the area of Upholstery and are the most vulnerable By the type of work they perform.
At present there are a total of 43 employees, including administrative and operational workers; Table 1 details their distribution by the type of work they perform.
The factory facilities are located in an area of greater commercial movement in the area.

3.1.1 Method LEST

It is a method of global evaluation, that is, that studies the post as a whole, valuing all aspects that surround it such as environmental, physical, mental, psychosocial and working time.

This method seeks to describe working conditions as objectively as possible, in order to have an overall view that allows a precise assessment of the position and working conditions, which serves as a basis for defining a program of improvements in the Different jobs.

The method was developed in order to be independent of the interpretations of whoever observes and collects data and information on working conditions, analyzed in the most objective way possible, to establish an accurate diagnosis about the position. An observation guide all the necessary information to characterize the conditions of work of a position, to establish a diagnosis and to determine the satisfactory or harmful working conditions, based on the existing norms, knowledge about the human being and his health in the work. The evaluation is done on a ten-point scale.

The method is applicable to industrial workers, who are little or nothing specialized, although their design does not include tasks where the worker is exposed to variations in environmental conditions due to irregular movement between different environments or work abroad, and Nor does it allow an adequate assessment of the mental load for jobs where the content of the task can vary daily. In order for workers to gain some control over their work, studies on working conditions should be undertaken by them or with them, and the LEST method can be considered as a tool made available to all those who are interested or involved For all these problems, but it is susceptible of being modified, discussed and perfected. (Bonilla, 2012).

For this method it is indispensable to take into account the opinion of the person who occupies the position evaluated. For this reason, an individual interview is carried out with the personnel of the carpentry sector who provide subjective information of the job in the sector previously mentioned. (Cañas, 2011).

Table 1 shows a Likert scale for the assessment of environmental conditions.

Tabla 1. Puntuación para valoración de condiciones ambientales

Puntuación	***Percepción del trabajador***
0, 1, 2	Situación satisfactoria
3, 4, 5	Molestias débiles. Algunas mejoras podrían aportar mayor confort al trabajador
6, 7	Molestias Medias. Riesgo de fatiga
8, 9	Molestias fuertes. Fatiga
10	Nocividad

Fuente: Creación propia.

3.1.2. Method o Plibel.

Use a checklist of 36 MR, MMC, and PF questions. - Evaluates: nape, shoulders, back, elbows, forearm, hands, feet, knees, hips and lower back. - It takes about 30 min. - Favorable cost-benefit ratio. - Handles a wide range of risk factors. The evaluation of a workplace using the PLIBEL list starts with a preliminary observation and an interview with the worker, then select parts of the activity that are representative for the evaluation, in addition to the tasks that the observer and / or worker consider Stressors in the musculoskeletal system - when an ergonomic risk is observed. The evaluation in the interview is conditioned by the capacity of the observer, then requires some skill in this task. (Bellοví, 2013).

Environmental conditions were evaluated in contrast with the Mexican Normativity.

3.1.3. Conditions Of Work (Llaneza, 2008).

Physical environment

1. Thermal environment
2. Noise
3. Lighting
4. Vibrations

Physical load

5. Static charge
6. Dynamic load

Mental load

7. Time requirements
8. Complexity
9. Attention

Psycho-sociological aspects

10. Initiative
11. Social status
12. Communications
13. Relationship to the command
14. Product identification
15. Working time

4. RESULTS

1. *Thermal environment*

The interior temperature of the room is very influenced by the outside temperature since the premises does not have centralized air conditioning equipment. Ventilation in the room is natural and is based on opening and closing windows. In this way, non-adjustable air currents are established.

The temperatures inside the premises in different periods of the year.

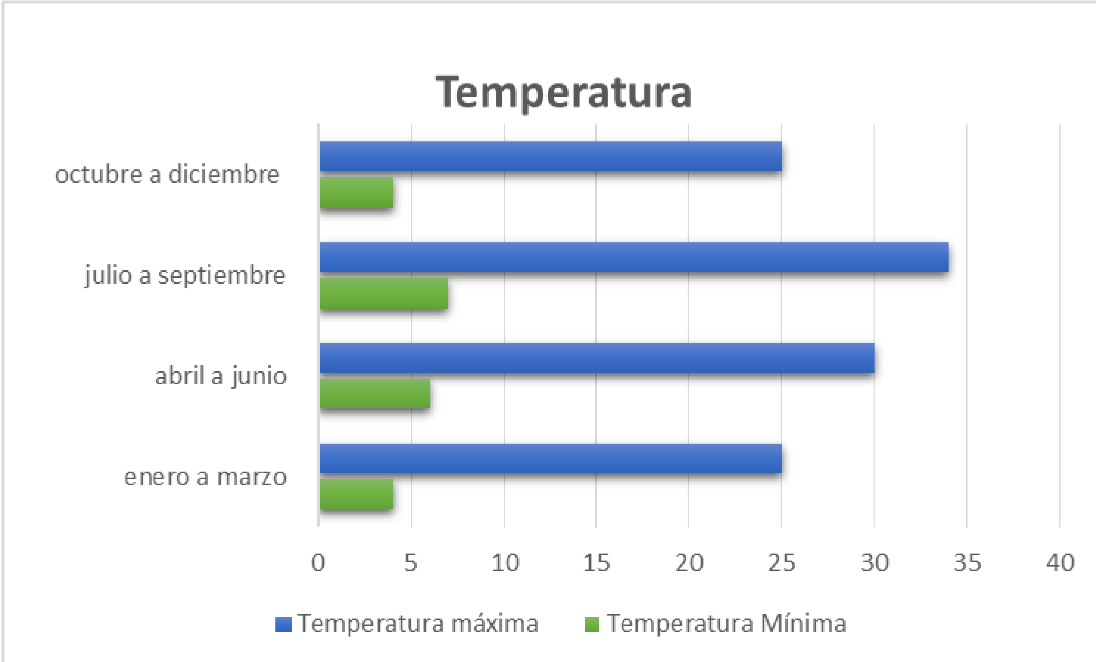


Figura 2. Temperaturas durante el año en la zona de producción.
***Fuente*:** Creación propia.

The relative relative humidity is 74% throughout the year.

2. Noise

The carpentry sector is noisy, ranging from 85-92 dBA when all the equipment is in operation (drills, planer, endless saw, among others). The Mexican Official NOM-011-STPS-2001, establishes the safety and hygiene conditions in maximum limits of exposure to noise, which for this case is a maximum of 90dBA, which is exceeded. (DOF, 2014)

3***. Lighting***

The room has natural light due to the windows, although the level is not enough to develop the work and is complemented by artificial lighting consisting of fluorescent tubes. This is not uniform, it is between 100 and 1500 lux, depending on the climatic conditions.

4***. Vibrations***

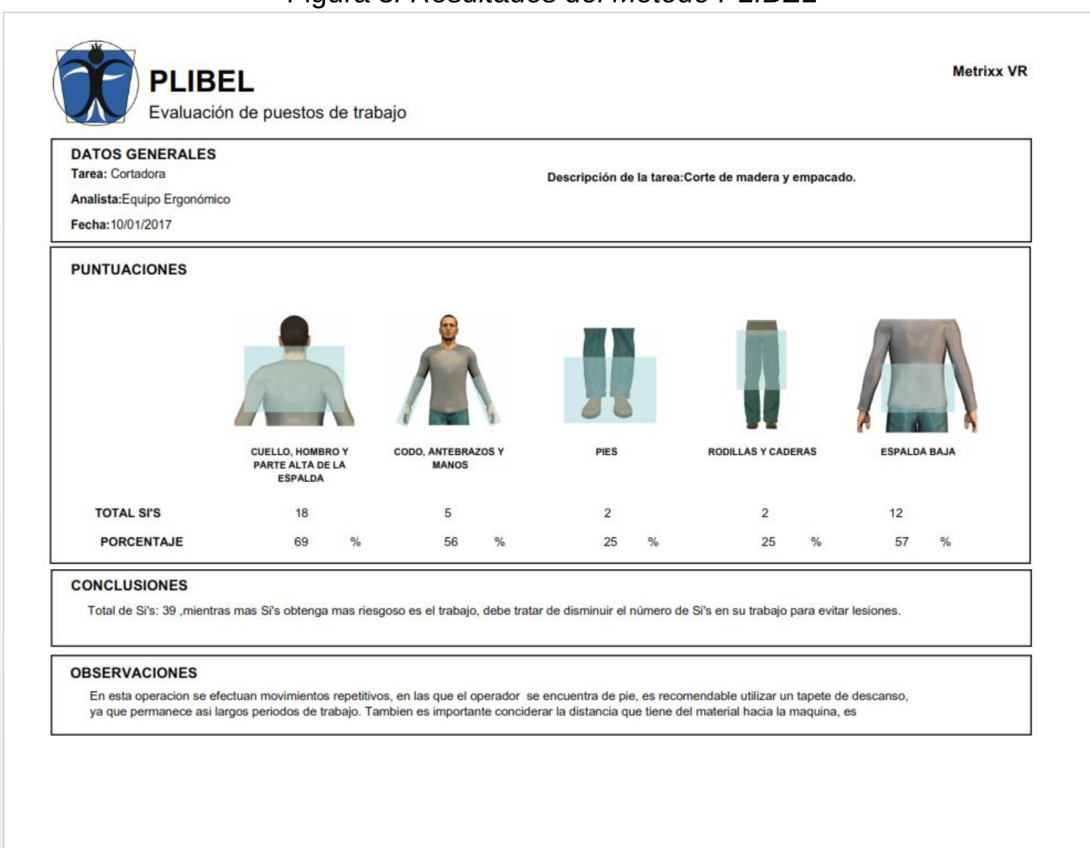
The only vibrations that occur in a slight way is when the parts are held when the electric machines are used.

Table 2 shows the overall results according to the table of:

		Puntuación	
Puesto de trabajo		Puesto de trabajo en Sierra de banco	Puesto de trabajo en Cepillo
Ambiente térmico	5	6	6
Ruido	7	8	8
Iluminación	6	6	6
Vibraciones	1	1	1
Carga estática	5	5	5
Carga dinámica	7	7	7
Exigencias de tiempo	4	4	4
Complejidad	0	0	0
Atención	8	7	6
Iniciativa	2	2	2
Estatus social	4	4	4
Comunicaciones	2	2	2
Relación con el mando	0	0	0
Identificación del producto	1	1	1

Fuente*: Creación propia.*

Figura 3*. Resultados del Metodo PLIBEL*



PLIBEL
Evaluación de puestos de trabajo
Metrixx VR

DATOS GENERALES
Tarea: Cortadora
Descripción de la tarea:Corte de madera y empacado.
Analista: Equipo Ergonómico
Fecha:10/01/2017

PUNTUACIONES

	CUELLO, HOMBRO Y PARTE ALTA DE LA ESPALDA	CODO, ANTEBRAZOS Y MANOS	PIES	RODILLAS Y CADERAS	ESPALDA BAJA
TOTAL SI'S	18	5	2	2	12
PORCENTAJE	69 %	56 %	25 %	25 %	57 %

CONCLUSIONES
Total de Si's: 39 ,mientras mas Si's obtenga mas riesgoso es el trabajo, debe tratar de disminuir el número de Si's en su trabajo para evitar lesiones.

OBSERVACIONES
En esta operacion se efectuan movimientos repetitivos, en las que el operador se encuentra de pie, es recomendable utilizar un tapete de descanso, ya que permanece asi largos periodos de trabajo. Tambien es importante conciderar la distancia que tiene del material hacia la maquina, es

Fuente: Creación propia.

5.CONCLUSIONS

Several proposals were made to improve the conditions of the workers, which were implemented gradually, among them is to carry out a continuous evaluation with the implementation of the methods LEST and PLIBEL with which are evaluated postures, forces and muscular activity In which they are working, permanently. (Camargo, 2013).

The obtained results indicate that the conditions in which the worker is found have improved, since the procedures are respected and in this way it is expected to minimize harmful consequences for his health. (Barrios, 2014).

With regard to environmental conditions it is proposed:

1. ***Thermal environment***

To improve this critical aspect place heating for winter and air conditioning for the summer, ie fans and heaters, depending on the season of the year.

Noise

- Perform work noise measurement according to Official Mexican Standard NOM-011-STPS- 2001 (DOF, 2014).
- Keep work equipment in good working order as machines or tools with poor maintenance produce a higher level of noise and vibration.
- Stop work equipment when not in use.
- Use hearing protection against all types of noise: automatic machines, motors, tools, surface beating.

3. ***Lighting***

Perform lighting measurement NORM Official Mexican NOM-025-STPS-2008, Lighting conditions in work centers. (DOF, 2014).

Perform a survey to replace burned and depleted lamps with new ones.

Start up a program of preventive maintenance of all the luminaires and that includes the cleaning of the same ones.

6. ***Dynamic load***

Use mechanical assistance to eliminate or reduce the effort required to handle tools and work objects. As for example, the cart that is currently used. At first they were proposed to incorporate a forklift vehicle that manipulates, loads and transports the blocks of wood to the sawmill mechanically, but because the company is of the family type and still does not have a large economic solvency was not very viable for the company , So it is necessary another multifunctional design for the handling of heavy raw material. (Alfaro, 2006).

After analyzing for several weeks the process of loading and unloading of wood and its complications this work caused, analyzed and exposed the most viable solution in both design and economics and that could solve the aforementioned problems of ergonomics. (Castro, 2016).

The project consists in realizing a system of rails or track with rotating axes that allow the sliding of the wood until the reach of the crane located in the sawmill, avoiding that the operator loads the block by the 10 meters of space of the patio to the mountain range; You only have to put the blocks and push them to reach the crane.

6. REFERENCES

Alfaro, K. (2006). La Ergonomía: Productividad y la prevención de riesgos a la salud. Copersa ingenieria, Vol.I pp13-19.

Barrios, M. (2014). Efectos de desgaste laboral, como riesgo psicosocial, en la productividad. Universidad de Carabobo. Estudios de psgrado. Barbula, Venezuela.

Belloví, M. B. (2013). Análisis coste beneficio en la acción preventiva (I): bases conceptuales. Notas Técnicas de Prevención.: Instituto Nacional de Segurida e Higiene en el Trabajo. España

Bonilla, E. (2012). La importancia de la productividad como componente. Revista académica de economía. V. IX. Pp 12-19.

Camargo, N. E. (2013). La enseñanza de la ergonomía en México, Arcos Design, V-7, pp. 115-137.

Cañas, J. (2011). ERgonomia en los sistemas de trabajo (Vol. I). Universidad Tecnopogica de Granada. España.

Castro, V. (2016). Propuesta de un programa de Salud en el Trabajo, basado en el estudio de riesgos disergonómicos para mejorar la productividad económica. USAT. Chiclayo, Perú.

DOF. (2014). Diario Oficial de la Federación. Recuperado de:http://www.diputados.gob.mx/LeyesBiblio/regla/n152.pdf

Llaneza, J. (2008). Ergonomía y psicosociología aplicada. Manual para la formación del especialista. Valladolid: Lex Nova.

Llomovatte, S., & Wischnevsky, J. (2007). Condiciones laborales de los docentes universitarios en los 90 y algunos resultados de investigación. Praxis Educativa, pp. 15-16.

DETERMINATION OF PHYSICAL FATIGUE IN WORKERS USING MANUAL SCISSORS

Martha Guadalupe Valdez Ochoa, Alberto Ramírez Leyva,
Alondra Cecilia Castro Zamora, Jesús Pioquinto Delgadillo Mora

marval_o@yahoo.com.mx
Technological Institute of Los Mochis
Los Mochis, Sin. Mexico

RESUMEN: Se cree que el uso de tijeras manuales afecta el desempeño de trabajadores en telas y costureras, por lo que se aplicarán dos metodos para la evaluacion ergonómica de estos empleos, los cuales son Yoshitake y 4 puntos de Luke para determinar el porcentaje de fatiga y cansancio que se esta presentando. Para la obtención de resultados se hizo un conteo de todas las encuestas aplicadas a los 15 trabajadores seleccionados, determinando cuales síntomas eran los más frecuentes, así como la evaluación de las personas con el más alto nivel de FQF en las diferentes semanas.

PALABRAS CLAVE: Cansancio, costureras, corte.

ABSTRACT: It is believed that the use of manual scissors affects the performance of workers in fabrics and seamstresses, so two methods will be applied for the ergonomic evaluation of these jobs, which are Yoshitake and 4 Luke points to determine the percentage of fatigue and tiredness that is being presented. To obtain results, a survey was made of all the surveys applied to the 15 selected workers, determining which symptoms were the most frequent, as well as the evaluation of the people with the highest level of FOQ in the different weeks.

KEYWORDS: Tiredness, seamstresses, cut.

1. INTRODUCTION

The presence of discomforts and ailments that suffer much of the work population indicates that the work is not adapted for an efficient performance of the same. Therefore, all aspects related to the activity must be rethought to prevent the worker from putting his health at risk and at the same time that his physical integrity is not affected.

When referring to cutting activities, it could be minimized that this part of the process could not generate major labor conditions, and when contemplating that there are some factors that could fatigue the worker as is the time of cutting action continuously or As well as the size of the area to be cut, in addition to the material that they will manipulate that could present some resistance to make cuts in it, it is difficult to find a position, technique or tool that allows the execution of a cut with less tension in Fingers and wrist, adapting to all the needs of the process and protecting the health of the operator.

2. JUSTIFICATION

To carry out this investigation was attended to the fabric stores where the behavior of workers was observed in the function of their work. Through small interviews with the workers, it was verified that they were actually inconvenienced by the use of scissors, which are their working tools.

Therefore, it is possible to present greater complications in the health of the workers, being necessary to apply the methods of subjective evaluation Yoshitake and Four points of Luke to determine if it presents or not fatigue in general.

3. OBJECTIVES

3.1 General Objective

To determine the presence of physical and mental fatigue caused by the use of manual scissors through the application of subjective assessment methods such as Yoshitake and Luke's Four Points. In addition to using the results obtained to follow up on this problem.

3.2 Specific Objectives

- To warn of the risks to which the operators are exposed, due to the cutting activities.
- Analyze the factors involved in the appearance of physical or mental fatigue, inside or outside of work.
- Identify the level of fatigue and fatigue experienced by workers.
- Find the relation between the different tasks that make use of scissors.

4. DELIMITATION

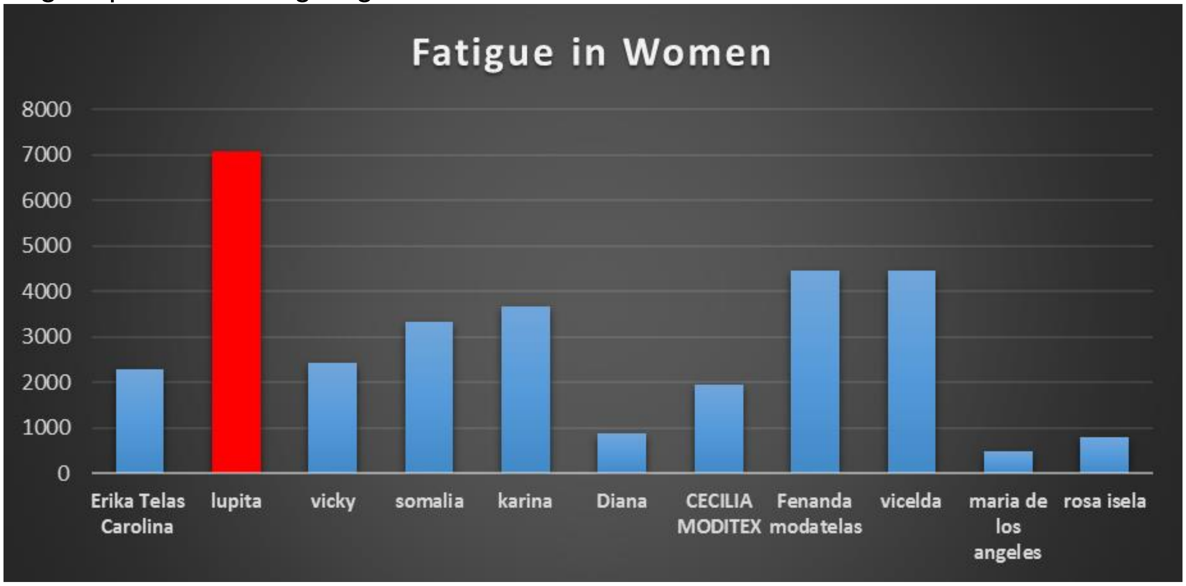
All those workers who need to use scissors as fabric dispatchers in the city of Los Mochis and who were also willing to cooperate for this investigation were surveyed.

5. METHODOLOGY

They were asked to collaborate with 15 different workers, such as seamstresses and local business cloth dispatchers for a period of three consecutive weeks from Monday to Sunday with a rest day, the average entry time is 10:00 a.m. And the time of departure being at 8:00 pm on their working days. For the determination of fatigue, the method of subjective evaluation of Yoshitake was used, for results the Luke 4-point method was used, being a simple scale to define the existence of fatigue or tiredness.

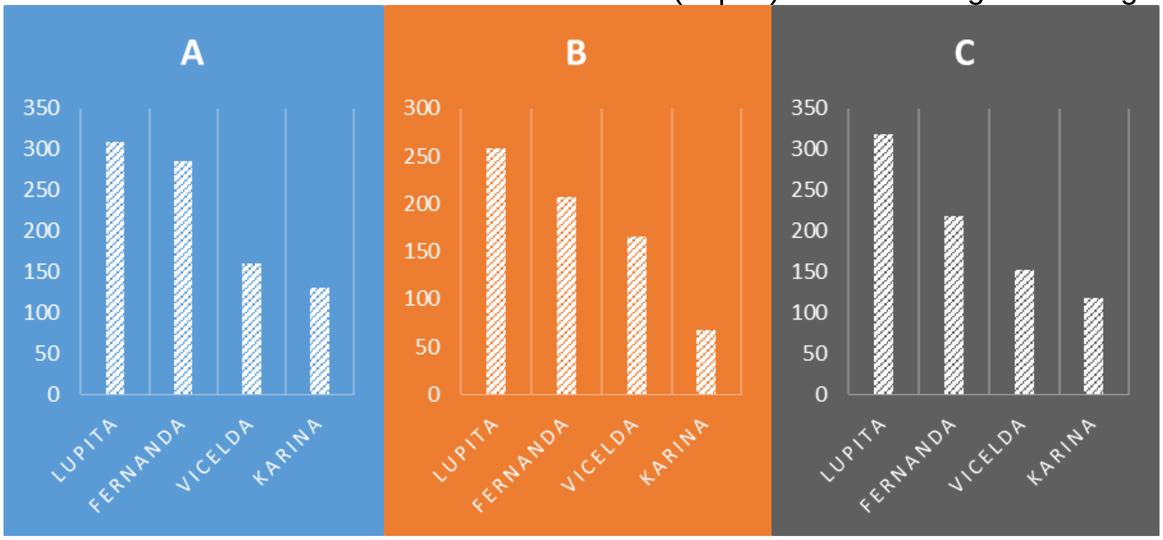
6. RESULTS

For the purposes of a better appreciation of the results, the sample was divided and 30% of the workers were selected, of which their accumulated Fatigue Frequency (FQF) was higher. With the answers of the volunteers, it was possible to determine that the FQF of the Symptoms of Drowsiness and Monotony registered at the beginning and the end of their working days during the 3 weeks of the application of the test, cause greater problems to the workers, this being Area that generates the largest portion of fatigue generate.



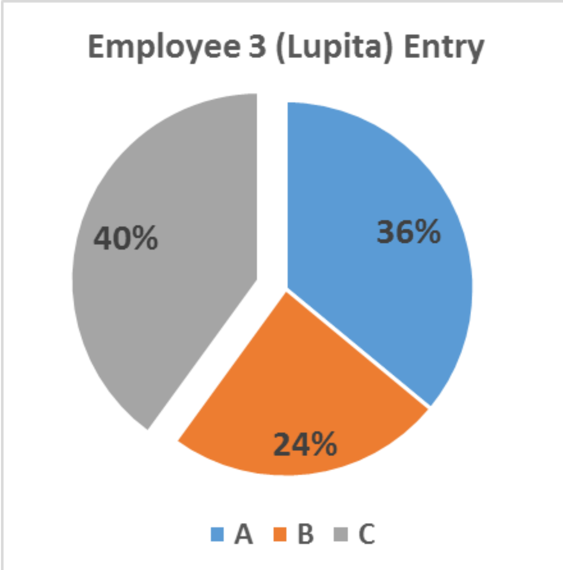
Graphic 1. Cumulative fatigue of all women who participated

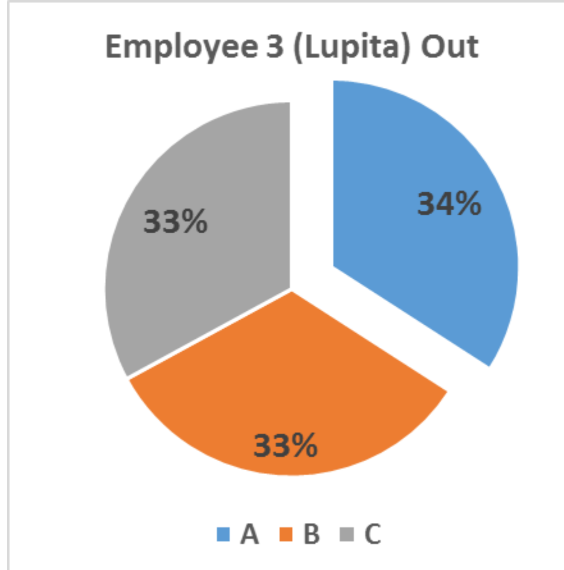
In the 3 areas it can be observed that worker 3 (Lupita) suffers from greater fatigue.



Graphic 2. Levels of fatigue with Yoshitake for the 4 employees most affected

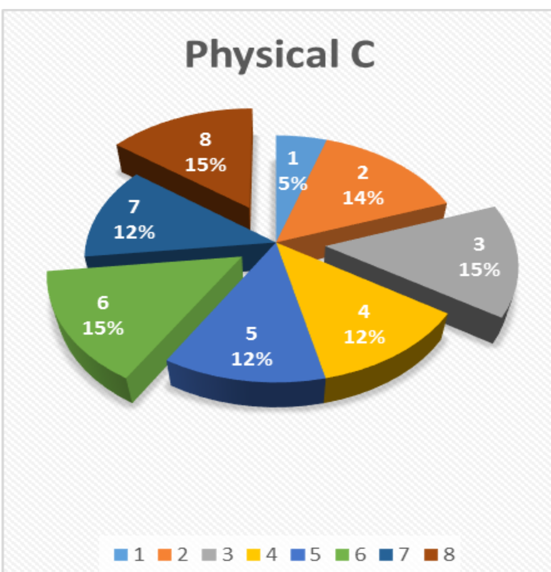
The symptoms of physical fatigue (C) at the beginning of the day were found to generate the most fatigue per day. And it is observed that the Monotony and Somnolence (A) zone presents a higher frequency of occurrence at the exit.

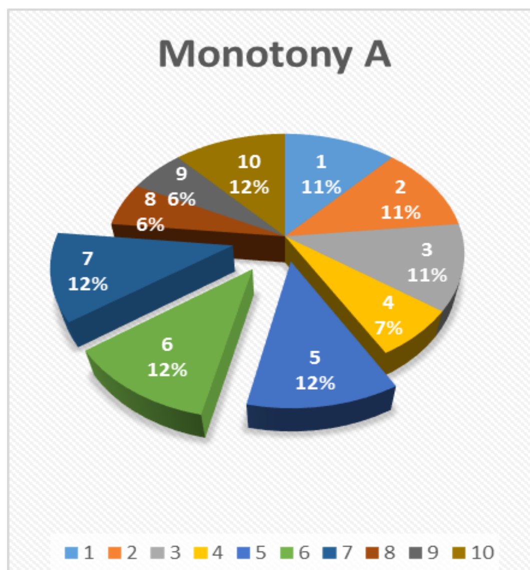




Graphic 3 and 4. FQF percentages, divided into the three areas at the entrance and exit

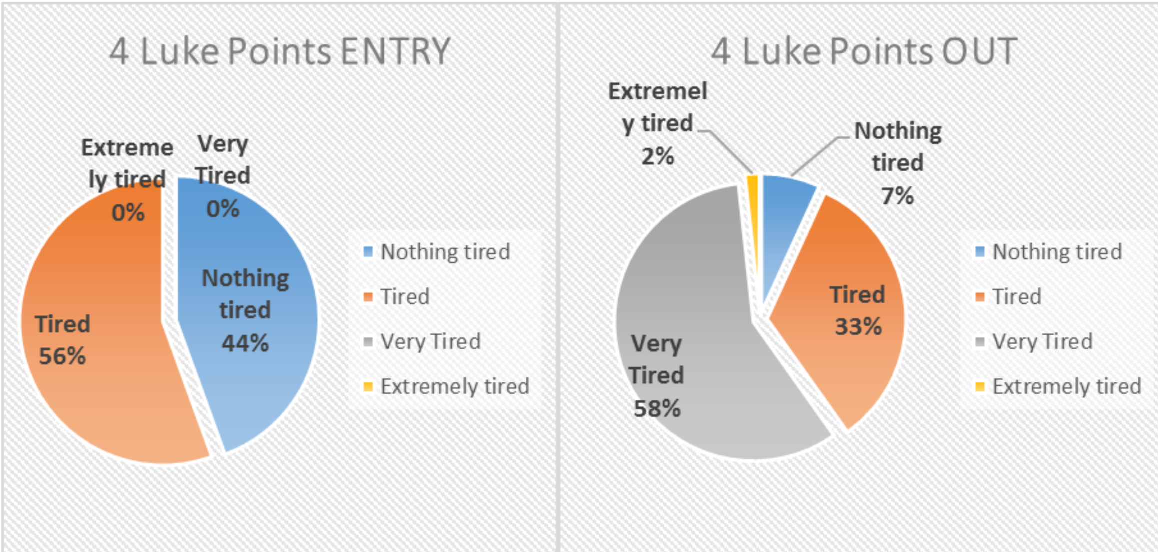
When analyzing the percentages of the Physical Fatigue area, the symptoms of Back Pain (3), Hoarse Voice (6) and Eye Blink (8), cause a great deal of general fatigue at the start of the day. In addition, in the percentages of the area of Sleepiness and Monotony, it is observed that the symptoms of major affection are Discomfort in the Brain (5), Sleep (6) and Fatigue in the Eyes (7), are the main symptoms that afflict the Lupita at the end of her working day.





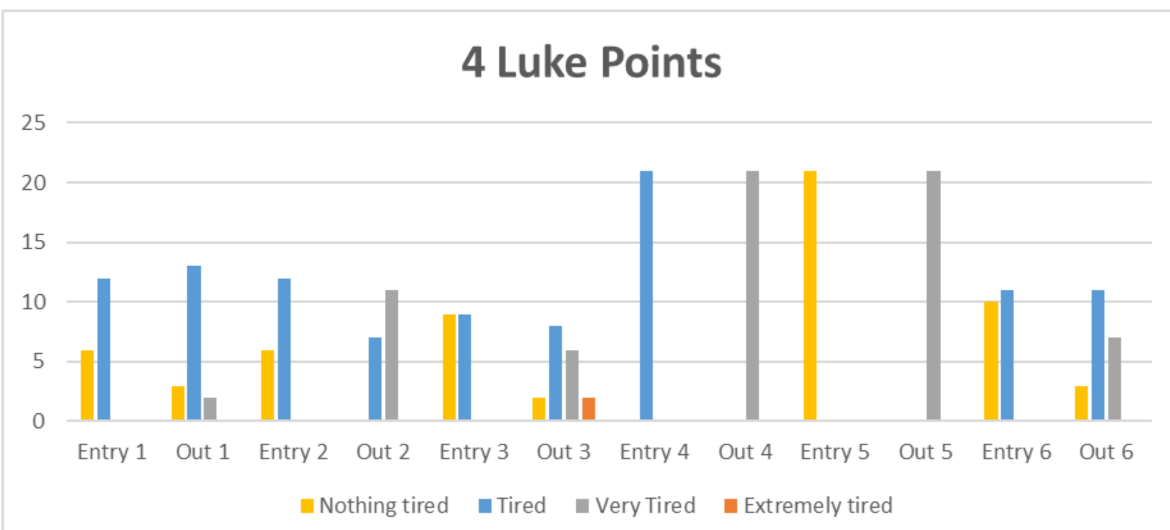
Graphic 5 and 6. Detection of symptoms of areas A and C, more frequently occurring

Going to 4 points of Luke we see that in the entrance there is a greater frequency of the fatigue factor that represents the fatigue limit and in the output can be observed that there is a 91% that represents fatigue according to the test.



Graphic 7 and 8. Percentages of Luke's 4-point levels on entry and exit

If you focus individually on the most affected workers, you could deduce that most of them suffer from fatigue, however, when they pass to workers 3 and 4, you can see that they start their work days with fatigue and end up with fatigue, it is worth mentioning that these two employees work in the same company.



Graphic 9. Luke's 4-point Fatigue Levels in the 6 Most Affected Employees

7. CONCLUSIONS

The analysis was determined that some volunteers of the study had complaints in the area of the palm of the hand and in the region of the wrists and even identified the particular case of a woman who presented pain throughout the arm, forearm and shoulder of the right side.

So having evidence about the consequences of repetitive use of common scissors, it is recommended to redesign this tool to reduce the bad postures of the most repetitive movements.

Once the results were obtained, it was concluded that some factors intervened so that these two women employees of the same company "Modatelas" resulted in the highest percentage of FQF. At the time of applying the surveys it was observed that this company and "Moditex", which also presented two women with a high level of fatigue, had different customer demands since "Modatelas" is cheaper in its prices than "Moditex ", It should be mentioned that the surveys were applied during the Christmas season, which increased the sales of both companies. Another important factor was that in "Moditex" they had the necessary employees to satisfy their demand, while in “Modatelas” were scarce the workers, which made that each of them gave their maximum effort causing this fatigue and additional fatigue.

In particular, Lupita is a 49-year-old lady, who has been working for 15 years in the same company, which has shown us the fatigue, fatigue and boredom of the routine she practices at work every day.

8. REFERENCES

Yoshitake H. Threecharacteristic patterns of subjective fatigue symptoms. Ergonomics 1978;21(3): 231-3.

ERGONOMIC ANALYSIS TO DETERMINE PHYSICAL FATIGE OF WORKERS IN AN ORGANIC FERTILIZER COMPANY

Juan C, Corrales Aguilar, Grace Erandy Báez Hernández, Juan S, Arredondo Barraza Carlos A, Félix Zavala y Freddy E, Parra Téllez

Department of Industrial Engineering
Instituto Tecnológico Superior de Guasave
Carretera a Brecha S / N, ej. Burrioncito
Guasave, Sinaloa, CP.81149
E-mail of the corresponding author:
juan_carlos.feb@hotmail.com, Gracebaezh@gmail.com

Resumen: La ergonomía puede tener un impacto grande sobre la productividad y las ganancias de una organización. Si los puestos de trabajo de los colaboradores tienen un mal diseño, tendrán fatiga muscular, vista cansada, dolores de cabeza y otros causantes que pueden llegar a ser factores que disminuyen la eficacia de su organización. A través de este trabajo se desarrolló una investigación ergonómica a una organización dedicada a la consultoría, asesoría y capacitación agrícola contando con biotecnología y las nuevas tecnologías agrícolas de vanguardia. El objetivo principal de este estudio es Identificar, analizar y determinar la fatiga física que presentan los trabajadores de la empresa de biofertilizante. Se analizaron las distintas áreas de trabajo en la empresa, se aplicó diferentes métodos entre ellos: una encuesta general, encuesta de principios ergonómicos y condiciones físicas de la oficina, y para los trabajadores. El método Corlett & Bishop y Método Yoshitake. Los resultados de los métodos que fueron utilizados reportan que existe fatiga de un 70%, y que a partir del 3 día la molestia en el cuerpo es constante no disminuye. Las principales zonas afectadas de jornadas de 10 horas es la espalda alta, baja, y algunas otras en menor grado como: cabeza, cuello, los hombros, codos, muñecas y manos, ocasionados por el tiempo excesivo de estar frente a monitores y no relajar el cuerpo. Conclusión, se presenta una propuesta de rediseño de una Sucursal con él personas que tiene más 5 años trabajando en esos puestos.

Palabras clave: Corlett & Bishop, Método Yoshitake, Ergonomía.

Abstract: Ergonomics can have a big impact on an organization's productivity and profits. If the jobs of the collaborators have a bad design, they will have muscular fatigue, tired sight, headaches and other causes that can turn out to be factors that diminish the effectiveness of its organization. Through this work an ergonomic research was developed to an organization dedicated to the consulting, advising and agricultural training counting on biotechnology and the new agricultural technologies of vanguard. The main objective of this study is to identify, analyze and determine the physical fatigue presented by the workers of the biofertilizer company. The different areas of work were analyzed in the company, different methods were applied among them: a general survey, survey of ergonomic principles and physical conditions of the office, and for workers. The Corlett & Bishop Method and Yoshitake Method. The results of the methods that were used report that there is a fatigue of 70%, and that from 3 days the discomfort in the body is constant does not decrease. The main areas affected by 10-hour workdays are upper back, lower back, and some to a lesser extent such as: head, neck, shoulders, elbows, wrists and hands, caused by excessive time being in front of monitors and not relaxing the body. Conclusion, a proposal for the redesign of a Branch with him is presented who has more than 5 years working in those positions.

Keywords: Corlett & Bishop, Yoshitake method, ergonomics.

Relevant ergonomic: In this research we obtained relevant data such as physical characteristics and inappropriate postures as well as activities that generate fatigue in workers. Generating information relevant to a proposal to redesign a branch, with the conditions of workers with more than 5 years of service, and future research.

1. INTRODUCTION

Ergonomics is the science that is responsible for adapting the worker to the machine. If employees' jobs have poor design, they will have muscle fatigue, tired eyesight, headaches and other causes that can become factors that diminish the effectiveness of their organization. Through this work an ergonomic research was developed to an organization dedicated to the consulting, advising and agricultural training counting on biotechnology and the new agricultural technologies of vanguard. This company has 4 branches, and in each of these, there are 3 workers in the office area (receptionist, manager and a deputy manager). In the work centers a safe, productive and economical environment is guaranteed, when we correctly apply Ergonomics. Since through the diagnosis that is elaborated we can structure a reliable work scheme where the worker does not fatigue when he carries out his activities. The main objective of this study is to identify, analyze and determine the physical fatigue presented by the workers of the biofertilizer company. The different areas of work were analyzed in the company, different methods were applied among them: a general survey, survey of ergonomic principles and physical conditions of the office, and for workers. The Corlett & Bishop Method and Yoshitake Method.

According to data from the Mexican Social Security Institute (2014) there are 983 men and 260 women in Sinaloa who are injured with wrist and hand injuries. Presenting constant situations of problems such as bad postures and forced movements such as: twisting the body, lifting loads, bending, can cause injuries to the back, wrists, shoulders, neck, among others, corrective actions must be taken You are to diminish them.

From that arises the need to present a proposal for rearrangement of those areas and significant improvements to the design, and furniture, based on the results of the survey of general conditions and ergonomic principles, and the application of methods.

2. OBJECTIVE

Identify, analyze and determine the physical fatigue presented by the workers of the biofertilizer company.

3. METHODOLOGY

In the company a tour was made through the different work areas, to analyze and identify the physical conditions and ergonomic principles that did not comply with an ergonomic station. It was applied in the 4 branches to have a more representative sample. Three phases were considered during the study:

The first part consisted of touring the facilities to visually detect the operations and processes that can lead to fatigue. As well as compliance with ergonomic principles.

The second phase focused on the general survey application and evaluation methods: CORLETT & BISHOP, YOSHITAKE.

The third phase was the analysis of methods and the application of general survey. Describing the physical characteristics of workers, and detecting those activities that can impose excessive demands on muscles, tendons or ligaments generating fatigue.

4. RESULTS

The results of the research were developed in phases. In the first, several anomalies were detected in the branches with workers who have a working day of 8 hours up to 10 hours.

1. After the tour different ergonomic principles were detected that were not applied and given as a proposal visual aids and posters in the places where there was greater influx of workers and that they were present in the correct way.

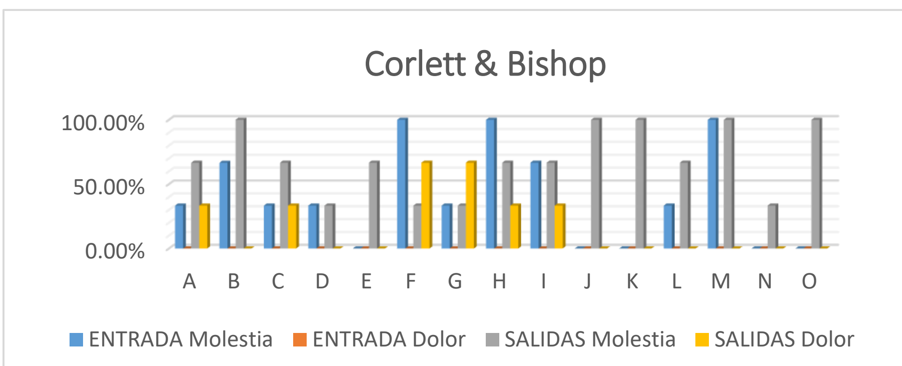
2. The methods that were used report that if there is a fatigue of 70% that from 3 days the discomfort in the body is constant does not decrease. The main areas affected by 10-hour workdays are upper back, lower back, and some to a lesser extent such as: head, neck, shoulders, elbows, wrists and hands, caused by excessive time being in front of monitors and not relaxing the body.

3. The results of the Yoshitake method determined the fatigue in workers being 20% at the time of entry and 43.33% at the exit, to counteract it is necessary to carry out different strategies so that the worker is rested and can carry in an appropriate way Their work, specifically decrease the symptoms of bodily fatigue and drowsiness. In addition it is necessary to opt for the workers to maintain the correct posture during their work and thus to avoid that this one has pain in its body or annoyances when it is carrying out its activities, for it was implemented a poster with the correct postures and visual aids to stop the Workers adopt these postures in their activities, as well as a series of exercises to make them active and encouraged to reduce drowsiness.

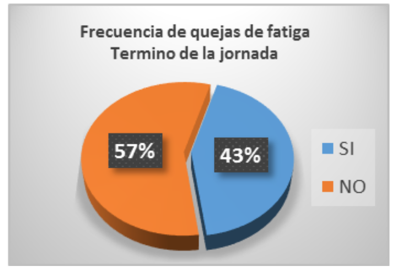
Graph 1. The General survey data

	ENTRADA			SALIDA		
	Secretaria	Sub-Gerente	Gerente	Secretaria	Sub-Gerente	Gerente
A	/	M	/	M	D	M
B	M	/	M	M	M	M
C	/	M	/	M	D	M
D	/	M	/	/	M	/
E	/	/	/	M	M	/
F	M	M	M	D	D	M
G	/	M	/	D	D	M
H	M	M	M	D	M	M
I	/	M	M	M	D	M
J	/	/	/	M	M	M
K	/	/	/	M	M	M
L	M	/	/	/	M	M
M	M	M	M	M	M	M
N	/	/	/	/	M	/
O	/	/	/	M	M	M

Table.1 Table of results of the method in the Corlett & Bishop



Graph 2. Results of the method in the Corlett & Bishop



Graph 3. Table of results of the Yoshitake Method

5. CONCLUSIONS

Among the proposals was to present to the workers the visual aids and poster, based on the ergonomic and normative principles that are not fulfilled in the process. Another improvement is the furniture with which the company counts as this is not the most suitable for the operator (chair, desk), as well as modify environmental factors such as lighting because this can cause fatigue, headache, migraine, between Others. The most affected area based on the results obtained from the different methods is the middle back, wrists and arms. Since sitting in long hours of work, or loading too heavy material, cause injuries, such as back pain. Generating that the operator does not yield to 100%, also the operators were explained the correct postures to avoid some musculoskeletal injury, or DTA.

6. REFERENCES

Barrientos-Gutiérrez, Tonatiuh, Martínez-Alcántara, Susana, & Méndez-Ramírez, Ignacio. (2004). Validez de constructo, confiabilidad y punto de corte de la Prueba de Síntomas Subjetivos de Fatiga en trabajadores mexicanos. Salud Pública de México, 46(6), 516-523. Consultado el día 14 de octubre del 2016. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0036-36342004000600006&lng=es&tlng=es

Chávez R, Preciado M, Colunga C, Mendoza P, Aranda C. Trastornos Músculo-esqueléticos en Odontólogos de una Institución Pública de Guadalajara, México. Cienc Trab. 2009 Jul-sep; 11 (31):152-155). Disponible en: http://www.cienciaytrabajo.cl/pdfs/33/pagina152.pdf

E,N. The ergonomics of spot welders, de science direct. Sitio web: http://www.sciencedirect.com/science/article/pii/0003687078902168

INS. (2012). PRINCIPIOS DE ERGONOMIA. 15/10/16, de INS Sitio web: https://portal.ins-cr.com/NR/rdonlyres/CA9CEF0F-A164-45A7-A441-79BFA5EF051C/5013/1007800_PrincipiosdeErgonomC3ADa_web.pdf

Martínez, R. ERGONOMÍA: ANÁLISIS DE LAS POSTURAS DE LOS OPERADORES EN UNA PLANTA DE INSUMOS MÉDICOS. Sitio web: http://www.semac.org.mx/archivos/5-26.pdf

Juan Luis Hernández Arellano, Jorge Luis García Alcaraz, José de Jesús Flores Figueroa, Nancy Estefanía Vázquez Álvarez. (2011). Versión en español de la escala de recuperación por agotamiento causado por fatiga. 2011, de AcademiaJournals.com Sitio web: https://www.researchgate.net/profile/Juan_Hernandez16/publication/236045

697_Version_en_espanol_de_la_escala_de_recuperacion_por_agotamiento_causado_por_fatiga/links/0deec515efe87c4c25000000.pdf

Yoshitake, H. Three characteristics patterns of subjective fatigue symptoms. Ergonomics, vol. 21 (3), pp. 231-233. 1978.

Guillén Fonseca M. Ergonomía y la relación con los factores de riesgo en salud ocupacional. Rev Cubana Enfermer. 2006Sep-dic; 22(4). Disponible en: http://scielo.sld.cu/scielo.php?pid=S0864-03192006000400008&script=sci_arttext

INSHT. (2010). NORMAS TÉCNICAS SOBRE PRINCIPIOS ERGONOMICOS. 25/09/16, de INSHT Sitio web: https://www.google.com.mx/url?sa=t&source=web&cd=1&ved=0ahUKEwjrkIK0xYnTAhVQw2MKHTNFBr0QFggaMAA&url=http%3A%2F%2Fwww.insht.es%2FErgonomia2%2FContenidos%2FPromocionales%2FGeneralidades%2FPromocionales%2520a%2520Contenido%2FNormativa%2520legal%2520y%2520tecnicaPrincipios%2520ergonomicos%2FNormasTecnicasPrincipiosErgonomicos.pdf&usg=AFQjCNFo8T36kyhdVUchejb9VG5ilqVeSw

Gonzales, D. Erginomía Y Psicosociología, pp. 663 https://books.google.com.mx/books?hl=es&lr=&id=oDBwCTg13HIC&oi=fnd&pg=PA37&dq=principios+ergon%C3%B3micos&ots=CDATgJRGmb&sig=tULjtngxwrRA6_SKv6_32Wg1u6M#v=onepage&q=principios%20ergon%C3%B3micos&f=false

CAUSES OF LABOR FATIGUE IN CARGO TRANSPORTATION OPERATORS

Ana Laura Pompa Sosa, Raquel Muñoz Hernández.

División de Ingeniería Industrial.
Universidad Politécnica del Valle de México.
Av. Mexiquense s/n, Col. Villa Esmeralda,
C.P. 54910, Tultitlán, Estado de México.
laura.pompa@hotmail.com[1], jael2222@hotmail.com[2].

Resumen: Esta investigación se realiza con operadores de transporte de carga en la CDMX, dado que las operaciones de transporte son muy dinámicas y es común que los conductores presenten alta variabilidad en los horarios de trabajo, alterando sus patrones de sueño y por consecuencia no pueden obtener suficientes horas de descanso. Esto se potencia más aún cuando el conductor no se atreve a reconocer que no logró dormir por temor a que su empleador crea que tiene algún problema médico o, peor aún, que no le asignen viajes lo cual lo perjudicará financieramente. Con base en lo anterior, se considera que el agotamiento, la fatiga y la somnolencia son causa de accidentes que lesionan y muchas veces cobran vidas: En el presente estudio se destaca la importancia del factor humano y la forma en que le afecta en sus sentidos el no dormir y acumular horas de sueño invisible para sus supervisores.

Palabras clave: Fatiga, riesgo, accidente

Abstract: This research is carried out with cargo transport operators in the CDMX, since the accidents are related to the importance of the human factor since they are related to fatigue and drowsiness, since transport operations are very dynamic, it is common That drivers present high variability in working hours, altering their sleep patterns and consequently can not get enough sleep during their rest, accumulating an invisible dream debt for their supervisors. This is further strengthened when the driver is not in a recognition that he failed to sleep due to the fear that his employer believes that he has a medical problem, which is not yet allocated by the trips, which is financially damaging.

Keywords: Fatigue, risk, accident

Relevance to Ergonomic: The study shows results where fatigue is found is an extremely complex phenomenon to analyze, because of many factors involved.

1. INTRODUCTION

Fatigue represents an alteration in the driver's level of consciousness and perception, which affects psychomotor processes that are crucial for safe driving

(Wylie et al, 1998). It is a product of causes such as an excessive number of hours of service; A deficit of hours of sleep; Night management, and having irregular work-rest schedules (Kaur, 1999).

Fatigue is an extremely complex phenomenon to analyze, because many factors are involved. It implies alterations in the levels of consciousness and of the driver's perception, which affect psychomotor processes crucial for safe driving. This is, in terms of the speed of reaction, levels of attention and perception, and in decision making (Wylie, 1998).

Drowsiness is one of the most notable effects of fatigue, although it is not the only manifestation. Fatigue is highly dangerous because it can occur without drowsiness and without the driver being conscious about reducing their safe driving abilities.

As for drowsiness, it is usually underestimated by the operators (Wylie, 1998). To further complicate the situation, it has been found that fatigue is in part a subjective experience, characterized by lack of motivation, feelings of boredom and discomfort, which induces a resistance to continue driving, affecting the attention that the driver provides To their work and to correct decision-making (Wylie, 1998).

Here are some factors that make fatigue worse:

A) Drive continuously without rest
B) Taking medicines
C) Poor diet, lots of fat and sugar
D) Eating irregularly
E) Dehydration

2. OBJECTIVES

1. Identify and describe the risk factors
2. Establish the causes of fatigue
3. Recommendations to prevent accidents

3. METHODOLOGY

Fatigue represents an alteration in the driver's level of consciousness and perception, which affects psychomotor processes that are crucial for safe driving (Wylie 1998).

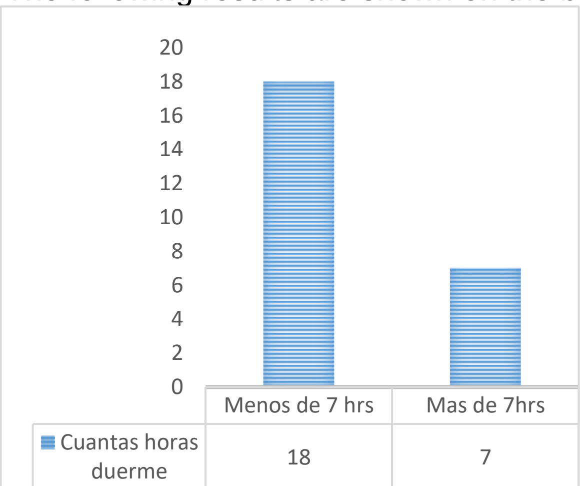
Some of the factors that cause fatigue in driving, are listed below:

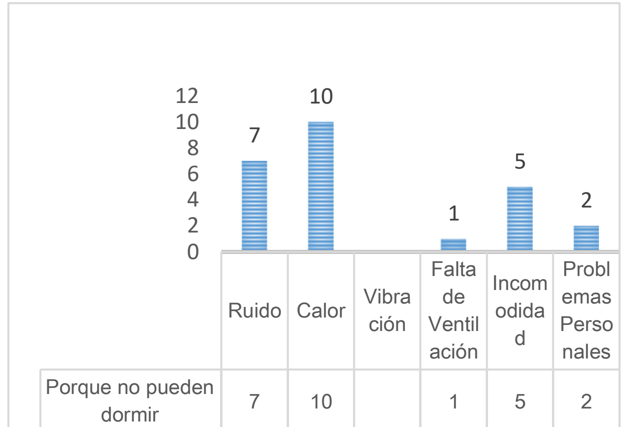
- Excessive number of driving hours.
- Inadequate number of hours of sleep.
- Night driving.
- Irregular working hours
- Eating disorders.
- Working environment conditions (heat, noise, vibration, etc.).
- Problems of family or work origin.
- Others.

4. FIGURES AND TABLES

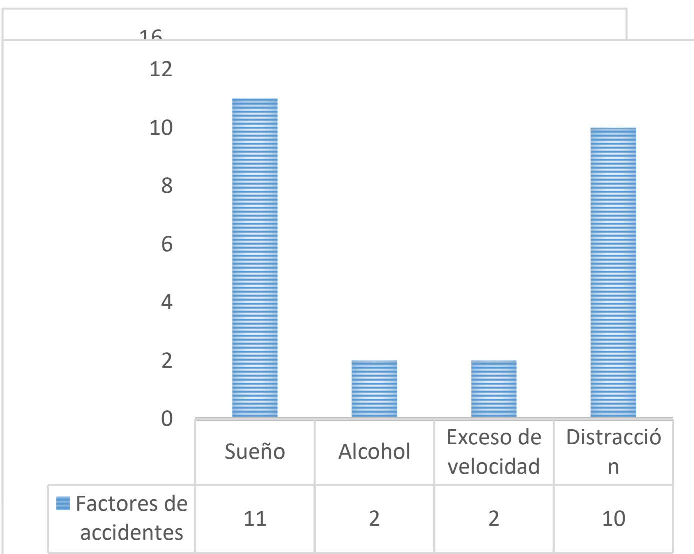
A continuación se muestran en base a los cuestionarios los siguientes resultados.

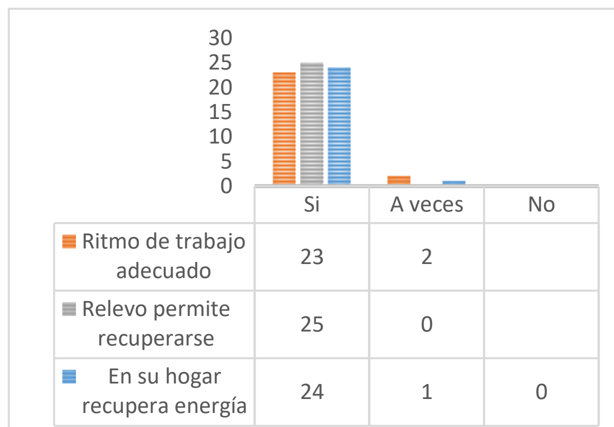
The following results are shown on the basis of the questionnaires.





Graph1. Cuantas horas duermen en un turno de 48hrs Graph 2. Motivos por los cuales los operadores no pueden dormir





Graph 3. Hora con mayor somnolencia en los operadores Graph 4. Ritmo de trabajo en los operadores.
Grafica 5. Factores de accidentes

5.CONCLUSIONS

Fatigue in driving is a complex event involving several psychological factors that are not underestimated and that the consequences are very serious, such as the integrity of the operator and the loss of goods. It must have a program to plan trips for those who have the opportunity to rest, it should be understood that the human being is able to recover his debt of sleep between 48 to 72 hours of consecutive rest. A study by Akerstedt (1986) empirically shows that if a person goes to bed at 11:00 PM on average he sleeps 8 hours; He goes to bed at 3:00 AM and, on average, sleeps 6 hours; And if you go to bed at 11:00 AM on average you sleep only 4 hours. This is a complex situation for drivers who work at night, since a measure that does not make the day the driver accumulates a "sleep debt" which the body requirements that the sea paid off. The problem is that sometimes, unconsciously, the body tries to pay off during driving.

As we observed in the results in Figure 1, 72% of the operators only rest less than 7 hours in a 48 hour shift confirming that fatigue is produced by the number of sleep.

In Graph 2, 40% of the operators who consider that their perception is an important factor (the heat) that causes fatigue in driving, we must consider that the place of rest must have the right conditions to guarantee a rest Good quality - ventilated room, temperature controlled, and external light insulation.

In Graph 3, 56% of the operators have more sleepiness at 4:00 am confirming that fatigue can be the cause of night driving.

Consider that their work rate is adequate with the base of graph 4, since the operators that work a shift from 48 to 72 hours, have a break of 2 days allowing recovery.

In figure 5 according to the perception of the operators 44% and 40% of the operators consider that the dream and the distraction are one of the factors that consider why they cause an accident.

To determine the fatigue in the conduction of the operators in a very complete task, since they involve physical, psychological and pathological factors. It is important that actions are taken to control the fatigue in the cargo transport operators and to pay attention to the operator and that wanting to finish their activity quickly can be risky and dangerous for their integrity.

6. REFERENCES

Cañas, José. Ergonomía Cognitiva. Granada: UGR, 2012.

De la Vega, Enrique. Metrix Vr. Guaymas: SEMAC, 2011.

Laurig, Wolfgang, y Joachim Vedder. «Ergonomia Herramientas y Enfoques.» En Enciclopedia de Salud y Seguridad en el Trabajo. 2010.

Melo, José Luis. Ergonomía práctica. Granada, España: Mapfre, 2009.

Morales Machado, Rafael , Aidé Maldonado Macias, y Salvador Noriega. Proyecto para el mejoramiento ergonómico. Cd. Juarez: SEMAC, 2015.

Ramirez Cavassa, César. Ergonomia y Producividad. México: Limusa, 1991.

Romero Salcedo, Arturo. Guía de diseño de espacios laborales ergonómicos para trabajadores con discapacidad. Segunda edición: septiembre, 2008. México, D.F.: STPS, 2008.

UGT, Ergonomia en los sistemas de trabajo. Vol. I. Granada:, 2011.

FISHMONGERS IN POPULAR MARKETS, A STUDY OF PHYSICAL FATIGUE IN WORKERS.

Martha Guadalupe Valdez Ochoa, Alberto Ramírez Leyva, Flor Angelica Armenta Meza, Luis Enrique Ortiz Zavala, Rosario Esther Castro Díaz

Departamento de Ingeniería Industrial
Instituto Tecnológico de los Mochis
Juan de Dios Bátiz y 20 de Noviembre
El Parque, Sin Nombre 81250
Los Mochis Sinaloa

marval_o@yahoo.com, alberto_ramirez_leyva@yahoo.com

Resumen: Es bien sabido que la fatiga, en sus inicios crea una sensación de cansancio y la persona afectada tiene que hacer un mayor esfuerzo al realizar sus actividades, afectando directamente su desempeño. Actualmente existen muchas personas que laboran en los mercados populares de la cuidad de Los Mochis Sinaloa, y tienen percepción del cansancio diario y acumulado que se genera en función de la herramienta que utilizan. La presente investigación dará a conocer a trabajadores que laboren en pescaderías ubicadas en mercados populares cual es el impacto de utilizar una herramienta inadecuada y que puede causar daños a la salud. Determinar mediante el cuestionario de Yoshitake y la escala de 4 puntos de Luke, el nivel de fatiga física que presenta un trabajador que labora en mercados populares de la zona centro de la ciudad de Los Mochis.

Para el presente estudio se tomó en cuenta la opinión de 10 trabajadores que laboran en el mercado popular Independencia en la zona centro de la ciudad de Los Mochis Sinaloa, y que decidieron apoyar en esta investigación respondiendo a los cuestionarios de evaluación de fatiga física de Yoshitake y la escala de 4 puntos de Luke a lo largo de 3 semanas. A partir del total de personas encuestadas, se seleccionaron aquellas que presentaron un mayor índice de fatiga determinado a partir de las encuestas. Después del análisis presentado se decidió evaluar un nuevo diseño del cuchillo que utilizan los trabajadores, esto para saber si era de ayuda para desempeñar el trabajo requerido y se concluyó que, este solo funciona en un cierto tipo de pescado; lenguado, y únicamente se utilizara para filetear, ya que en otros tipos de pescados se hacen movimientos que no serían ergonómicos con el cuchillo planteado.

Keywords: Cuchillos, 4 puntos de Luke, Yoshitake

Abstract: It is well known that fatigue, in its beginnings creates a feeling of tiredness and the affected person has to make a greater effort to carry out their activities, directly affecting their performance. Currently there are many people who work in the popular markets of the city of Los Mochis Sinaloa, and are aware of the daily and accumulated fatigue that is generated depending on the tool they use. The present investigation will give workers working in fish markets located in popular markets what is the impact of using an inadequate tool and that can cause damages to health. Determine by means of the questionnaire of Yoshitake and the scale of 4 points of Luke, the level of physical fatigue that presents / displays a worker who works in popular markets of the downtown area of the city of Los Mochis. For the present study we took into account the opinion of 10 workers who work in the popular Independencia market in the downtown area of the city of Los Mochis Sinaloa and who decided to support this research by answering the questionnaires of evaluation of physical fatigue of Yoshitake And Luke's 4-point scale over 3 weeks. From the total of people surveyed, those with the highest fatigue index determined from the surveys were selected. After the analysis presented, it was decided to evaluate a new design of the knife used by the workers, this to know if it was of help to carry out the required work and it was concluded that, this only works in a certain type of fish; Sole, and will only be used for filleting, since in other types of fish movements are made that would not be ergonomic with the raised knife.

Keywords: knife, 4 points by Luke, Yoshitake

INTRODUCTION

The exigency in the work at the moment, causes a fatigue and to the measure of its progress can be turned into fatigue. It is well known that fatigue, in its beginnings creates a feeling of tiredness and the affected person has to make a greater effort to carry out their activities, directly affecting their performance. Currently there are many people who work in the popular markets of the city of Los Mochis Sinaloa, and are aware of the daily and accumulated fatigue that is generated depending on the tool they use. However, there is no specific study directed towards their area, and therefore it is not possible to make recommendations to avoid the health problems that they are probably developing. Due to the repetitive activities that the workers perform are mainly in the arms by the use of an inadequate knife, the study of Jayro Delgado Days 2011 exposes that the most common that occurs, are diverse types of tendinitis, consequently to a continuous mechanical overload And their appearance may be progressive or experience acute pain suddenly.

For the above, the present investigation is aimed at identifying the possible symptoms of fatigue that workers in popular markets located in the downtown area of the city of Los Mochis Sinaloa, could suffer in their work, due to the use of tools that do not are adequate.

Importance for Ergonomics

This research will inform workers working in fish markets located in popular markets, which is the impact of using an inadequate tool that can cause health damage. It will help to obtain new data on the occupational health of this type of workers and avoid injuries by creating awareness about the use of incorrect tools.

Objective
Determine by means of the questionnaire of Yoshitake and the scale of 4 points of Luke, the level of physical fatigue that presents / displays a worker who works in popular markets of the downtown area of the city of Los Mochis. Identify people who have the highest rates of fatigue and possible traumas they may develop, as well as show the workers the knife to file, which will avoid some types of damage.

Delimitation
For the present study we took into account the opinion of 10 workers who work in the popular Independencia market in the downtown area of the city of Los Mochis Sinaloa and who decided to support this research by answering the questionnaires of evaluation of physical fatigue of Yoshitake And Luke's 4-point scale over 3 weeks.

Theoretical framework
Fatigue
Barbany (1990) defines fatigue as a functional state of protective, transient and reversible significance, the expression of a homeostatic response, through which the need to cease or at least to reduce the magnitude of Effort or power of the work being done.

Yoshitake Physical Fatigue Assessment
The Cuban journal of Health and Work (2004) describes Yoshitake's fatigue symptom test as the following: "test to measure fatigue at the beginning and end of the working day, used to study the negative effects of work. It consists of 30 questions, which explore general symptoms of fatigue, mental fatigue and physical fatigue. They are characterized as follows: general symptoms of fatigue, heaviness in the head and fatigue in the body. Mental fatigue is characterized by difficulty in thinking, nervousness, attention problems, anxiety and restlessness, and physical fatigue, including headache, body aches and general physical fatigue. These symptoms are grouped into three factors: boredom-monotony, inability to concentrate and projection of physical damage. "

Luke's 4-Point Scale
Luke and Col. used a scale to determine the level of fatigue. In this scale, called Luke's 4 points, the fatigue levels are cataloged after a normal working day, where the measurement scale is as follows: "nothing tired" 1 point, "tired" 2 points, "very Tired "3 points and" extremely tired "4 points.

METHODOLOGY

To begin with the study you will visit the popular markets of the downtown area of Los Mochis. Subsequently, the market is selected that conforms to the investigation and communicates with the owners and workers of the fishmongers, the study that is being carried out.

Continuing to select the study subjects who decided to support the research, and also, they are informed about the benefits they can get in supporting the research. In addition, before starting with the surveys, general information about the workers to be surveyed is collected.

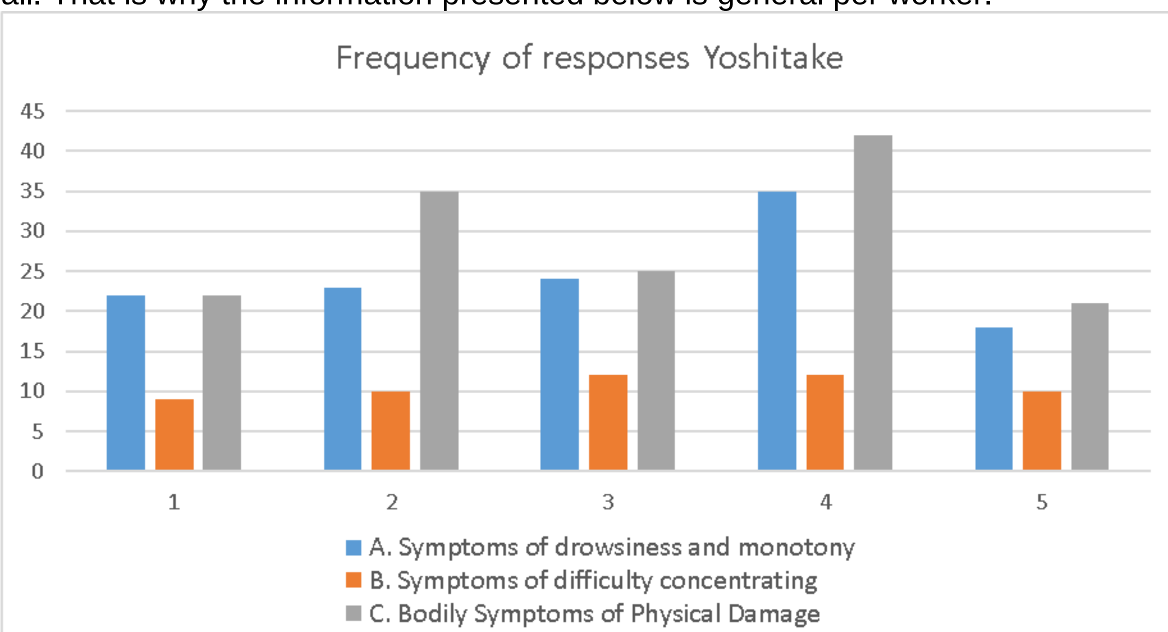
For 3 weeks, the markets in the downtown area are sampled using the Yoshitake questionnaire and Luke's 4-point scale to 10 workers. Workers' responses were recorded at the time of entry (usually 5.30 am) and exit (variable from 3:00 pm to 6:00 pm) to assess fatigue and / or fatigue at the beginning and end of the day labor. The workers answered a total of 30 questions divided into 3 subgroups: symptoms of drowsiness and monotony, symptoms of difficulty concentrating and bodily symptoms

From the application of the surveys the results are analyzed to determine the main reason for the problems detected.

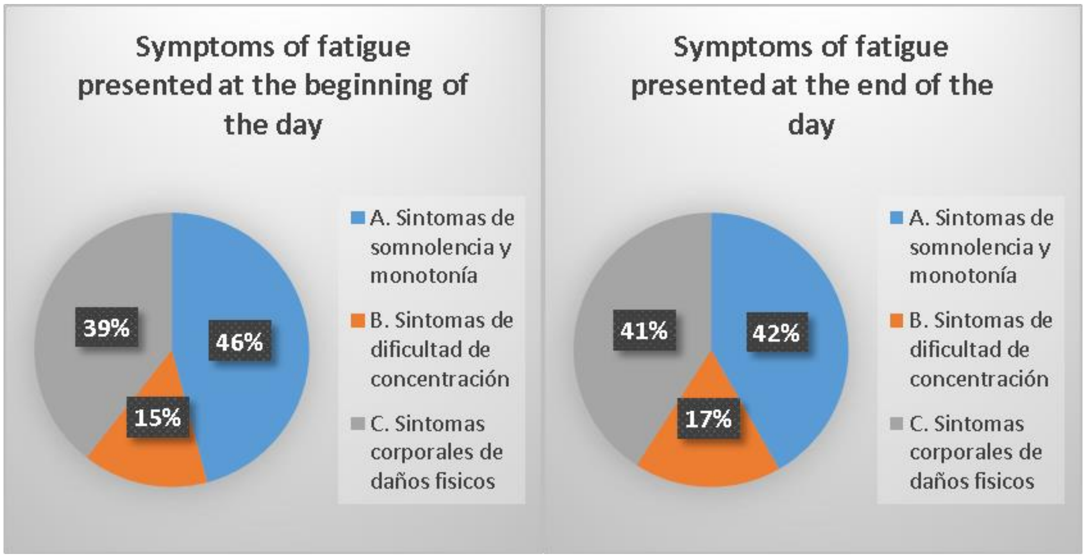
RESULTS

From the total of people surveyed, those with the highest fatigue index determined from the surveys were selected. Below is a general table of results by sections of the Yoshitake survey.

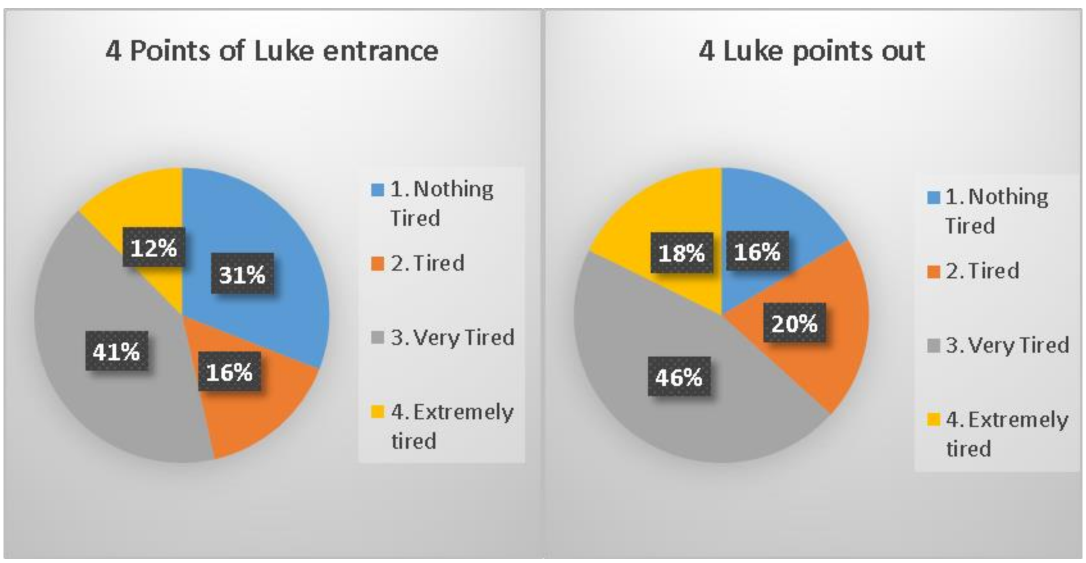
The workers who were selected have a standardized job position, being equal for all. That is why the information presented below is general per worker.



Graph 1. Frequency of response to the Yoshitake subjective fatigue analysis survey



Graph 2. Fatigue symptoms presented at the beginning of the day



Graph 3. Fatigue symptoms presented at the end of the da

CONCLUSIONS

After the analysis presented, it was decided to evaluate a new design of the knife used by the workers, this to know if it was of help to carry out the required work and it was concluded that, this only works in a certain type of fish; Sole, and will only be used for filleting, since in other types of fish movements are made that would not be ergonomic with the raised knife.

Likewise, it is also concluded that one of the main causes that cause fatigue mentioned above, is due in large part to the work area. All the people who work in the markets have limited space to carry out their activities and this forces them to work uncomfortable.

RECOMMENDATIONS

A general analysis of all the people working in the market allowed us to know what the activities were after their working hours. One of the ways to avoid tension in the shoulders is to lower the height of the counter, but because it is made of cement, the optimal solution is to adapt a scale along the entire counter.
In addition, a tool specially designed for this type of work is required.
Work only 8 hours a day and if necessary only cover 2 extra hours 2 days a week.

To avoid the headaches that present the greater part of the week, it is necessary that the workers arrive breakfast every day, and that they have a certain schedule for the rest of the meals.

IMPROVEMENT OF ERGONOMIC POSTURES IN ELECTRONIC COMPANY IN THE DRAW AREA "

Villarreal-González Y[1]., Amado-Moreno M[1]., Escárcega-Zepeda P[1] ., Navarro- González C.[2]., Perez Jauregui Daniel Alejandro[1].,

Department of Industrial Engineering[1]
Instituto Tecnológico de Mexicali
Avenida Tecnológico s/n
Colonia Elías Calles
mcvillarrealy@hotmail.com

[2]Departmento de Ingeniería Industrial
Universidad Autónoma de Baja California
Mexicali, Baja California 21376
Department of Ingeniería Industrial
navarrocarlos@uabc.edu.mx,

Resumen: La necesidad de evaluar los factores de riesgos ergonómicos en los puestos de trabajo, aparte de la regulación que se realizó en el 2015 del nuevo Reglamento Federal de Seguridad y Salud en el Trabajo el cual en el artículo 42 y 43 hace mención de factores de riesgo ergonómico y psicosocial en puestos de trabajo. Por lo que este nuevo reglamento obliga a que se relicen analisis en los puestos de trabajo, esta investigacion se busca determinar el diseno y selección de las herramientas ergonomicas adecacuadas para la mejora de posturas y ambiente en el área de máquinas conocido como sorteadora.

Palabras clave: Posturas ergonómicas, selección de herramientas ergonómicas, diseño ergonómico.

Abstract: The need to evaluate the factors of ergonomic risks in the workplace, apart from the regulation that was made in 2015 of the new Federal Regulation on Occupational Safety and Health which in article 42 and 43 mentions risk factors Ergonomic and psychosocial jobs. As a result of this new regulation, it is necessary to analyze the work positions, this research seeks to determine the design and selection of ergonomic tools suitable for improving postures and environment in the machine area known as raiser.

Keywords: Ergonomic postures, selection of ergonomic tools, ergonomic design.

Goals:

Identify suitable ergonomic postures in racking machines within the company through the selection and design of tools in the area of drawing machines.

Delimitation
The delimitation of the work of ergonomic positions was performed to 100% of the population of the Company in the area of the scanner machine, semiconductor product inspection industry in Mexicali B.C. With a total of 10 workers two of them in training, of the 4 shifts of 12 hrs.

Methodology:
A verbal survey was carried out where the information of working time of each worker was obtained being two people in turn of the four shifts that work in the companies being remarkable the short time of duration having a critical rotation due to the training of three months that are Require to achieve that position in the process of the dispensing machine.

According to Nogareda-Bestratén (2011), in order to maintain a considerable level of attention or to carry out continuous physical efforts, no matter how small, it is imperative to introduce pauses at different frequencies and not always easily predictable, in order to recover the expected optimum levels of performance and Not to generate damages to the health. But there are many types of rest needed. After a few weeks of working in the area, they themselves expressed their feelings about their illnesses and intensity, when they started their work day, what activities they did in their free time and what their rest times were

Results:
Based on the times taken it was observed in the observation of the monitor after 5 min observing or working on the discomfort was present in the neck when starting to move this part of the body to continue entering data of the lot to draw, although the longer document was 10 min. They did not generate as much ailment, if the batches were large, but as it evolved in the days arrived smaller batches therefore they needed to introduce more followed that data, as well as when it is necessary to review the lot of each tablet, to maintain an ordered follow up being So a very tiring action for the neck.

In the same area, the waist and lower part was clear his illness in the workers since the standing the 12-hour day combined with the tables were at the height of the hip with 60 cm. By doing the material filling activity you have to find inclines and the area on the table to place material at least 30 of the table, where being in wedges for short periods during work hours are felt in the legs and back. In the 100% of the interviewed subjects that are the population of the machine of draw.

An anthropometric measurements were made of the subjects and none of them because their measurements were accessible and adequate to their height, the standard measure that was obtained from the measurements made in the subjects was:

Waist 92 cm /
Height: 161 cm.
Floor elbow 104 cm.
Shoulder floor 139 cm.
Width from shoulder to shoulder 38 cm.

With this there is a table for the high computer, but it is prohibited to use it for the material, the spaces are short and monotones where they are always standing

Conclusions and Contribution to Ergonomics:
It is necessary the redesign of tables, stairs, chairs and heights of monitors based on the measurements of the population of the operators in the process work operations to adapt the stations with security Ergonomics, so studies of this type provide information for the Improvement Ergonomics of companies, which helps to efficient the work of the operators is the responsibility of the companies, giving them less turnover by reducing less fatigue in the process.

This information can be used in conjunction with other measurements of different processes of the same company and with the improvement it was determined to realize the anthropometric dimensions of the personnel that works. As well as being able to determine the percentiles for the design of the different areas of work of the company .

In the ergonomic contribution we find that it is an improvement in the health of the worker, since studies of this type will help the companies to ergonomically redesign adequate stations in the different areas in standing stations or seated stations.

References

Anil Mital,R., Ram R., Bishu T. Y S.G. Manjunath. “Review and evaluation of techniques for determining fatigue allowances,”International Journal of industrial ,ergonomics, 8 de Junio de 1991.

Camara de diputados de México. (2016).Leyes biblio.Recuperado de http://www.diputados.gob.mx/LeyesBiblio/pdf/125_120615.pdf

Ergonautas. (2016).Herramientas selectas.Recuperado de http://www.ergonautas.upv.es/herramientas/select/select.php

Optometristas de México. (2015). Posturas y descansos.Recuperado de http://www.somosoptometristas.com/ergonomia-visual-posturas-y-descansos/

Relajación en el trabajo. (2014).Pausas saludables. Recuperado de http://salud.ccm.net/faq/6181-ejercicios-de-relajacion-para-hacer-en-el-trabajo

REENGINEERING IN ASSEMBLY STATION IN A MEDICAL TYPE COMPANY, TO ACHIEVE PAINFUL SHOULDER SYNDROME REDUCTION.

Hermelinda Guzmán Virgen1, Laura Orozco y Jiménez[2], Rosa María López García[3], C. Rigoberto Zamora Alarcón[4]

[1]Teleplan Service Logistics./Tecnomex Industrial S.A. de C.V.
Rubilinas # 3 CP 21600 Parque Industrial Palaco, Mexicali, B.C.
hermelinda.guzman@teleplan.com

[2]Universidad Autónoma de Baja California
Health Sciences
Blvd. Benito Juárez S/N CP 21280 Mexicali, B.C.

[3]Honeywell Productos Automotrices
Blvd. Lázaro Cárdenas # 2545 CP 21376 Mexicali, B.C.

[4]Universidad Autónoma de Baja California
Blvd. Benito Juárez S/N CP 21280 Mexicali, B.C.

Resumen: El objetivo del trabajo realizado fue reducir la incidencia de Síndrome de hombro doloroso debido a un caso calificado como enfermedad de trabajo por el Instituto Mexicano del Seguro Social, en una empleada del área de ensamble de catéter médico (catéter para oxígeno y líquidos intravenosos) al someterlo a temperatura con pistola de calor para redondear la punta. Se determinó aplicar el método observacional, aplicación de cuestionario, lista de verificación de posturas, evaluación ergonómica (Suzanne Rodgers, RULA, OCRA) así como revisión del historial médico en el periodo de 2014 al 2016 en los trabajadores del área. El análisis retrospectivo mostró la frecuencia de incidencia de los casos mientras que el análisis por el método Ishikawa demostró el factor contribuyente del problema.

Aplicando la reingeniería en la estación de trabajo se redujo la incidencia de síndrome de hombro doloroso obteniendo mejoras en la postura de cuello, espalda y extremidades superiores e inferiores.

Palabras clave: Síndrome de hombre doloroso, Punto de ensamble medico

Summary: The goal of the developed work was to reduce the Shoulder Pain Syndrome due to a qualified case as work illness by the Mexican Institute for Social Security, in a medical catheter assembly area employee (oxygen and intravenous liquids catheter) when submitting it to temperature with a heat gun to round up the tip. It was determined to apply the observational el method, questionnaires application, postures checklist, ergonomic evaluation (Suzanne Rodgers, RULA, and OCRA) as well as a medical historic review during the time period of 2014 to

2016 in the area workers. The retrospective analysis showed the case incidence frequency while the Ishikawa method analysis showed the problem contributing factor.

Applying reengineering at the work station the Shoulder Pain Syndrome incidence was reduced obtaining improvements in the neck, back and lower & upper extremities postures.

Key Words: Shoulder Pain Syndrome, medical assembly point

Ergonomics Contribution:
By doing reengineering at the medical assembly working stations reduces the incidence of Shoulder Pain Syndrome in benefit of the worker health.

1. INTRODUCTION

The Shoulder Pain Syndrome can show up in people from all regions, countries and societies according to the World Health Organization (OMS) which can appear in painters, carpenters, above the age of 40; while doing everyday activities (dress, or sleep over the shoulder or with the arm over the head) due to repetitive movements and incorrect postures, being these the most frequent. At work, ergonomic risk factors are featured and are the causes of various cumulative disorder traumas, like the painful shoulder syndrome, by arm raised above the shoulder or by wrist tendinitis due to repetitive movements (Rosemont, 2001). This study purpose is to eliminate the Shoulder Pain Syndrome incidence in the assembly area of a maquiladora company.

The shoulder is a complex structure conformed by the humerus proximal part, clavicle, scapula and the bones joints with the breastbone, rib cage and soft tissues. It is formed by various joints: sternoclavicular, acromioclavicular, glen humeral y scapulothoracic, which work together in a synchronous rhythm, to allow movement. This complexity gives the characteristic of being one of the most movable body joints, thus a place of multiples injuries and inflammatory traumatic pathologies, as well as degenerative among them the rotator cuff injuries, being this, a frequent cause of pain and function al limitation. The combined effect of the coracoacromial arch extrinsic compression and the age tendon degeneration, this is more frequent above the 40 years old, in jobs with arm movements above the head.

OBJETIVE

Reduce the Shoulder Pain Syndrome incidence in medical assembly stations through the application of reengineering working station.

2. METHODOLOGY

Information is collected through a survey that is divided in categories of age, gender, work seniority, working positions satisfaction index and working positions rotation to the population occupationally exposed (9 persons) that work in the tube burning working position. An ergonomic questionnaire was applied to the study's population with the intention of detecting any possible Shoulder Pain Syndrome symptomatology (figure 1).

A position analysis is performed through observation in order to detect forced or incorrect postures, forced movements, lengthy sitting work, and times and movements. The frequency prevalence of Painful Shoulder Syndrome from 2014 to 2016 from the area enquired workers is reviewed by the medical service personnel (figure 2).

A root cause analysis is performed by applying the Ishikawa method, with which the following causes are defined: Method: incomplete, not followed, no shoulder rest operation; Workforce: distracted, no knowledge of the ergonomic risk, performing incorrect positions.

Figure 1: Methodology

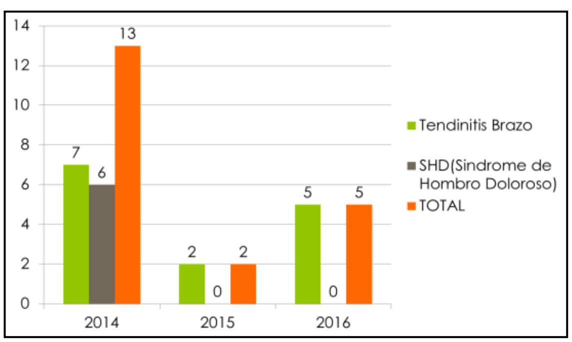


Figure 2: Cumulative trauma disorder

Developing the evaluation under the OCRA Suzanne Rodgers, RULA y methods, that the ergonomically risks factors identified are high (figure 3).

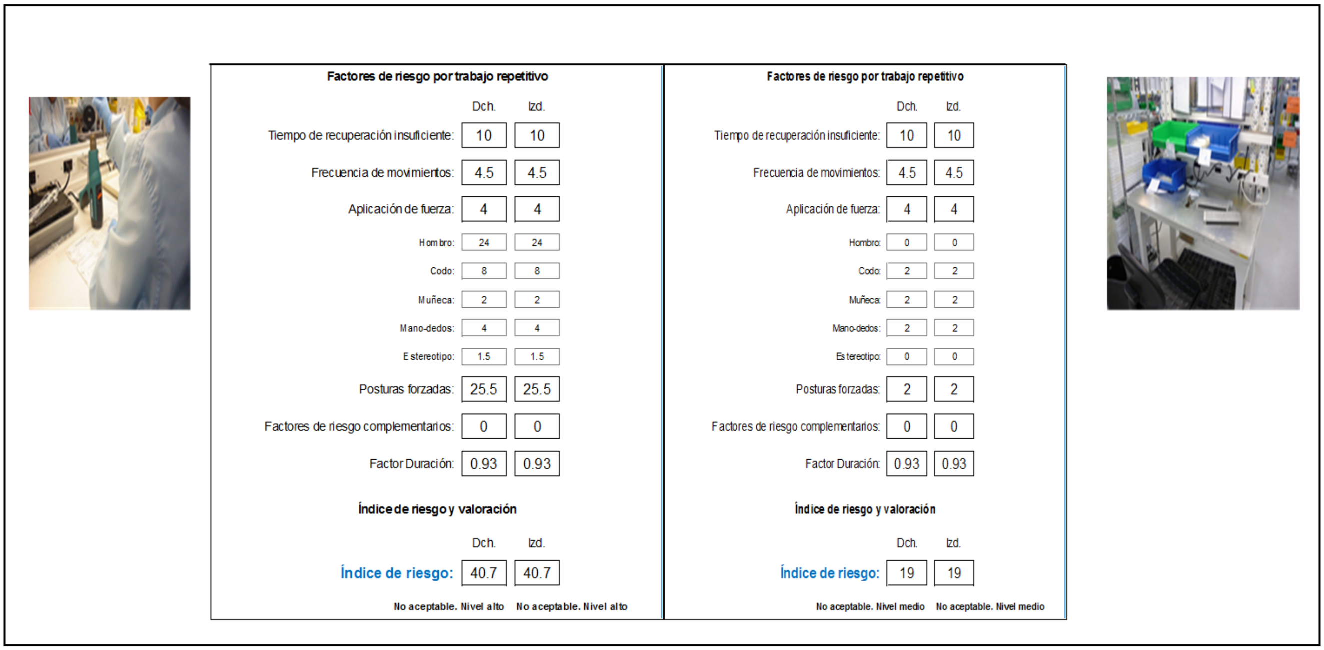


Figure 3 Risks index before and after the ergonomic modifications OCRA CHECKLIST

Table 1 Suzanne Rodgers evaluation before and after the ergonomic modifications.

Suzanne Rodgers Ensamble de cateter antes					
	Esfuerzo	Duracion	Frecuencia	Calificación	Evaluación
Cuello	3	1	3	313	Alto
Hombro	2	2	3	223	Alto
Espalda	1	2	3	123	Moderado
Brazos, codos	3	2	3	323	Muy Alto

Suzanne Rodgers Ensamble de cateter despues					
	Esfuerzo	Duracion	Frecuencia	Calificación	Evaluación
Cuello	1	1	1	111	Bajo
Hombro	1	2	1	121	Bajo
Espalda	1	2	1	121	Bajo
Brazos, codos	1	2	3	123	Moderado

Table 2 RULA evaluation before and after the ergonomic modifications

PUNTUACIÓN FINAL|CLASIFICACIÓN DE GRAVEDAD	
ETAPA 9: Puntuación de brazos, antebrazos y muñecas	18
ETAPA 16: Puntuación de cuello, espalda y piernas	12
Secuencia de dos dígitos FINAL(de los datos anteriores)	18:12
ETAPA 17: Puntuación final de la Tabla C	15
CLASIFICACIÓN DE GRAVEDAD (con el uso de la puntuación de la etapa 17)	4
A - Considerable: puntuación final mayor a 15: **+6 puntos**	
B - Grave: puntuación final de 11 a 15: **+4 puntos**	
C - Leve: puntuación final de 6 a 10: **+2 puntos**	
D - Insignificante: puntuación final <6: **0 puntos**	
CLASIFICACIÓN DE FRECUENCIA	3
más de 1 vez por mes a 1 vez por turno: **+1 punto**	
de 1 a 4 horas por turno: **+2 puntos**	
más de 4 horas por turno: **+3 puntos**	
CLASIFICACIÓN DE PROBABILIDAD	1
Alta: más de 1 incidente, más de 1 de un incidente cada 3 años: **+1 punto**	
Media: 1 incidente cada 3 a 25 años: **0 puntos**	
Baja: Ningún incidente. <1 incidente cada 25 años: **-1 punto**	
CLASIFICACIÓN DE GRAVEDAD:	8
Puntuaciones de clasificación: de 1 a 4 baja; de 5 a 7 moderada; de 8 a 10 alta	

PUNTUACIÓN FINAL|CLASIFICACIÓN DE GRAVEDAD	
ETAPA 9: Puntuación de brazos, antebrazos y muñecas	8
ETAPA 16: Puntuación de cuello, espalda y piernas	12
Secuencia de dos dígitos FINAL(de los datos anteriores)	8:12
ETAPA 17: Puntuación final de la Tabla C	10
CLASIFICACIÓN DE GRAVEDAD (con el uso de la puntuación de la etapa 17)	2
A - Considerable: puntuación final mayor a 15: **+6 puntos**	
B - Grave: puntuación final de 11 a 15: **+4 puntos**	
C - Leve: puntuación final de 6 a 10: **+2 puntos**	
D - Insignificante: puntuación final <6: **0 puntos**	
CLASIFICACIÓN DE FRECUENCIA	3
más de 1 vez por mes a 1 vez por turno: **+1 punto**	
de 1 a 4 horas por turno: **+2 puntos**	
más de 4 horas por turno: **+3 puntos**	
CLASIFICACIÓN DE PROBABILIDAD	1
Alta: más de 1 incidente, más de 1 de un incidente cada 3 años: **+1 punto**	
Media: 1 incidente cada 3 a 25 años: **0 puntos**	
Baja: Ningún incidente. <1 incidente cada 25 años: **-1 punto**	
CLASIFICACIÓN DE GRAVEDAD:	6
Puntuaciones de clasificación: de 1 a 4 baja; de 5 a 7 moderada; de 8 a 10 alta	

RESULTS

With the obtained data a statistical analysis is performed, 100 % of the population is observed, 6 cases are identified with painful shoulder syndrome symptomatology. The enquired population is only from the feminine gender, in which prevalence is from 20 to 39 years old corresponding to 66%; and from 40 to 59 years old the 34% (figure 4).

Just one case was defined as left Shoulder Pain Syndrome work illness, in an operator of 45 years old when laying on her shoulder, adopting an inadequate posture when developing her job for long periods of time.

The ergonomic risk index in shoulder was reduced to 54%.

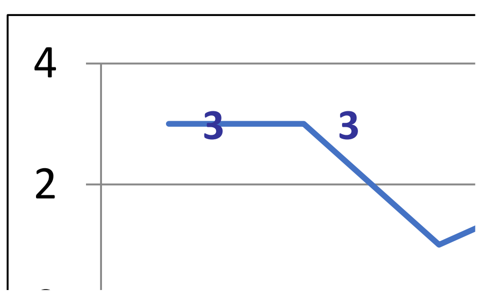


Figure 4: Number of people by age group in the assembly area.

CONCLUSIONS

According to the ergonomic evaluation in the work area, improvements were made through the medical catheter assembly station reengineering, which allowed to observe the unnecessary movement reduction among them we can highlight:

1. The arm raising was avoid through the ergonomic redesign by positioning the heat gun table level.
2. Workers comfort was raised by placing the heat gun in a neutral elbow position (fig 5).
3. Incorrect neck, arm and back positions were eliminated at the tube burning stations by remaining correctly sitting in the ergonomic chair at the burning tube stations.
4. It was concluded that the qualified left Shoulder Pain Syndrome operator had adopted an incorrect position by laying on her shoulder when developing her job.
5. The risk in the worker fingers still persist by the clamp effect when rotating the catheter over the gun keeping the arms in the air.

It is recommended to automate the rotation system when submitting it to temperature with the heat gun for the tip round up. Develop work instructions with visual aids so they can adopt correct postures. Provide training of the correct working method with the use of the work instructions to all involved including new hires; as well as providing timely follow up to the personnel detected with this type of problems.

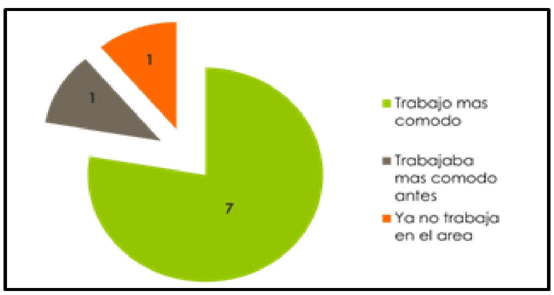


Figure 5: Ergonomic Improvement Quiz

5. REFERENCES

Rosemont (2001). American Academy of Orthopedic. AAOS Clinical Guideline on shoulder pain: Support Document.

Carlos Eduardo Ugalde Ovares, Daniel Zúñiga Monge, Ricardo Barrantes Monge (January 22, 2013) Forensic Medicine Costa Rican Association - ASOCOMEFO Painful Shoulder Syndrome Update.

Clinical practices guide Master Catalog IMSS 085-08

EVALUATION OF ERGONOMIC RISKS IN AN AEROSPACE INDUSTRY AT SOUTHERN SONORA

Adriana Ramírez Mexia, Ernesto Ramírez Cárdenas, Arnulfo Naranjo Flores, Rosa María Curiel Morales, Julio Cesar Gil Manríquez

Department of Industrial Engineering
Instituto Tecnológico de Sonora
Highway to Airport km 3
Guaymas, Sonora

adriana.ramirez@itson.edu.mx; ernesto.ramirez@itson.edu.mx; anaranjo@itson.edu.mx; rcuriel@itson.edu.mx; juliogil@outlook.com

Resumen: La evaluación ergonómica de puestos de trabajo es importante ya que en ella se detectan los diferentes factores de riesgo ergonómico que pudieran afectar en los empleados, analizan la interacción que existe entre la maquinaria y las herramientas con aquellos trabajadores que las utilizan. La finalidad de este trabajo es identificar los factores de riesgo ergonómico del proceso de torsión mecánica a través de estudios posturales y de repetición de movimientos, para establecer mejoras que permitan reducirlos o eliminarlos por completo. Para ello se siguieron los pasos sugeridos por Llaneza, así como herramientas tales como el cuestionario nórdico de Kuorinka, las cinco cuestiones básicas sugeridas por González, los métodos de evaluación BRIEF, REBA y JSI. Con el análisis anterior se establecieron acciones de mejora y se evaluó nuevamente el puesto de trabajo para corroborar la reducción de riesgo. Como conclusión se tiene que los objetivos se cumplieron mejorando la calidad de vida de los empleados así como también el sistema productivo en general.

Palabras clave: Ergonomía, factores, riesgo, discomfort, desordenes de trauma acumulativo.

Abstract: The ergonomic evaluation of workstations is important because it detects the different ergonomic risk factors that could affect employees, they analyze the interaction between machinery and tools with those workers who use them. The purpose of this work is to identify the ergonomic risk factors of the mechanical torsion process through postural studies and repetition of movements, to establish improvements that allow to reduce or eliminate them completely. For this, the steps suggested by Llaneza were followed, as well as tools such as the Kuorinka Nordic questionnaire, the five basic questions suggested by González, the BRIEF, REBA and JSI evaluation methods. With the previous analysis, improvement actions were established and the job was evaluated again to corroborate the risk reduction. In conclusion, the objectives were achieved by improving the quality of life of employees as well as the production system in general.

Keywords: Ergonomics, factors, risk, discomfort and cumulative traumatic disorders.

Relevance to Ergonomics: To promote a culture in ergonomics in organizations.

1. INTRODUCTION

During the last few years, it has been observed how industries with aerospace production have been installed in Mexico, which led to an increase in their installed capacity, as proof of this is that for 2010 they present a 10 percent annual growth and it is expected that for By 2015 this is 13 percent (Datamonitor, 2011), these numbers put the country in the sixth place of the main foreign suppliers for the US aerospace industry (Academia de Ingeniería de México, 2013). In Sonora there are 53 companies dedicated to manufacturing of components for turbines and airplanes, highlighting activities such as pressure casting, lost wax and sand mold, as well as thermal and surface treatments (De la Madrid, 2015). According to data of the Instituto Mexicano del Seguro Social (IMSS), of work diseases presented in the state include enthesopathy, carpal tunnel syndrome, shoulder injuries and other tenosynovitis (IMSS, 2013); the company under study is located in the south of Sonora. When interviewing the staff regarding the discomfort presented, the following was obtained:

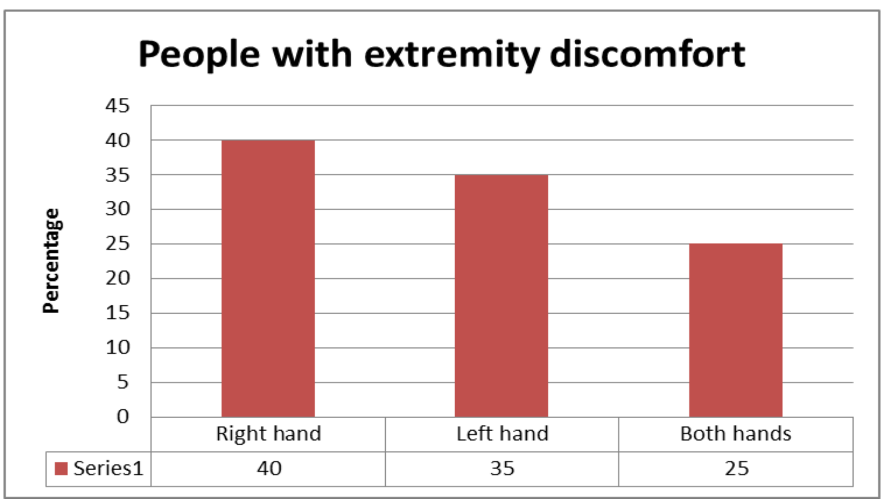


Figure 1. Relationship of people with discomfort in their extremities.

Of the 133 people who work in the productive process, 40 percent have right hand discomfort, 35 percent have left hand discomfort and 24 percent have both hands. Although it has a wide range of products and processes, it will focus on the mechanical torsion, which consists of the application of force when turning the tool manually, it is considered as the most interesting according to a value judgment issued by the area supervisor. Given this: There is a need to carry out a study that allows the identification of ergonomic risk factors in the torsion process and its subsequent decrease and / or elimination through improvement actions.

2. OBJECTIVE

To identify the ergonomic risk factors of the mechanical torsion process through postural studies and repetition of movements and establish actions that allow the reduction or elimination of the level of risk in the operational personnel.

3. METHODOLOGY

For the project development, an adaptation of the steps suggested by Llaneza (2007) were used. As a first step we have to identify the area or process under study, for this we will take into consideration the ergonomic risk factors present, as well as the application of the Nordic questionnaire of Kuorinka (1987) to detect symptoms of the musculoskeletal system; then the tasks will be analyzed through the Five Basic Questions suggested by González (2007) to describe in detail the process. The third step is to assess the risk factors, applying the BRIEF method. According to the results obtained from the previous point, the evaluation method to be used will be selected, using the method selector of the Universidad Politécnica de Valencia (2013) of Diego- Mas (2016). Subsequently, the evaluation of risky or significant activities will be carried out using the REBA methods of Hignett and McAtamney (Diego-Mas, 2016; Hignett & McAtamney) and JSI of Moore and Garg (1995) ((Diego-Mas, 2016; Moore & Garg), to continue the analysis of the results obtained in relation to limbs affected and level of risk, generating corrective actions that reduce or eliminate identified risks. Finally, the results will be validated evaluating the activities of the process once the improvements have been implemented.

4. RESULTS

In order to identify the area or process under study, the mechanical torsion process, which involves exerting force on the upper extremities until the assembly is adjusted to the desired force, is performed in 80 percent of the part numbers. Subsequently the Kuorinka Nordic questionnaire was applied to the person performing this operation in the line to identify symptoms (see Figure 2).

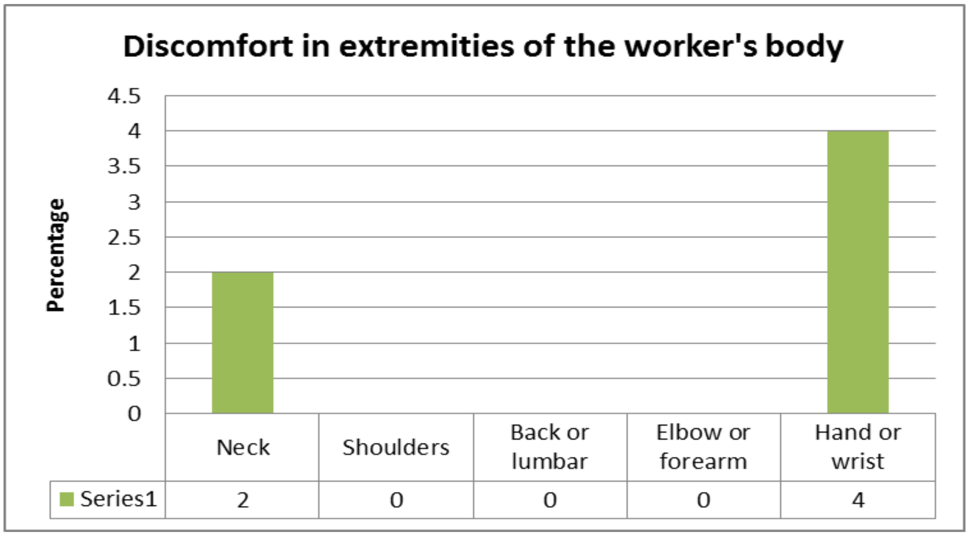


Figure 2. Body discomfort based on the Kuorinka Nordic questionnaire

Regarding the result obtained, it was identified that the operator apparently presents discomfort in the hand or wrist and in the neck. As part of the analysis of the tasks, the Five Basic Questions of González (2007) were applied, which describes what, how, with what, why and who does the process or activity. In this way the operator performs the mechanical torsion in the assemblies manually, in addition it helps to the rest of his mates to realize other assemblies; to do it, must be moved to the work table, to begin with the twist according to the type of force required in the specification, the activity performed standing, tilting his neck and back; using tools such as die, screwdriver and wrench. Due to the flexions of the limbs and the repetitiveness in the movements of the wrists when performing the task, it is corroborated that it is probably risky. To assess the risk factors, the BRIEF method was applied using the field sheet with the following results (see Table 1):

Table 1. Factors identified with the BRIEF method

Factor	Punctuation	Risk rate
Left hands and wrists	4	High
Right hands and wrists	3	High
Left elbow	0	Low
Right elbow	0	Low
Left shoulder	2	medium
Right shoulder	2	medium
Neck	3	High
Back	2	medium
Legs	0	Low
It has soft tissue pressure to perform the operation as it applies force to your hands to carry it out		

From the above it was identified that the wrists perform radial deviation and pinching movements and are bent at 45 °, with a duration of movements greater than 10 seconds and a frequency less than 30 minutes; the neck has a bent posture greater than 30 ° which remains in a time greater than 10 seconds, concluding that the detected risk factors were forced postures and repetitive movements. When selecting the evaluation method, it was obtained that the suitable ones to make the study are the methods REBA and JSI. When evaluating risky or significant activities, the following results were obtained (see Table 2):

Table 2. Results of the process evaluations

Activity	Rating REBA	Risk Level	Level of accion	Affected extremities	Risk Factor
Mechanical torsion	5	Medium	Action is needed	Neck, Back and wrist	Angles of neck and back greater than 20° and wrist with flexion
	Rating JSI	Risk Level	Level of accion	Affected variables	Risk Factor
	13.5	Risky	Probably dangerous task	Intensity and duration of effort	N/A

Due to the confidentiality of the company it is not possible to show photographs during the application of the method, however, when analyzing the methods, it is necessary that with the level of risk and action actions must be taken so that it is reduced. As improvement actions, the way of carrying out the process was modified by automating it with a cordless screwdriver. The work table was also modified by making its height from 95 to 120 cm adjustable, as stipulated in the OSHA standard. A precision work thus avoiding the forced postures of the neck and back. Due to the change in working method, it was necessary to place a press to hold the piece while working with it, so that the operator only places the type of die required by the assembly, actuates the mechanical torsion and adjusts the force avoiding repetitive movements of the parts. Wrist no need to take the piece while performing the operation. Finally, to validate the results, the methods for verifying the decrease in risk were applied again, which when compared to those presented in the current situation a reduction in the score is observed as shown in figure 3.

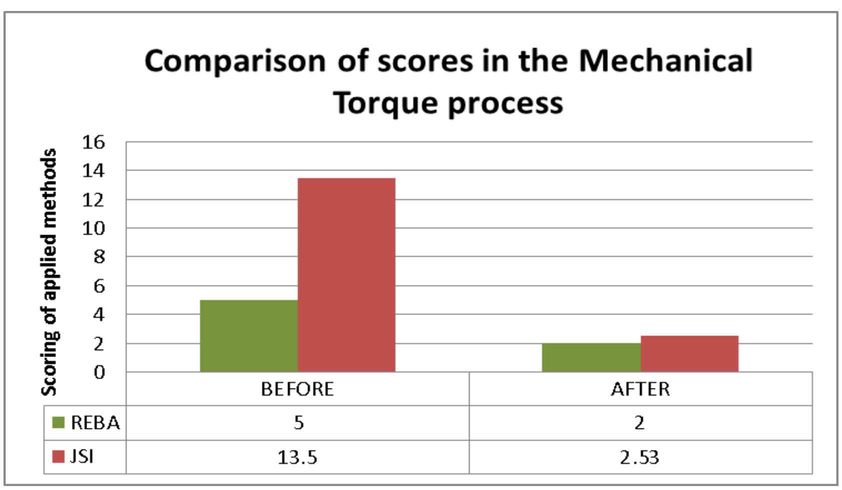


Figure 3. Comparison of results

As observed in the previous figure, with both methods applied after the improvements the score was reduced. In the case of the REBA method a required level of action and an average risk was reduced to a low risk and action may be necessary. As far as the JSI is concerned, being a high-risk task for the worker, was modified to a safe job for the worker. In the other hand, the implementation of these improvements to the process also benefited the reduction of standard time established for the task, reducing by 49 percent, a total of 220 minutes a week reflecting in its production capacity.

5. DISCUSSION/ CONCLUSIONS

With the results obtained, it is concluded that the objective was fulfilled satisfactorily, thus providing a competitive advantage in the improvement of the processes and therefore of the operational indicators of the company. In the same way, the physical integrity of the workers is improved since they eliminate or reduce those risk factors that could affect them in the medium or long term. One of the mistakes that companies make is to give priority to those improvements that directly influence the increase of production, leaving aside the worker's safety, since this is the most important resource that the company has, which is why ergonomic studies and culture in ergonomics are relevant in the companies.

6. REFERENCES

Datamonitor. 1 de Diciembre de 2011. Aerospace & Defense: Global Industry Guide. Recuperado el 04 de 10 de 2016, de http://www.datamonitor.com/store/Product/aerospace_defense_global_industry_guide? productid=8B245D93-AEFA-470F-B369-D282251DF233

De la Madrid, E. 2015. Revista Comercio Exterior Bancomext. La industria Aeroespacial y el despegue de la productividad en México. Recuperado el 15 de marzo de 2016 en: http://revistacomercioexterior.com/articulo.php?id=54&t=la-industria-aeroespacial-y-el-despegue-de-la-productividad-en-mexico

Diego-Mas, José Antonio. Evaluación de la repetitividad de movimientos mediante el método JSI. Ergonautas, Universidad Politécnica de Valencia, 2015. Recuperado el 04 de Abril de 2016 en: http://www.ergonautas.upv.es/metodos/jsi/jsi-ayuda.php

Diego-Mas, José Antonio. Evaluación postural mediante el método REBA. Ergonautas, Universidad Politécnica de Valencia, 2015. Recuperado el 04 de Abril de 2016 en: http://www.ergonautas.upv.es/metodos/reba/reba-ayuda.php

Diego-Mas, José Antonio. Selección de métodos de evaluación ergonómica. Ergonautas, Universidad Politécnica de Valencia, 2015. Recuperado el 12 de Abril de 2016 en: http://www.ergonautas.upv.es/herramientas/select/select.php.

Instituto Mexicano del Seguro Social. 2013. Memoria estadística 2013. Recuperado el 28 de Enero del 2015 de http://www.imss.gob.mx/conoce-al-imss/memoria-estadistica-2013

Kuorinka, B. Jonsson, A. Kilbom, H. Vinterberg, F. Biering-Sørensen, G. Andersson, K. Jørgensen. 1987. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics

Llaneza, J. 2007. Ergonomía y Psicología aplicada. 8va ed. España: Lexnova.

Occupational Safety Health Administration (OSHA). 2014. Prevención de lesiones musculo esqueléticas en el procesamiento avícola. Recuperado el 26 de Junio de 2016 en: https://www.osha.gov/Publications/OSHA3749Spanish.pdf

REENGINEERING IN MICRO WELDING WITH SOLDERING IRON IN AN ELECTRONIC COMPANY.

Laura Orozco y Jiménez[1], Hermelinda Guzmán Virgen[2], Rosa María López García[3], Rigoberto Zamora Alarcón[4]

[1]Universidad Autónoma de Baja California
Health Sciences
Blvd. Benito Juárez S/N CP 21280 Mexicali, B.C.
Lauraorozco_1404@hotmail.com

[2]Teleplant Service Logistics /Tecnomex Industrial S.A. de C.V.
Rubilinas # 3 CP 21600 Parque Industrial Palaco, Mexicali, B.C.

[3]Honeywell Productos Automotrices
Blvd. Lázaro Cárdenas # 2545 CP 21376 Mexicali, B.C.

[4]Universidad Autónoma de Baja California
Blvd. Benito Juárez S/N CP 21280 Mexicali, B.C.

Resumen: Una estación de trabajo en una empresa electrónica donde se realiza microsoldadura con cautín bajo microscopio, necesitó disminuir los riesgos a la salud como son posturas, movimientos repetitivos, fatiga visual y exposición a humos de soldadura en la población ocupacionalmente expuesta, para la mejora continua en el proceso.

Una vez identificada el área de trabajo se emplearon los métodos de evaluación ergonómica, medidas antropométricas, así como cuestionario, entrevistas y evaluación médica.

Como resultado se obtuvo que a través de la reingeniería se mejoraron posturas de extremidades superiores e inferiores, posición de cuello y espalda, se redujo la reflectancia y fatiga visual.

Se concluyó que a través de la reingeniería y ergonomía de la estación de microsoldadura con cautín, se obtienen mejoras en la salud, confort de los trabajadores, así como la eliminación de movimientos innecesarios, y la disminución de reflactancias y fatigas visuales.

Palabras clave: Reingenieria, microspdadura, riesgos a la salud

Abstract: A work station an electronic company performs micro welding with soldering iron and microscope, needs to reduce health risks such as postures, repetitive movements, eye strain and exposure to fumes from welding in the occupationally exposed population, in order to continuously improve the process.
Once the working area was identified, ergonomic methods, anthropometric measurements, as well as the application of questionnaires, interviews, and medical evaluations were used.

Through applying reengineering at the workstation, we obtained postures improvement of upper and lower extremities, neck and back positions, reflectance and eye strain was reduced as a result.

It was concluded that through the micro welding with soldering iron station reengineering and ergonomics, health improvements, workers comfort, as well as unnecessary movements elimination; and the reflectance and eye strain reduction.

Ergonomics Contribution: How to avoid eye strain and postural fatigue in the micro welding with soldering iron work station in an electronic company.

1. INTRODUCTION

Since 2007 an electronic company performs micro welding with soldering iron and microscope, in twelve workstations; they stated the need to reduce health risks, such as postures, repetitive movements, eye strain and exposure to fumes from welding in the occupationally exposed population. Ergonomic methods, questionnaires, interviews, medical examinations, and anthropometric measurements were applied. Through applying reengineering at the workstation, has yielded the remission of such risks.

OBJECTIVE

Applying reengineering at the micro welding with soldering iron workstation, through ergonomic proposals, in order to improve operator’s health and comfort.

2. METHODOLOGY

Questionnaire, historic working clinic, medical evaluation, including step zero were applied Table 1. Evaluation methods used were OKRA, RULA and Suzanne Rodgers, photographs, station videos, operators Anthropometrics measures; as well as ergonomic checkpoints.

Location and equipment anthropometry: each operator of the twelve micro welding with soldering iron stations were measured to determine their percentiles, as shown in Table 2, this measures were also compared to the chairs dimensions, tools and equipment location in table, Figure 1. (Prado León, Ávila Chaurand, Herra Lugo, 2005).

The luxometry in the workstation corresponding to the reflex was 110 lux

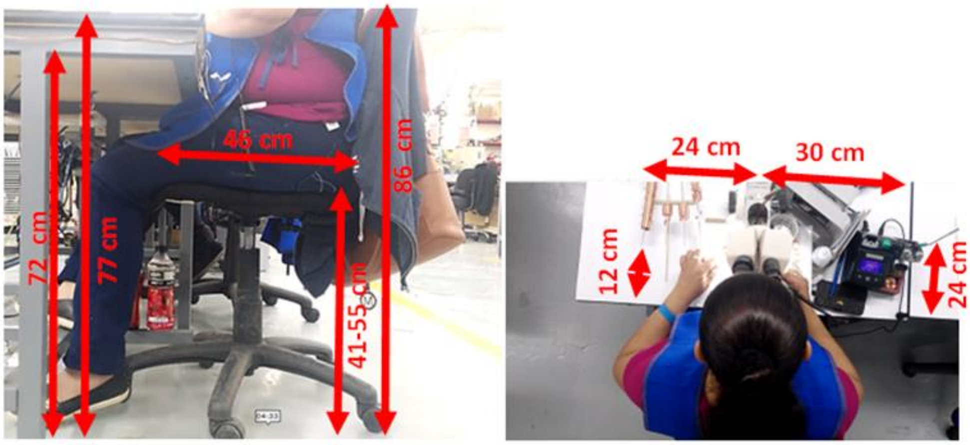


Figure 1 chair dimensions and locations on micro welding Table

Table 1. Survey of health step zero

Paso 0									
Operador	Peso	Talla	Frutas y Verduras	Agua	Deporte	Tabaco	Alcohol	Edad	Antigüedad
1	86.0	1.54	2 a 3 X Sem	1.5 L	No	Si	Si	46	6 Años
2	62.0	1.58	2 a 3 X Sem	1.0 L	No	No	Si	28	10 Años
3	70.0	1.52	2 a 3 X Sem	1.5 L	Diario	No	No	33	2 Años
4	82.0	1.62	2 a 3 X Sem	2.5 L	No	No	Si	27	5 Años
5	66.0	1.57	Diario	2.0 L	No	No	Si	24	2 Años
6	74.0	1.60	Diario	2.0 L	Diario	No	No	32	2 Años
7	110.5	1.62	1 a 2 X Sem	1.0 L	No	No	Si	27	1 Años
8	63.0	1.55	2 a 3 X Sem	1.0 L	No	No	No	39	3 Meses
9	95.0	1.56	Diario	1.5 L	No	No	No	42	5 Años
10	107.0	1.71	Diario	2.0 L	No	No	No	32	4 Meses
11	72.5	1.62	2 a 3 X Sem	2.0 L	No	No	Si	27	1 Año

	Fatiga		Desorden por Trauma AcumulativoDTA					Molestia X	
Operador	Lentes	Visual	Cuello	Hombro	Mano	Brazo	Dorso Lumbar	Humo	Rota
1	No	Si	Si	No	Bilateral	Derecho	Si	No	No
2	No	No	No	No	No	No	No	No	No
3	No	No	No	No	Derecha	No	No	No	No
4	Si	No	Si	No	Izquierda	No	Si	No	No
5	Si	Si	No	No	No	No	No	No	No
6	Si	No	No	No	No	No	No	No	No
7	No	No	No	No	No	No	No	No	No
8	No	No	Si	No	No	No	No	No	No
9	No	Si	No	No	No	No	No	No	No
10	No	Si	Si	Si	No	No	Si	No	No
11	No	No	Si	Si	Si	Derecho	No	No	No
	No	Si	No	Si	Izquierda	No	Si	No	No

Table 2. Operators anthropometrics, compared with chair dimensions and table locations

Descripción Antropométrica		Percentiles(Cm)			Dimensiones (Cm)	
		P_{05}	P_{50}	P_{95}	Silla	Mesa
8	Alcance de brazo frontal	65.3	73.0	80.8		-24*
9	Alcance de brazo lateral	66.2	71.8	77.5		36*
11	Profundidad máx. del cuerpo	21.4	28.7	36.0		24*-
13	Anchura máxima Bideltoidea	40.4	48.3	56.3		
14	Anchura de tórax	25.2	34.9	44.6		
15	Anchura codo -codo	41.6	51.2	60.8		
19	Diámetro de empuñadura	2.8	3.5	4.1		
23	Altura sentado	79.2	83.5	87.8		
24	Altura al omoplato	33.7	42.3	50.9	86*-	
25	Altura al codo sentado	21.5	25.0	28.5		77*-
26	Altura al muslo sentado	12.3	15.4	18.5		72*-
27	Altura a la rodilla sentado	46.4	50.2	54.1		72
28	Altura poplítea	34.2	37.2	40.2	41-55	
29	Longitud nalga-poplítea	41.2	46.0	50.8	46	
30	Anchura de cadera sentado	38.7	44.8	50.9	49	
31	Longitud de brazo	28.1	33.7	39.2		
32	Longitud de antebrazo	31.8	35.6	39.4		

RULA Method

The corresponding analysis was performed obtaining results shown on Table 3. A Final RULA Score of 4, which indicates a level 2 risk, showing improvements implementation is required.

Table 3. RULA Method for Micro welding with soldering iron on microscope Analysis

MÉTODO RULA Microscopio			
	Puntos		Puntos
GRUPO A. Análisis de brazo, antebrazo y muñeca		GRUPO B. Análisis del cuello, tronco y pierna	
Puntuación de Brazo	2	Puntuación del cuello	3
Puntuación de antebrazo	2	Puntuación del tronco	2
Puntuación de la muñeca	4	Puntuación de las piernas	1
Puntuación giro de muñeca	1	Puntuación del tipo de actividad muscular (Grupo B)	0
Tipo de actividad muscular(Grupo A)	1	Puntuación de carga/Fuerza (Grupo B)	0
Puntuación de carga/Fuerza (Grupo A)	0		
NIVELES DE RIESGO Y ACTUACIÓN			
Puntuación Final RULA	**4**		
Nivel de Riesgo	**2**		
Actuación	**Se requiere una evaluación más detallada y posiblemente, algunos cambios**		

Suzanne Rodgers Method

The corresponding analysis was performed obtaining results shown on Table 4. A black color evaluation on the right hand where the soldering iron is being hold, shows a very high risk, for which is necessary to implement changes.

Table 4. Suzanne Rodgers Method to analyze Micro welding with soldering iron supported by microscope

Sue Rodgers Miocrosoldadura Microscopio						
	Intensidad	Duración	Por minuto	Puntaje	Evaluación	
Cuello	2	2	3	**8**	**ALTO**	
Hombro	1	2	3	**5**	**MODERAR**	
Brazo y Codo	1	2	3	**5**	**MODERAR**	
Muñeca, mano, dedo	3	2	3	**10**	**MUY ALTO**	

OCRA Method

The analysis had shown on Table 5. A risk and valuation index of 26 for the right hand, which is not acceptable high level, because values are above 22.5 which are indicated in the rating scale; thus for the left hand is 15.5, which is not acceptable medium level, because the values are between 14.1 y 22.5 as indicated in the rating scale, it is essential to establish changes in the right hand where the soldering iron is hold.

RESULTS

As we could observe in the Suzanne Rodgers method, in which we were indicated to develop changes, this were weighed by comparing with digital display solution having significant improvements up to 60% on neck, which were the main manifestations indicated by operators, as shown on table 6 and chart 1, however the improvements on right hand did not changed much just 10%.

Table 5.OCRA Method to analyze Micro welding with soldering iron supported by microscope

MÉTODO OCRA. Factores de riesgo Microscopio		
	Derecha	Izquierda
Tiempo de recuperación insuficiente	**2**	**2**
Frecuencia de movimientos	**4.5**	**0**
Aplicación de Fuerza	**8**	**2**
Hombro	1	1
Codo	8	8
Muñeca	8	2
Mano-dedos	8	4
Estereotipo	1.5	1.5
Posturas Forzadas	**9.5**	**9.5**
Factores de riesgo complementario	**2**	**2**
Índice de Riesgo y Valoración	Derecha	Izquierda
Índice de Riesgo	**26** No aceptable nivel alto	**15.5** No aceptable nivel Medio
Escala de valoración del riesgo		
No aceptable nivel Medio	14.1-22.5	
No aceptable nivel alto	≥22.5	

Table 6. Suzanne Rodgers Method to analyze Micro welding with soldering iron supported by microscope

Análisis Sue Rodgers						
Microsoldadura con Pantalla Digital					Antes	Mejora
	Intensidad	Duración	Por minuto	Puntaje	Puntaje	Mejora
Cuello	1	2	2	2	8	60%
Hombro	1	2	2	2	5	30%
Brazo y Codo	1	2	2	2	5	30%
Muñeca, mano, dedo	3	2	2	9	10	10%

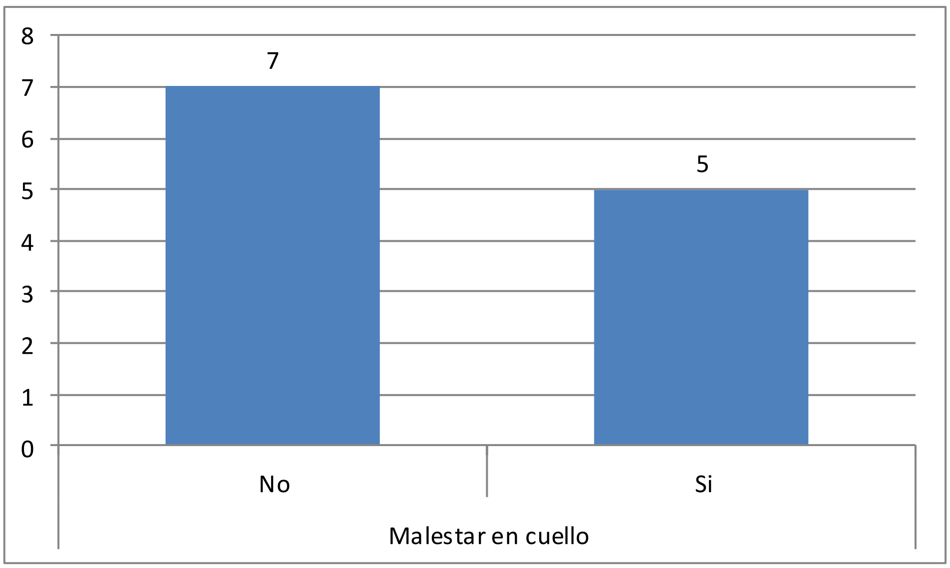


Chart 1 Number of operator’s manifestations in neck Micro welding with soldering iron supported by microscope

1. Improved neck and back position with digital display and ergonomic chair by straightening the neck and supporting the back correctly.
2. Improved upper extremities posture by bringing closer the tools and components to the point of use by utilizing the display.
3. Improved visual comfort while performing the micro welding tasks through the use of the digital display.
4. Reduced reflectance and eye strain.
5. Improved position of lower extremities by putting in place the use of ergonomic Chairs

CONCLUSIONS

According to the ergonomic evaluation in the work area, improvements were implemented through the station reengineering of micro welding with soldering iron, by substituting the microscope for a digital display and the conventional chair for an ergonomic one; which allowed to obtain health and comfort improvements for the workers as well as the unnecessary movements elimination in which we can highlight:

1. The use of a digital display allowed improved neck and back postures
2. Elimination of supination and pronation movements by laying tools and material supply (components) in a near reach to the operation point (point of use) and the manual extractor.
3. The total adjustable ergonomic chair use enabling operators to support their legs on the floor, allowing comfortable operating positions.
4. A digital camera was selected to project joint images between the welding and terminals, which made it possible to decrease reflectance and visual fatigue with the elimination of the microscope use.

Recommendations:

It is recommended to acquire ergonomic chairs for lower height personnel; as well as armrests to support the insulated soldering iron (Ergonomics Check Points, 2001); in the left hand a welding wire guide holder; rotate personnel and continue with the healthy breaks.

6. REFERENCES

Ergonomics Check Points (second edition) International Labour Office International Ergonomics Association (2001).

Peter J. Goodhew, John Humphreys, Richard Beanland. (2001) Electron Microscopy and Analysis, 3rd Edition.

Douglas B. Murphy. (2002) Fundamentals of Light Microscopy and Electronic Imaging.

Ian M. Watt (1997) The Principles and Practice of Electron Microscopy, 2nd Edition.

ERGONOMICS AND PSYCHOSOCIOLOGY OF WORK IN KEY OCCUPATION

OLGA BEATRIZ GUZMÁN SUÁREZ

Department of Human Occupation
National University of Colombia
School of Medicine offices 504 - 525
Avenue career 30 # 45 - 03
Bogotá, D.C. Colombia
Corresponding author's e-mail: obguzmans@unal.edu.co

Resumen: Antecedentes**.** La ergonomía y la psicosociología del trabajo, son tendencias que se han hecho presentes en la implementación de estrategias, para el logro de una cultura preventiva en riesgos laborales. La presencia de riesgos biomecánicos y psicosociales cada vez es más frecuente, por lo que, su abordaje requiere de intervenciones multidisciplinarias, y el concurso de profesiones como la Terapia Ocupacional, que a través del trabajo en clave ocupación, visibiliza al ser humano en su interacción persona – ambiente - ocupación.

A partir de este modelo, se interviene desde la promoción de estilos de vida y trabajo saludable, la prevención de accidentes de trabajo y enfermedades laborales, hasta los procesos de rehabilitación integral y de calificación de la pérdida de capacidad laboral de los mismos.

Objetivo. Determinar los alcances de la ergonomía y psicosociología del trabajo desde una perspectiva ocupacional, en los casos de enfermedad reconocidos como de origen laboral.

Materiales y métodos. Estudio descriptivo, de corte transversal, realizado a partir de la revisión de 50 evaluaciones de puesto de trabajo que determinó la identificación de 42 casos de enfermedad laboral con diagnóstico principal desórdenes músculo esqueléticos de miembros superiores o columna y 8 casos de Trastornos mentales derivados del trabajo o secundarios a patologías de base de origen laboral, en el período 2012 – 2016.

Resultados. Los diagnósticos reconocidos como enfermedad laboral, se corresponden con los resultados de la Segunda Encuesta Nacional de Condiciones de Salud y Seguridad en el Trabajo, aplicada en Colombia en 2013; además de las estadísticas registradas en fuentes oficiales nacionales, y en estadísticas internacionales que dan cuenta de las tasas de enfermedad laboral, en donde los diagnósticos por desórdenes músculo esqueléticos y trastornos mentales representan importantes cifras de absentismo laboral, como consecuencia de la exposición a riesgos biomecánicos y psicosociales relacionados con el trabajo y el entorno en que se desempeñan las personas calificadas.

Conclusión. La evidencia científica muestra la relación causa – efecto, entre los factores de riesgo biomecánicos y los psicosociales, con la consecuente aparición de desórdenes músculo esqueléticos y los trastornos mentales respectivamente, los cuales se relacionan con las labores que realizan las personas, lo que sugiere un claro abordaje desde la ergonomía y psicosociología del trabajo en clave ocupación, como un enfoque que requiere la implementación de estrategias multidisciplinarias, y que desde la perspectiva de Terapia Ocupacional adquieren un significado importante en la articulación entre la persona, las tareas que realiza (demandas de la actividad), y el ambiente en que las desarrolla (condiciones de trabajo y del contexto).

Palabras clave. Ergonomía, Psicosociología, Trabajo, Ocupación.

La importancia de este artículo, radica en reconocer las tendencias de disciplinas como la Ergonomía y Psicosociología del Trabajo que aportan a los nuevos retos de atención de riesgos emergentes que afectan el desempeño ocupacional humano, entendido éste desde la Terapia Ocupacional como *"el actuar ocupacional de las personas en ambientes específicos"* (Trujillo, 2002). El reporte de los casos revisados, pone de manifiesto la necesidad de articular estrategias preventivas de la exposición a riesgos biomecánicos y psicosociales, con aspectos de la ocupación y del contexto, que impactan de manera importante en la calidad de vida de las personas y en la productividad para las empresas.

Summary: Background**.** The ergonomics and the psychology of work, are trends that have been made in the implementation of strategies for the achievement of a culture of prevention in occupational hazards. The presence of biomechanical and psychosocial risks is becoming more frequent, so, your approach requires multidisciplinary interventions, and the contest of professions such as occupational therapy, which through work on key occupation, makes visible to humans in their interaction, person - environment - occupation.

From this model, it intervenes from the promotion of lifestyles and healthy work, prevention of accidents at work and occupational diseases, to the processes of rehabilitation and the loss of labour capacity of the same rating.

Objective. To determine the scope of ergonomics and psychosociology of work from an occupational perspective, in cases of illness recognized as of work origin.

Materials and methods. Descriptive, cross-sectional study, based on a review of 50 workplace evaluations that determined the identification of 42 cases of occupational disease with a diagnosis of major skeletal muscle disorders of the upper limbs or column and 8 cases of Mental Disorders Derived from Work Or secondary to basic pathologies of work origin, in the period 2012 - 2016.

Results. The diagnoses recognized as occupational disease correspond to the results of the Second National Survey of Health and Safety at Work, applied in Colombia in 2013; In addition to statistics from official national sources and international statistics on occupational disease rates, where diagnoses for musculoskeletal disorders and mental disorders represent significant numbers of absenteeism due to exposure to risks Biomechanical and psychosocial issues related to work and the environment in which qualified persons perform.

Conclusion. Scientific evidence shows the relation cause – effect, between biomechanical and psychosocial risk factors, with the consequent appearance of musculoskeletal disorders and mental disorders, respectively, which are related to the work performed by the individuals, suggesting a clear approach from ergonomics and psycho-sociology of work in key occupation, as an approach that requires the implementation of multidisciplinary strategies, and that from the perspective of Occupational Therapy acquire an important meaning in the articulation between the person, the tasks performed (demands of The activity), and the environment in which it develops them (working conditions and context).

Keywords: Ergonomics, Psychosociology, Work, Occupation.

The importance of this article lies in recognizing trends in disciplines such as Ergonomics and Occupational Psychosociology that contribute to the new challenges of attention to emerging risks that affect human occupational performance, understood as Occupational Therapy as "the occupational act of People in specific environments "(Trujillo, 2002). The report of the reviewed cases shows the need to articulate preventive strategies for exposure to biomechanical and psychosocial risks, with aspects of occupation and context, which have an important impact on people's quality of life and productivity for companies.

1. INTRODUCTION

The International Labor Organization (ILO), in its report "Prevention of occupational diseases", emphasized that occupational diseases cause enormous suffering and losses in the world of work.

According to results of the II National Survey of Occupational Health and Safety Conditions in the General System of Occupational Risks of Colombia (Ministry of Labor & OISS, 2013), skeletal muscle disorders continue to be the first cause of labor morbidity among the population worker. However, an important factor is evident and is the emergence of Mental Disorders derived from work as another of the top 10 diseases that have occurred in the last decade. These data are consistent with ILO reports (2013).

This is how the implementation of improved working conditions requires an approach from an integral and interdisciplinary perspective, focused on the recognition of people as holistic beings, who work in a profession or trade and therefore it is inevitable to depart from the occupation, in relation to the individual and the environment (Polonio, 2003).

This suggests the competition of various areas of training such as ergonomics and work psychology, as well as the recognition of professionals who bring theoretical and practical knowledge of their training, to the solution of situations arising from frank exposure to risk factors that Continue to appear in the world of work, following the emergence of dangerous working conditions and increasing physical and mental demands (Romero, 2005).

Speaking in occupational key, it requires the presence of Occupational Therapists of profession in the interdisciplinary teams, since it is a race with a hundred years of world-wide trajectory, whose object of study is the human occupational performance (Trujillo, 2002). The World Federation of Occupational Therapists (2012) argues that "occupational therapists achieve this result in working with individuals and communities to improve their ability to participate in the occupations they want, need, are expected to do, or through the modification of the occupation or the environment to better support their occupational commitment ". Its basic training brings together the necessary elements to address promotion and prevention activities, as well as rehabilitation of pathologies derived from any event and type of risk (Trujillo, 2002).

In Colombia, Occupational Therapy is regulated by Law 949 of 2005 and its competences are recognized by the Ministry of Health and Social Protection (2016). The relationship with ergonomics is established in the literature and scientific articles available in databases and on the web, which makes it possible to visualize its scope with different population groups (Guzmán, 2008).

1.1 Ergonomics

The International Ergonomics Association (2017), considers ergonomics (or human factors) as "a scientific discipline related to the understanding of interactions between humans and other elements of a system (...) "

The term ergonomics derives from the Greek words erg = work. Nomos = study, laws. What literally means "the study of work" (Real Academia Española, 2017). As a discipline, ergonomics aims to adapt teams, tasks and tools to the needs and capacities of human beings, improving their efficiency, safety and well-being (Society of Ergonomists of Mexico, s.f.).

1.2 Psychosociology

The word psycho-sociology, comes from Psycho and Sociology. This results in the psychological study of human societies and social phenomena (Royal Spanish Academy, 2017).

The International Labor Organization (1986) considered psychosocial factors at work as "the interactions between work, its environment, job satisfaction and the conditions of the organization, on the one hand, and on the other, in The workers' capacities, their needs, their culture and their personal situation outside work, all of which through perceptions and experiences can influence health, performance and job satisfaction "(ILO, 1986, p. 3).

1.3 Occupation

The word occupation comes from the Latin *occupatio*. It contemplates several definitions between the one that stands out by its approach with the subject of study, the one of Work, employment, office (Real Academia Española, 2017).

However, the perspective of occupation, finds in Occupational Therapy a meaning and meaning that goes beyond work; The study of the occupation, from the point of view of its power to promote well-being, to preserve or recover health and to promote the quality of family, educational, work and social life, has been object of study by the community of therapy Occupational since the beginning of the 20th century (Trujillo et al, 2011, p.28).

The key occupation in relation to the ergonomics and psychosociology of work, does not lose sight of the triad Person - Environment - Occupation proposed from Occupational Therapy, considering that the components of occupational performance must be approached in an integral manner and show their Functionality to identify risk factors, assess and intervene.

2. MATERIALS AND METHODS

The study was carried out between 2012 and 2016 within the framework of the transformation period of the General System of Labor Risks in Colombia. This is a descriptive, cross-sectional, study based on the review of 50 work evaluations that determined the identification of 42 cases of occupational disease with a diagnosis of major skeletal disorders of the upper limbs or column and 8 cases Mental disorders derived from work or secondary to basic pathologies of work origin.

The review was carried out under the documentary file inspection technique, where variables related to diagnosis, economic activity, job functions, physical load and mental load levels, working environment conditions, conditions Security, job design and organizational aspects. The relevance was obtained in the analysis of tasks rather than in the quantification of risk.

3. RESULTS

The study findings reflect, in a significant way, the influence of biomechanical factors (Romero, 2005), and psychosocial factors (Romero, 2005) and (Mintrabajo, 2015), which are dangerous factors in the presentation of symptoms and clinical Work and occupation performed by the people, as shown in Table 1.

Table 1. Biomechanical and Psychosocial Factors that Influence the appearance of diseases mental, and skeletal muscles respectively.

Factors	**Risks**	**Possible Occupational Diseases**

Biomechanics	Physical load	• Repetitive movements • Repeated movements • Concentric movements • Forced Posture • Prolonged Posture • Posture Maintained • Antigravity Posture • Handling, lifting or transporting loads above the permissible limits for both men and women. • Handling of high frequency loads	**Upper limbs:** • Rotator Cuff Syndrome. • Medial, Lateral or Mixed Epicondylitis. • Carpal Tunnel Syndrome. • Tenosynovitis of Quervain, Tendonitis of flexors / extensors of the carpus and fingers, Channel of Guyón. **Column:** • Herniated disc • Low back pain • Neck pain
Psychosocial	Mental Load	Organization of work • Working day • Pace of work • Automation • Communication • Command Styles • Content of work • Social status • Level of responsibility • Identification with the task or product. • Initiative • Lack of knowledge • Lack of motivation or improper attitude • Lack of physical or mental capacity.	• Mixed Anxiety and Depression Disorder. • Adaptive and Behavioral Disorders. • Post-traumatic stress disorder. • Burnout syndrome • Sleep disorders • Heart attack • Gastritis • Irritable colon

Source: self made.

It was established that of the 42 cases of labor illness 35 were reported with major diagnosis musculoskeletal disorders of the upper limbs, with emphasis on bilateral carpal tunnel syndrome with 52%, Bilateral Mixed Epicondylitis 18% Qervain Right Tenosynovitis 12%, Cuff Syndrome Bilateral rotator 12%, other synovitis and tenosynovitis 6%. The 7 remaining cases corresponded to pathologies of spine, among the most frequent acute lumbar pain with 69% and Hernia disc 31%; Of this the cervical region represents 23% of the cases, dorso-lumbar 52% and lumbo-sacra 25%.

By sex, the proportion was 29 women representing 69% and 13 men representing 31%, clearly women are more affected than men, understanding that this situation is related to individual factors of age and occupation. By age range, the mean for women was between 26 and 35 years, while men were classified between 36 and 45 years.

By occupation, women were more frequently charged in entities of the financial sector, administrative and general service, packaging and flower workers. In men the operational work in warehouses, storage, maintenance areas and civil works was the most significant.

Of the 8 cases of Mental Disorders derived from work, 4 correspond to Mixed Disorders of anxiety and depression, 1 to post-traumatic stress and the remaining 3 to adaptive disorders secondary to work-related basic pathologies.

By sex, men are more affected than women in basic disorders, this is related to the level of position and responsibilities that they manage to be part of groups of senior management, the age is represented in the range of 46 to 55 years.

A case of post-traumatic stress classified as an occupational disease given as a sequel to the basic event "robbery in a financial institution", classified as an occupational accident, a 53-year-old woman. Secondary disorders were focused on 67% of women and 23% with diagnoses related to musculoskeletal disorders of the upper limbs.

4. CONCLUSIONS

Of the total cases identified, 93.6% are directly related to the causal factor and only 6.4% showed indirect effects. 84% of the cases reviewed correspond to some skeletal muscle disorder and 16% to mental disorders.

Most diagnoses continue to account for the lack of efficiency and effectiveness of prevention systems.

Although the biomechanical and psychosocial risks are often treated separately, the statistics and the historical moment of occupational health, require a comprehensive approach in which Ergonomics and Psycho-sociology of work recovers, two basic axes in the formation of Occupational Therapists, with greater recognition in Latin American countries with strength in Colombia.

The cases identified with Occupational Illness, require evaluation of jobs with emphasis on physical load or mental load, depending on the nature of the study, the professional is required. For the processes of monitoring, risk management and tertiary prevention in rehabilitation, the need for inter and multidisciplinary work is evident.

The ergonomics and psycho-sociology of work represent a current challenge and is set in a set of actions that are integrated with each other, can be applied to the diversity of occupations performed by people, design and adaptation of jobs, assignment of tasks and Organization of work.

With the implementation of Occupational Health and Safety Management Systems, a greater tendency of teamwork is evident.

5. REFERENCES

Guzmán Suárez, O. (2008). Ergonomía y Terapia Ocupacional. *TOG (A Coruña) (5) 1, 1 - 23.* Recuperado de http://www.revistatog.com/num7/pdfs

International Ergonomics Association –IEA-. (2017). Ergonomía. Recuperado de http://www.iea.cc/whats/index.html

Organización Internacional del Trabajo –OIT-. (1986). Los factores psicosociales en el trabajo: reconocimiento y control. Ginebra: Oficina Internacional del Trabajo.

Organización Internacional del Trabajo –OIT- (2013). The Prevention of Occupational Diseases. Recuperado de http://www.ilo.org/safework/info/publications/WCMS_208226/lang--es/index.htm

Polonio, B.; Durante, P. y Noya, Blanca. (2003). Conceptos fundamentales de Terapia Ocupacional. Madrid: Medica Panamericana.

Real Academia Española. (2017). Ergonomía. Recuperado de http://dle.rae.es/?id=G1kAF4l

Real Academia Española. (2017). Psicosociología. Recuperado de http://dle.rae.es/?id=UXCCoB3

Real Academia Española. (2017). Ocupación. Recuperado de http://dle.rae.es/?id=Qu0oRKT

República de Colombia. Congreso de la República. Ley 949 de 2005 Por la cual se dictan normas para el ejercicio de la profesión de terapia ocupacional en Colombia, y se establece el Código de Ética Profesional y el Régimen Disciplinario correspondiente. Diario Oficial No. 45.853 de 17 de marzo de 2005.

República de Colombia. Ministerio del Trabajo & Organización Iberoamericana de Seguridad Social –OISS- (2013). Segunda Encuesta Nacional de Condiciones de Seguridad y Salud en el Trabajo en el Sistema General de Riesgos Laborales. Bogotá: OISS.

República de Colombia. Ministerio del Trabajo & Pontificia Universidad Javeriana. (2015). Promoción, prevención e intervención de los factores psicosociales y sus efectos en población trabajadora. Bogotá: JAVEGRAF.

República de Colombia. Ministerio de Salud y Protección Social. (2016). Perfil profesional y competencias del terapeuta ocupacional. Recuperado de https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/VS/TH/perfil-competencias-terapeuta-ocupacional.pdf

Romero M, J. (2005). Manual de Ergonomía y Psicosociología. Ibermutuamur. Madrid (España): PyCH&Asociados, S.L.

Sociedad de Ergonomistas de México. (s.f.). Ergonomía. Recuperado de http://www.semac.org.mx/index.php/ergonomia.html

Trujillo Rojas, A. (2002). Terapia Ocupacional, conocimiento y práctica en Colombia. (pp. 36 – 83) Bogotá: Universidad Nacional de Colombia.

Trujillo, A., Sanabria, L., Carrizosa, L., Parra, E., Rubio, S., Uribe, J., Rojas, C., et al. (2011). Ocupación: sentido, realización y libertad. Diálogos ocupacionales en torno al sujeto, la sociedad y el medio ambiente. Grupo de Investigación Ocupación y Realización Humana. Bogotá: Universidad Nacional de Colombia.

World Federation of Occupational Therapists. (2012). Definición de Terapia Ocupacional. Recuperado de http://www.wfot.org/AboutUs/AboutOccupationalTherapy/DefinitionofOccupationalTherapy.aspx

ERGONOMICS GUIDELINES APPLICATION IN SEWING OPERATIONS OF MEDICAL TOURNIQUET.

Daniel Laborin Hurtado, Lamberto Vázquez Veloz, Carlos Alfredo Serrano Leyva, Edmundo Antonio Carrillo Medina, Kevin Alexis Moreno Rey

Industrial Engineering Department
Instituto Tecnologico de Agua Prieta.
Ave. Tecnologico and Road to Janos Chihuahua
Agua Prieta, Sonora, 84200
dlaborin2015@gmail.com, drlamberto@gmail.com

Resumen: La alta demanda de productos comerciales ha generado en la mayoría de las empresas poner atención al cumplimiento de éstos requerimientos, los problemas de calidad día a día demandan de mayor atención si se quiere permanecer en el mercado, equipos de trabajo como círculos de calidad entre otros son utilizados para resolver algunas de las problemáticas presentadas y poder mantener las empresas en un concepto manejado por la manufactura esbelta llamado mejora continua, sin embargo existe un punto que al paso de los últimos años ha venido generando problemas dentro de las líneas de producción, la fatiga excesiva y la presencia de desórdenes musculo esqueléticos en los trabajadores que poco a poco han desviado la vista de los empresarios para atender situaciones de ausencias, incapacidades médicas y hasta en algunos casos infracciones impuestas por las autoridades correspondientes por el incumplimiento de normas de seguridad.

Un incremento gradual se ha presentado ante las instituciones de asistencia medica públicas y privadas para atender éste tipo de situaciones, he incluso instituciones no gubernamentales poco a poco ponen atención a éste fenómeno, los problemas más recurrentes son lesiones en la columna vertebral sobre todo en vértebras cervicales y lumbares, sin dejar de lado túnel del carpo entre otras.

El caso de estudio que hoy se presenta trata la situación de una estación de trabajo de costura en una empresa del noreste del estado de Sonora, donde las directrices ergonómicas han sido ignoradas en su totalidad, la operación se llama “ensamble de torniquete de uso médico” y consta de coser sobre un velcro una hebilla de sujeción.

Palabras clave: Ergonomía, repetitivo, Predeterminado.

Abstract: The high demand of commercial products has generated in most of the companies to pay attention to the fulfillment of these requirements, the quality problems day by day demand of more attention if one wants to remain in the market, work teams like circles of quality among others are used to solve some of the problems presented and to be able to keep the companies in a concept handled by the lean manufacturing called continuous improvement, nevertheless there is a point that to the step of the last years has been generating problems within the lines of production, the excessive fatigue and the presence of musculoskeletal disorders in

workers who have gradually diverted their eyes from employers to deal with absences, medical incapacities and even in some cases violations imposed by the corresponding authorities for non-compliance with safety standards.

A gradual increase has been presented to public and private health care institutions to address this type of situation, and even non-governmental institutions gradually pay attention to this phenomenon, the most recurrent problems are spinal injuries especially in vertebrae cervical and lumbar, without leaving aside carpal tunnel among others.

The present case study deals with the situation of a sewing workstation in a company in the northeastern state of Sonora, where ergonomic guidelines have been completely ignored, the operation is called "medical use tourniquet assembly "And consists of sewing a buckle on a velcro.

Key words: Ergonomics, repetitive, Predetermined.

Relevance to Ergonomics: The procedure development that allows ergonomics guideline application and ergonomics improvements at work stations where is required a sewing station, implies consistently an improve of productive efficiency in the interaction machine – man, and at the same time an increment in its quality of life, actions intrinsically related with ergonomics postulates.

1. INTRODUCTION

The products elaboration that require in its transformation process, a sewing operation, has been increased in the last years, specifically at manufacturing industries at northeast of Sonora State. This has been generated work stations which don't accomplish ergonomic guidelines designs. This, in its temporal conditioner reaches to structure the necessary and able condition to develop a Musculoskeletal disorder (MSD).

Added to this, the specifications set used at non ergonomics considered designs, increase operation cycle time at sewing operation and hence minimize operator productive performance and increase the possibility to generate an injury or hurt health. (Vázquez, 2012).

This job starts using a practical procedure for ergonomics risk evaluation at work stations, showing the necessity of structural changes on itself.

On the other hand, line production efficiency is affected, mainly due cycle time increase, brought about job rhythmus reduction. In consequence, if work stations are designed under ergonomics guidelines, the productive systems will be more efficient.

1.1 General objective: Design an ergonomic procedure to improve a sewing operation able to increase productive performance of operator and its quality of life.

1.2 Specific objectives:

1. Value scientist theoretical issues related with the job done in sewing areas, applying ergonomic improvement guidelines of study object stations.

2. Design an ergonomic procedure that improves tourniquet sewing.
3. Validate increased productive performance of operator and its quality of life from its designed procedure.

2. DELIMITATION

The present practical case is limited to itself tourniquet sewing characteristics, performed in those intermittent production line with inline flows at manufacturing and maquiladora export industries in Northeast of Sonora State.

3. METHODOLOGY

The present practical case carries with it pragmatic actions described next:

A first moment where a tack is done in production lines at an export maquiladora in Agua Prieta, Sonora. In this journey is detected a sewing operation which shows operator making some movements defined as non-ergonomic.

After authorizations have been obtained, video and cycle time has taken to detailed review. Pic. 1 show as static manner a set of complex postures used to develop study tasks.

A time and motion study is performed to establish the production capacity of the station where the following operations are contemplated:

a) Position ring and loop
b) Sewing
c) Cut threads
d) Search material
e) Transfer material

The performance of this activity gives us a standard operating time of 12.7080 seconds.

Picture 1. Actual tourniquet sewing process.

The specialized literature on the subject shows that there is a strong variation in the result of the risk reached by the station and the method of evaluation, in this sense it is established that: "*the statistical evidence provided by the study suggests the use of the methods of rating that score higher*”. (Lopez, et al 2003).

The recommendation given by the aforementioned study refers to the use of methods such as RULA, Joyce Institute and Ergotec, such as methods that may result in a higher risk in a workstation, while Suzanne Rodgers and OSHA check list, evaluate results as medium and low risk respectively for a single operation. Since this, RULA method is selected for ergonomic evaluation of work station object of study.

To accomplish mentioned analysis is necessary to apply some ergonomic tools such as: Rapid Upper Limb Assessment (RULA), this evaluation gives a score of 7, which means than current work station has to be stopped and modified as soon as possible.

Another important point of procedure is to establish an evaluation mechanism of impact of productive results in the work station made from application of ergonomic guidelines.

While presented case typology, is necessary consider than productivity capacity of work station will be analyzed through predetermined time studies; the application of select method of predetermined time is analyzed depending of kind of movement demanded by operation these movements can be classified in two categories:

a) By distance traveled
b) By extremities which makes movement

MODAPTS technics works with second’s allowing less calculus and a high velocity. At same time extremities and distance traveled are closely linked.

The predetermined time studies require measurements systems of each traveled distance. Instead of, MODAPTS use classification of different parts of the body. This technic use as units of work a “MOD”, every “MOD” is equal to 0.129 seconds. (García, R. 2005)

For this, a study of predetermined times is chosen, MODular Arrangement of Predetermined Time Standards (MODAPTS), is applied after the use of ergonomic guidelines, which will prove if modification of work station represent an increment in productivity and efficiency of operator.

Table 1: MODAPTS application in work station study object

Left hand activities		Right hand activities	
Activity	MOD’s	Activity	MOD’s
Reach material	22		
Put in position	2	Take buckle	3
Stretch base material	4	Insert buckle	6
Hold base material	1	Turn material in buckle	2
Hold material for backstitch	2	Actuate backstitch handle	3
		Hold buckle	2
Arrange material for second backstitch	3	Arrange material for second backstitch	2

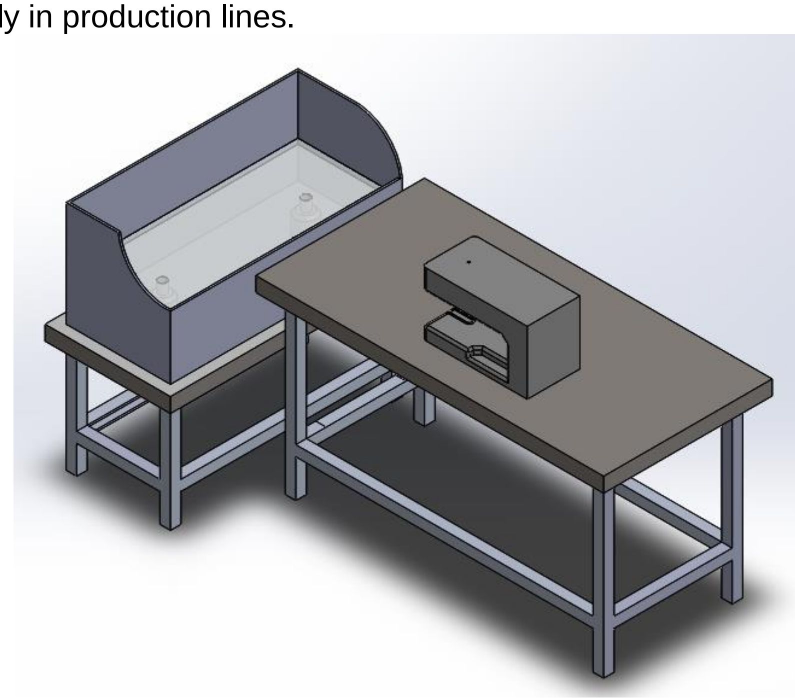
Sew complete material	3	Actuate backstitch handle	3
Withdraw sew material	3	Take scissors	2
		Cut bobbin thread	3
Bring material to front	3	Cut excesive thread	4
		Release scissors	2
Stretch material	4	Hold material	2
Arrange material in final position	4	Arrange material in final position	4
Left hand total movement	51	Right hand total movement	38
Total MOD's made 51+38= 89 89* 0.129= 11.481 sec			

4. RESULTS

Solid Works software was used to design a new work station for tourniquet sewing, a set of ergonomic guidelines has been used to create the right interaction machine – man. The mentioned modification establish as input, the way to level to the same axial plane the raw material to be processed, avoiding turning movement and decreasing spine torsion that operator apply in lumbar area.

This modification at the same time that avoids risk of generating a MSD, cuts radically distance between raw material and operator, creating an increment in productivity of the station. Reducing operation time standard from 12.7080 to 11.4810 sec.

Picture 2 shows a proposal for a new design of a sewing station which works systematically in production lines.



Picture. 2 Work bench added with spring lifting mechanism.

Table 2, shows comparative related to decreasing operation standard time once ergonomics guidelines has been applied.

Table 2: Comparative standard time before and after ergonomics guideline application

<table>
<tr><th>Work station</th><th>Standard time</th><th>Difference</th></tr>
<tr><td>Before ergonomics guidelines application</td><td>12.7080 Sec</td><td rowspan="2">1.2270 Sec per operation Which represent increasing daily production of 10.68 %</td></tr>
<tr><td>After ergonomics guidelines application</td><td>11.4810 Sec</td></tr>
</table>

5. CONCLUSIONS

The ergonomic guidelines application in a sewing work station achieve substantial improvement in worker task, decreasing consistently the probability of generating a MSD, in workers that develop activities in sewing performed in those intermittent production lines with inline flows at manufacturing and maquiladora export industries in Northeast of Sonora State.

The practical application of designed procedure shows a reduction of amount of necessary movements consistently of task, and at the same time a reduction of negative impact of work over operator, which is reflected in a better quality of life. These actions that obviously are of high urgency in this type of tasks and that as a whole manage to impact on a productive plant of high effectiveness.

6. REFERENCES

Garcia, R. (2005). *Estudio del Trabajo.* México: Mc Graw Hill

López, F.O. (2003). *Estimación del riesgo al usar métodos de evaluación ergonómica de puestos de trabajo.* En: Cuarto Congreso Nacional de Estudios del Trabajo. Recuperado de: http://www.izt.uam.mx/sotraem/Documentos/Documentos/Amet2003/templates/res/tema%209/OCTAVIO%20LOPEZ-ENRIQUE%20DE%20LA%20VEGA.pdf

Vázquez, Lamberto. (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.

ERGONOMIC FACTORS IN TEACHING PERFORMANCE IN HIGHER EDUCATION INSTITUTIONS.

[1]Raquel Muñoz Hernández, [2]Javier Nava García

[1]División de Ingeniería Industrial y de Sistemas.
Universidad Politécnica del Valle de México.
Av. Mexiquense s/n, Col. Villa Esmeralda,
C.P. 54910, Tultitlán, Estado de México
jael2222@hotmail.com

[2]División de Ingeniería Industrial
Tecnológico de Estudios Superiores de Coacalco,
Avenida 16 de Septiembre 54, Cabecera Municipal,
Coacalco de Berriozábal, México, C.P. 55700
javinavag@hotmail.com

Resumen: En el presente estudio se analizaron factores relacionados con la ergonomía organización y la productividad del desempeño académico, para identificar si existe incidencia entre ellos. Para su análisis se identificaron variables agrupadas en tres dimensiones: ergonomía física, ergonomía del factor humano, y ergonomía ambiental, las cuales conforman la ergonomía organizacional. En la ergonomía física se evaluaron factores posturales, dimensiones del puesto de trabajo y del mobiliario, aplicando el Método Rapid Upper Limb Assessment (RULA). En la ergonomía del factor humano se analizaron aspectos psicosociales, aplicando el método Laboratoire d'Economie et Sociologie du Travail (LEST). Para la ergonomía ambiental se realizaron mediciones directas con equipo especializado. El análisis global se llevó a cabo a través de métodos estadísticos: ANOVA entre la productividad del desempeño docente (Variable suma de productos que en forma conceptual se expresa como la producción de recursos por unidad de tiempo), y las variables de la ergonomía organizacional. Para darle sustento explicativo a las variables, se utiliza una matriz de correlaciones con distribución de Pearson (Xi^2). Los resultados obtenidos muestran que existe significancia estadística entre las variables de ergonomía organizacional y la productividad en el desempeño académico. Con lo cual se puede concluir que es determinante considerar la ergonomía organizacional para incrementar la productividad en el desempeño académico

Palabras clave: Ergonomía organizacional, desempeño académico, productividad.

Relevancia para la Ergonomía: Uno de los factores considerados relevantes para la investigación ergonómica actual es el uso progresivo de las nuevas tecnologías por parte de los profesores que, además de la cátedra, deben realizar

investigaciones y pasar gran parte de su jornada laboral frente a una pantalla de computadoras para mostrar datos y gestionar los diversos periféricos que componen el área de trabajo.

Teniendo en cuenta lo anterior, en nuestro país no existen registros de estudios basados en los riesgos desergonicos a los que están expuestos los docentes universitarios, centrándose principalmente en su impacto en el rendimiento docente

Palabras clave: Ergonomia organizacional, ejecución academica, productividad

Abstract: In this paper, we analyzed factors related to academic performance Productivity and organizational ergonomics, in order to identify if there exist incident on Productivity's increasing or decreasing in an institution of High education at State of Mexico. For this analysis, three groups of variables were identified: physical ergonomics, human factor ergonomics, and environmental ergonomics, all of them conforming the whole organizational ergonomics. Within physical ergonomics, postural factors, furniture and working place dimensions were analyzed, applying Rapid Upper Limb Assessment Method (RULA). Concerning the human factor ergonomics, psychosocial factors were analyzed, applying Laboratoire d'Economie et Sociologie du Travail method (LEST). The environmental ergonomics was measured with specialized equipment. The analysis was carried out using statistical methods such as ANOVA comparing educational performance productivity (Variable sum of products which expresses, in conceptual form, resources production per unit of time), with organizational ergonomics variables. With the aim to explain the variables, a correlation matrix was constructed in order to analyze Pearson's distribution (Xi^2). Great statistical evidence was found in which productivity is highly correlated with organizational ergonomics focusing the academic behavior of the analyzed institution. Finally, the study concludes that considering organizational ergonomics towards increasing academic performance productivity is reliable.

Keywords: Organizational ergonomics, academic performance, productivity.

Relevance to Ergonomic: One of the factors considered relevant to the current ergonomic research is the progressive use of new technologies by teachers, who, in addition to the chair, must carry out research and spend much of their working day in front of a screen of Computer to display data and manage the various peripherals that make up the work area.

Taking into account the above, in our country there are no records of studies based on disergonomic risks to which university teachers are exposed, focusing mainly on their impact on teacher performance

1. INTRODUCTION

In recent years the number of companies worldwide has increased in both the production and service sectors. The International Labor Organization (ILO, 2013) reports that over 317 million accidents occur on the job annually and 6,300 people die each day from work-related accidents or illnesses. The cost of this daily adversity is enormous and the economic burden of poor health and safety practices is estimated at 4 percent of the Gross Domestic Product (GDP), global of each year, implying in addition to human losses, financial losses.

In 2008, the ILO adopted the Occupational Safety and Health Program and the Environment, which aims to raise global awareness of the magnitude and consequences of accidents, injuries and work-related diseases and disergonomic hazards. At present there is a considerable gap in the application of ergonomics and it is only applied in some manufacturing jobs, without considering that it contributes to improving the conditions of workers in general and reduces the risks.

For Márquez (2007), work activities in the educational field must be rethought: from the way of teaching, the means used for it and the infrastructure, as well as the organizational structure of the centers and their culture, that is, of existing relationships Between the teacher and his work environment, where the term environment is used in an integral sense, which includes apparatus, tools, materials, methods and derives the need to study the Ergonomic aspects.

Another approach is that which considers ergonomics as an "educational element of the environment, which facilitates the interaction between the individual and his work environment; It translates into better quality of life, reduction of possible accidents and diseases, increase of well-being, productivity, health care and the environment (Ramírez, 2010, p.97).

For Márquez (2007), work activities in the educational field must be rethought: from the way of teaching, the means used for it and the infrastructure, as well as the organizational structure of the centers and their culture, that is, of existing relationships Between the teacher and his work environment, where the term environment is used in an integral sense, which includes apparatus, tools, materials, methods and derives the need to study the Ergonomic aspects. Another approach is that which considers ergonomics as an "educational element of the environment, which facilitates the interaction between the individual and his work environment; It translates into better quality of life, reduction of possible accidents and diseases, increase of well-being, productivity, health care and the environment (Ramírez, 2010, p.97).

2. OBJECTIVES

Analyze if there is a relationship between Organizational Ergonomics and the productivity of academic performance in Higher Education. Analyze if there is a relationship between Organizational Ergonomics and the productivity of academic performance in Higher Education.

3. METHODOLOGY

The present research is an exploratory, transversal, descriptive and correlational study that consists in identifying the relationship between the Organizational Ergonomics and the productivity of the academic performance in the Higher

Education of a University in the State of Mexico of the State of Mexico through the Measurement with ergonomic methods in teaching-learning environments.

Pre-experimental design, with informed consent and then apply a measurement on one or more variables. Also in this design there is no manipulation of the independent variable, there is no comparison group.

3.1. Characteristics of the study

Because the research evaluates environmental conditions and jobs, the sample focused only on the PTCs, because they have the required characteristics; However not included at all; The research was limited by staff working times.

Study Factors.- In order to know the aspects that they infer in the teaching performance, the Organizational Ergonomics factors were identified, which are presented below:

Ergonomics of the human factor.
- Sex
- Age
- Participation, involvement, responsibility.
- Training, communication and information.
- Time Management
- Group cohesion.

Environmental Ergonomics.
- Luminous Environment
- Thermal Environment
- Sound Environment.

Physical Ergonomics
- Static Posture
- Dynamic stance
- Repetitions
- Mental Burden
- Metabolic expenditure
- Anthropometry

Production
- Academic products to support learning.
- Academic products with registration (Arbitration).
- Book or chapter book with ISBN.
- Articles in journals with ISSN.
- Papers with ISBN.
- Participation in Academic Bodies.
- Hours of Teaching.
- Postgraduate studies: masters and doctorates.

- Number of theses addressed.
- Hours for Human Resources training.

The sample consisted of 31 teachers, based on the above, this research is a prospective study of Organizational Ergonomics and its relation to the productivity of academic performance of full-time teachers; We study the association between these variables in a University in the State of Mexico and will establish the importance of disease prevention in teaching, in addition to creating and establishing a preventive culture.

The work activities in the educational field, as well as the structure of the existing relationships between the teacher and his / her work environment, are possible ergonomic risk factors that can lead to over-exertion, repetitive movements or forced postures in the work developed, with The consequent fatigue, errors, accidents and work diseases.

From the above it is considered that environmental conditions can influence performance, health, well-being and quality of life. The application of ergonomics translates into improved quality of life, reduction of possible accidents, diseases and increased well-being; And productivity, health care and the environment. (Ramírez, 2010).

It is also very important to consider the cost benefit of ergonomic applications and their impact on Productivity to encourage Ergonomic applications should justify their profitability.

As well as evaluating the work situation that prevails in the educational performance and the Ergonomic factors, considering that this discipline is little exploited in Mexico and even more in the educational sector, where apparently, the teachers are not exposed to risks in their work scope, Nor are the contextual factors inherent to the workplace analyzed in terms of their ergonomic effects.

In this research basically two variables are defined; The independent Variable are the ergonomic conditions of the job that hereafter referred to as Organizational Ergonomics (EO), because it contains all the characteristics of the context in which the activity in the teaching performance takes place, the analysis of the factors is carried out Through the statistical analysis procedure

The construction of research design is the formulation of research objectives and its link with quantitative or qualitative methodologies; These constitute the theoretical blocks that, articulated with each other, support the argumentative structure of an investigation and operate as the nucleus of each of its stages. This subtle and complex design aspect, although not specified, makes the study valid. (Sautu, 2005).

The proposed Method is Statistical analysis between the productivity of teaching performance (Variable sum of products since in conceptual form is expressed as the production of resources per unit of time), and the Organizational Ergonomics Variables to give explanatory sustenance, a Matrix of correlations with Pearson distribution (X^2).

The database was formed in SPSS for Windows in version 15.0, to be able to perform the analysis of the variables in said program and in the software Amos 16.0.

Subsequently, the scores for each of the latent variables were obtained, following the process indicated in the operationalization of the variables.

After having completed the database, descriptive statistics (measures of central tendency, variability, normality and detection of atypical and absent data) were used to clean the database and to be able to obtain the information to evaluate the behavior of the variables Main.

4. RESULTS

For the university, the consequences of such alterations would be economic and social, poor or incorrect use of budgetary resources, loss of efficiency and efficiency in the training of future professionals, decrease in the quality of social response, inadequate implementation of organizational policies, among other.

Due to his work, the university teacher seems little exposed to accidents at work, however, in the university space there are occasions of work accidents, mostly ignored by both the organization and the teacher himself, perhaps because of that individual perception that the causes are always external. (*Méndez, Figueredo, Chirinos, Goyo & Rivero, 2011).*

Disergonomic hazards cause a great deal of back injury, abnormal wear of joints and muscles, carpal tunnel syndromes, tendonitis, gastrointestinal and cardiovascular disorders, among others, non-recoverable physical fatigue, increase the harmful effects of other contaminants , As fatigue increases the amount of air inhaled. (Barba, Fernández, Morales & Rodríguez, 2014).

Figure 1 PC Desk.*Fuente: Own e*laboration

The poor orientation of many of the centers of natural light, causes inadequate natural lighting, as well as annoying reflections on the blackboards of the classrooms, with the consequent disruption for both the teacher and students to develop their activities, which gives rise To have to close the curtains, forcing them to work in some occasions with artificial light during the class hours.

To the above, we must add that in many cases the lack of maintenance of the lamps that causes a lower level of illumination than required, with consequent visual discomfort. (Barba, Fernández, Morales & Rodríguez, 2014). In Figure 21 you can see one of the corridors where there are four cubicles of full-time teachers you can see the penumbra that basically affects the vision causing, Irritation, eye fatigue and collateral discomfort such as headache, nausea and dizziness.

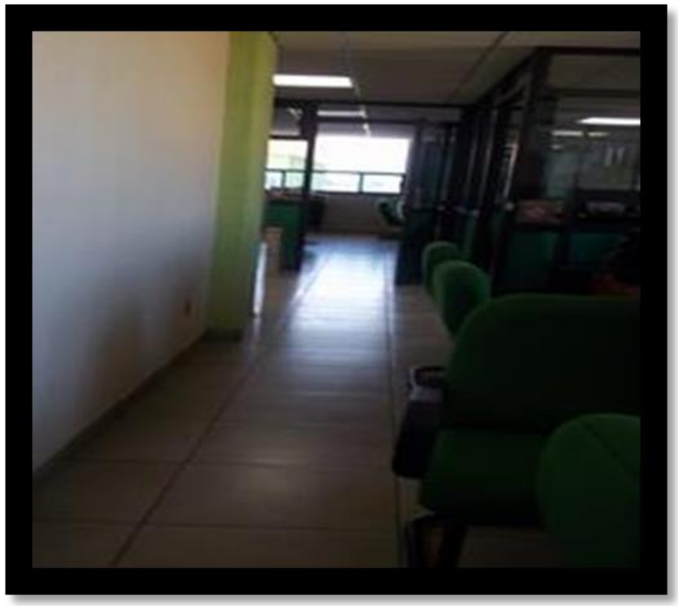


Figure 2. Light level. *Fuente:* Elaboración propia.

The conditions of humidity and temperature are not stable in all areas of the university, which causes both teachers and students, to leave in short periods of break of the classrooms, to corridors, looking for a better thermal sensation. Because in the interior of the classrooms, the temperature in summer season can reach between the 29 ° C. and 30 ° C.

The direct effects: colds, dehydration, heat stroke. Indirect effects may be behavioral disturbances, increased fatigue, discomfort, increased likelihood of accidents. (Barba et al., 2014).

As in any organized work, certain psychosocial requirements are needed that can favor or prevent the work satisfaction of the people as well as the quality of their work. They relate to the characteristics of workers. If the demands of the working environment exceed the workers' capacities to deal with them, there are symptoms that lead to stress.

Psychophysiological reactions (fatigue, irritability, sleep disorders, anxiety) behavioral (medication consumption, social withdrawal, smoking, violence). Hypertension, generalized anxiety, adjustment disorders, depression and musculoskeletal disorders. Cardiovascular diseases. Burn out: emotional and cognitive collapse.

The teaching sector is one of the professional sectors with the most tendency to suffer pathologies related to psychosocial factors. (Barba et al., 2014).

The most used posture by the teacher is standing in class hours and sitting for research, with twists and trunks by:

- Working posture.
- Repetitive movements.
- No ergonomic furniture.

The need to spend extended periods in the same posture generates postural fatigue, as well as a great number and variety of musculoskeletal disorders, among which we could highlight: sciatica, lumbago, disorders of the cervical region, joint disorders, sprains of ankles and foot. Likewise, the time in which it is seated passes in a disergonomic position, which causes the absence of periods of muscle relaxation so necessary to reduce the postural fatigue. (Barba et al., 2014).

4.1 Comparative analysis between organizational ergonomics and teacher performance.

For the statistical analysis, the IBM SPSS Statistics Base 20 program was used, applying ANOVA, using contingency tables in a Pearson Chi square analysis, and the organizational Ergonomics variables were subdivided into three dimensions: Ergonomics of the factor Human, environmental ergonomics and physical ergonomics compared to the variables of teacher performance.

Tabla 1. *Indicadores, del coeficiente (r y r^2), entre la Ergonomía ambiental y el desempeño docente.*

ANOVA

		Suma de cuadrados	gl	Media cuadrática	F	Sig.
Inter-personas		1372,194	30	45,740		
Intra-personas	Inter-elementos	40468,645	1	40468,645	1071 ,209	, 501
	Residual	1133,355	30	37,778		
	Total	41602,000	31	1342,000		
Total		42974,194	61	704,495		

Source: Own elaboration.

Tabla 2. *Indicadores, del coeficiente (r y r^2). de Ergonomía Física y el desempeño docente.*

Modelo	Estadísticos de cambio				
	Cambio en r cuadrado	Cambio en F	gl1	gl2	Sig. Cambio en F
1	,452ª	23,927	1	29	,590

Source: Own elaboration.

Additionally, the correlation coefficient is 0.452, which indicates a weak linear relationship. Similarly, the variables temperature, luminic and noise, environmental ergonomics are independent of the productivity of teaching performance explain in 45% of the behavior of the variable production, the remaining percentage should be explained by other variants. In short, the variables of environmental ergonomics are not independent of the productivity of teaching performance.

Tabla 3. *Contraste de Hipótesis y chi-cuadrado de Pearson de variables de ergonomía física y variables de desempeño académico.*

H_0: Son independientes H_A: No son independientes		Chi-cuadrado de Pearson	$p <$,05 se rechaza H_0 $p >$,05 no se rechaza H_0
V.D. Productividad	**V.I. Ergonomía Ambiental.**	**p**	**Decisión**
Mat. de aprendizaje	Ambiente Luminoso	**,037**	**se rechaza H_0**
	Ambiente térmico	**,004**	**se rechaza H_0**
	Ambiente sonoro	**,036**	**se rechaza H_0**
Artículos Arbitrados	Ambiente Luminoso	**,017**	**se rechaza H_0**
	Ambiente térmico	**,014**	**se rechaza H_0**
	Ambiente sonoro	**,043**	**se rechaza H_0**
Productos con ISBN	Ambiente Luminoso	***,042***	**se rechaza H_0**
	Ambiente térmico	***,018***	***se rechaza H_0***
	Ambiente sonoro	***,032***	***se rechaza H_0***
Productos con ISSN	Ambiente Luminoso	**,029**	***se rechaza H_0***
	Ambiente térmico	**,017**	***se rechaza H_0***
	Ambiente sonoro	**,013**	***se rechaza H_0***
Ponencias	Ambiente Luminoso	*,667*	*No se rechaza H_0*
	Ambiente térmico	*,534*	*No se rechaza H_0*
	Ambiente sonoro	*,781*	*No se rechaza H_0*

Source: Own elaboration.

Due to the large number of contingency tables generated for each of the cross-factor contrasts between the variables, Table 48 was elaborated, showing the concentrate of the result of independence (H_0), or no independence (H_1), between the variables.

5.CONCLUSIONS

After traversing the areas of work of university teachers and environmental conditions, it is concluded that the possible occupational risks to which the teacher is exposed, are multifactorial; Which may be impaired by induced or spontaneous external causes; Or internal causes attributable to the worker.

Risks include job dissatisfactions, accidents, occupational or occupational diseases, physical and mental disabilities, and disabling; There are many ways to classify risks, but always for this, both the material and technical aspects of the workplace must be considered, as well as the social aspects that affect the worker, that is, they can be triggered by possible psychological alterations and significant degrees of stress, Which can even generate significant physical limitations.

It is also observed that University teachers are generally not aware of the existence of dysergonomic risks, nor of their role in the possible generation of back injuries, abnormal wear of joints and muscles, carpal tunnel syndromes, tendinitis, Gastrointestinal and cardiovascular disorders, non-recoverable physical fatigue, as fatigue increases the amount of air inhaled.

According to the investigations studied in this chapter it is inferred that the teaching sector is one of the professional sectors with more tendency to suffer pathologies related to psychosocial factors.

The consequences can be economic and social, poor or incorrect use of budgetary resources, loss of efficiency and efficiency in the training of future professionals, decrease in the quality of social response, inadequate implementation of organizational policies, among others.

The relationship of the analysis performed, shows the variables that obtained the highest degree of statistical significance through ANOVA, scatter plots and Hypothesis contrast between the physical ergonomics variables and the productivity variables, through the chi-square analysis of Pearson

6. REFERENCES

Barba, E., Fernández, M., Morales, N. & Rodríguez, A. (2014). Aportes para una cultura de la prevención. Argentina: OIT

Márquez, M. (2007). Fundamentos de Ergonomía Industrial. Guía Práctica. Venezuela: Fondo Editorial UNET.

Méndez, E., Figueredo, C., Chirinos, E., Goyo, A. & Rivero, R. (2011). Cultura preventiva del riesgo laboral del docente Universitario. Multiciencias, 11(1) 44-49.

Ramírez, C. (2010). Ergonomía y productividad. México: Limusa.

Sautu, R. (2005). Todo es teoría: objetivos y métodos de investigación. Buenos Aires: Lumiere.

IMPLEMENTATION OF OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM UNDER THE OHSAS 18001-2007 STANDARD IN A COMPANY DEDICATED TO THE PRODUCTION AND SALE OF PREMIXED CONCRETE AND PRECAST CONCRETE COMPONENTS

Claudia Selene Castro Estrada[1], Haydée Avilés Anaya[1] Grace Erandy Báez Hernádez[2], Guadalupe Higuera Torres[1]

[1]Departamento de Ingeniería en Sistemas de Calidad
Universidad Intercultural del Estado de Sinaloa
Juárez 39
Mochicahui, El Fuerte, Sinaloa 81890
Klaudy_00@hotmail.com

[2]Departamento de Ingeniería Industrial
Instituto Tecnológico Superior de Guasave
Carretera Internacional y entronque a la Brecha
Ej. El Burrioncito, Guasave, Sinaloa
gracebaezh@gmail.com

Resumen: Actualmente, existen muchas empresas dedicadas al ramo de la construcción, compitiendo por acaparar la atención de los clientes y utilizando los medios necesarios que le funcionen como estrategia competitiva. Es por ello, que la empresa dedicada a la producción y venta de concreto premezclado y prefabricados de concreto decidió implementar un sistema de gestión de seguridad y salud en el trabajo utilizando la norma OHSAS 18001-2007, que le permita alcanzar un crecimiento sostenido en el mercado, minimizar los riesgos a los que se exponen día a día sus trabajadores, contribuir con su bienestar y aumentar la productividad y la calidad de sus operaciones. Para poder lograr el objetivo de la investigación, primeramente se realizaron diagramas causa-efecto y análisis de modo y efecto de la falla (AMEF) en cada una de las áreas de la empresa con la finalidad de identificar los riesgos a los que están expuestos los trabajadores. Posteriormente, se realizó un diagnóstico de la situación actual de la empresa respecto a los requerimientos legales y los establecidos por la norma OHSAS 18001:2007. Con base en el diagnóstico, se establecieron los planes de acción correctivos y preventivos para ajustar la situación de la empresa frente a los requisitos exigidos por la normatividad. Finalmente la empresa se sometió a varias auditorías internas y externas hasta lograr la certificación en la norma.

Palabras clave: Salud ocupacional, administracion, OHSAS 18001

Abstract: Nowadays there are many companies dedicated to the construction area, competing among themselves to get customers ‘attention and to do so they use the necessary means that work as a competitive strategy. Reason why the company dedicated to the production and sale of premixed concrete and precast concrete components decided to implement an occupational health and safety management system using the OHSAS 18001-2007 standard, which allows it to achieve sustained growth in the market, minimize the risks to which workers are exposed every day, contribute to their well-being and increase the productivity and quality of its operations. In order to achieve the objective of this research, first cause and effect diagrams and Failure Mode Effect Analysis (FMEA) were made in each area of the company in order to identify the risks to which workers are exposed. Subsequently, a diagnosis of the company´s current situation was made regarding the legal requirements and those established by the OHSAS 18001: 2007 Standard. Based on the diagnosis, corrective and preventive action plans were established to adjust the situation of the company against the requirements required by the regulations. Finally, the company went through several internal and external audits until obtaining the certification in the standard.

Keywords: Occupational, Health, Management, OHSAS 18001

1. INTRODUCTION

Currently, if a company wants to grow and to be consolidated in the market, it must not only guarantee quality products and services at a low cost, but it also needs to have production processes that promote the health and safety of its personnel. In recent years, many organizations have opted for the implementation of occupational health and safety management systems (OHSMS) as part of their strategy to cope with competition (Pozo *et al.,* 2012).

According to the above paragraph, Occupational Health and Safety (OHS) has become a matter of vital importance (Dyna *et al.,* 2011), for this reason the company dedicated to the production and sale of premixed concrete and precast concrete components decides to start with the project of implementation of occupation health and safety management system, which will enable it to be certified in the OHSAS 18001: 2007 Standard.

The implementation of the system in the company will provide the necessary tools to identify, measure and evaluate the occupational risks, to establish corrective and preventive measures to eliminate and/or to control risks that threaten the integrity of company resources such as: Personnel, equipment and machinery and it will also help to improve worker's relationship to his/her activities by being in a safe and healthy work environment, which will be reflected in his/her performance and therefore in the productivity of the company (Arévalo *et al.,* 2013).

In Mexico, companies must comply with health and safety occupational guidelines, not only because working with such guidelines will help to protect workers' health; But because occupational health and safety is a legal obligation that is regulated by several precepts contained in Article 123 of the Constitution, in the Federal Labor Law, the Federal Regulations on Occupational Safety and Health as well as in Mexican official Standards (Solis *et al.,* 2013).

2. OBJECTIVES

To implement an occupational health and safety management system which allows the company to get a certification in the OHSAS 18001: 2007 Standard.

2.1 Specific objectives

To diagnose the company´s current situation in terms of occupational health and safety.

To ensure compliance with legal requirements regarding occupational health and safety that apply in the company.

Contribute to generate adequate conditions of occupational health and safety.

3. METHODOLOGY

3.1 Research area

The research was performed in the different work areas that form the company (concrete metering, block production, maintenance, logistics and inventory, quality assurance, purchasing and sales) dedicated to the production and sale of premixed concrete and precast concrete components, located in the north of the state of Sinaloa.

3.2 Materials

For the implementation of OHSMS, it was necessary to use the OHSAS 18001: 2007 standard, the Federal Labor Law (FLL), the Mexican Official Standards (NOM) applicable to the company, the procedure for developing the failure mode effect analysis (FMEA) of occupational health and safety and the guide for the evaluation of compliance with occupational health and safety regulations.

3.3 Research method

An extensive review of different sources of bibliographical information as well as the applicable normativity in matters of occupational health and safety was carried out.

In this research, direct observation was used as a fundamental tool for the detection of risks at the time of performing the analysis, valuations and inspections, being this technique very useful during the development of cause and effect diagrams. Numerous non-formulated inspections were also carried out, firstly to become familiar with the general working environment and then to identify those risk factors which are overlooked in previous observations.

On the other hand, the staff working in the different areas of the company were also interviewed and consulted, in order to obtain direct information, taking into consideration that it is actually the worker who knows well his/her job and the risks that he/she is exposed to every day.

Once identifying the risks and analyzing the history of accidents and incidents of the company, they were quantified, assigned a weighting according to the evaluation criterion and the degree of risk in accordance with the value of the risk priority level (RPL) with the purpose of identifying which risks require action to prevent or detect them and to establish priority.

4. RESULTS

4.1 Integral Policy

In order to comply with the requirements of the OHSAS 18001: 2007 Standard, the company decided to integrate the quality system, environment and occupational hazards under a single system and to be able to define an integral policy, for such situation it was necessary the participation of the heads of each of the areas of the company.

4.2 Cause and effect diagram

A diagram was developed for each work area (concrete metering, block production, maintenance, logistics and inventory, quality assurance, purchasing and sales) to facilitate the analysis of the risks that workers are facing when performing their activities, diagrams consist of the graphic representation of the relationship between an effect and all its causes or factors that could origin accidents and/or work diseases.

Workers of this area have mainly chronic diseases caused by continued and prolonged exposure to chemicals, injuries and diseases by poor postures, diseases from noisy excesses, as well as fatigue by excessive workload, harassment and intimidation.

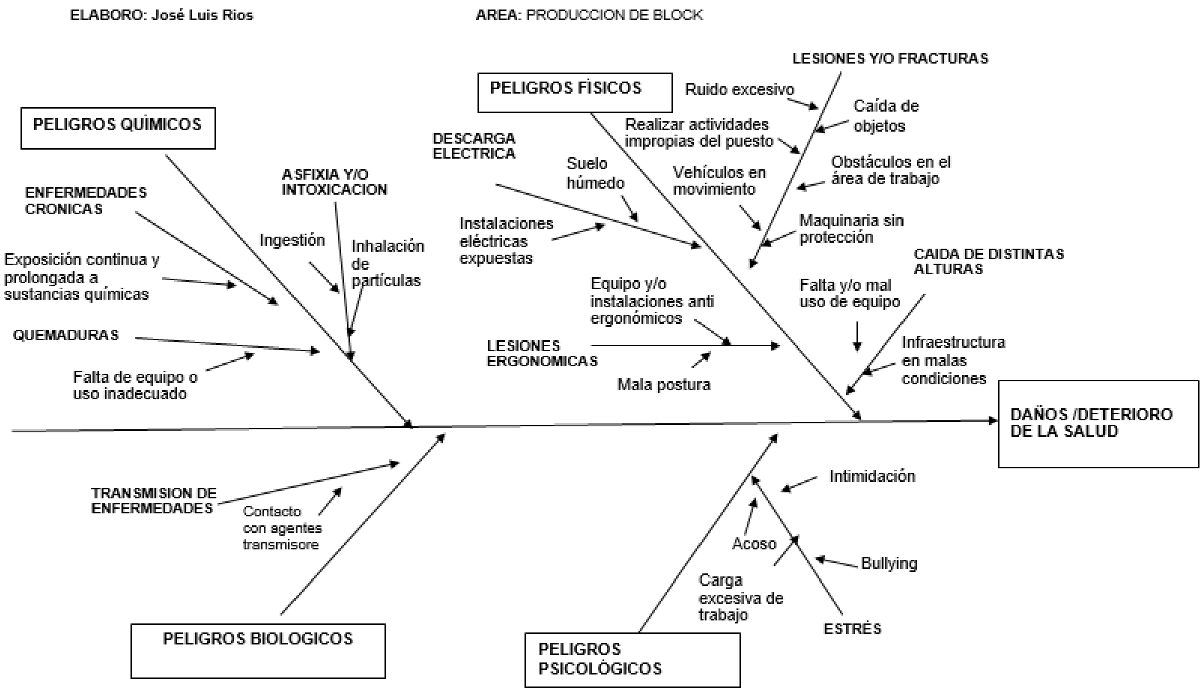


Figure 1. Cause and effect diagram of block production area

4.3 Failure Mode Effect Analysis (FMEA)

As a requirement of the OHSMS, the FMEA was developed with the objective of establishing the guidelines for the process of determination of the hazards and evaluation of the risks derived from them present in the processes and operations of the company, since it is an analytical technique used as a mean to ensure that, as far as possible, hazards and risks and their possible associated causes have been considered and the company is prepared for their possible occurrence; for its elaboration it was necessary the analysis of the history of the company with respect to accidents and diseases, as well as it was necessary to observe the personnel performing their activities, in addition cause and effect diagrams previously elaborated were used.

In the FMEA physical, chemical, biological and psychosocial hazards were analyzed using the following criteria: repetitions/time, severity of the risk, occurrence of the incident/accident or disease, controls, demands and legal requirements.

AREA: PRODUCCION DE BLOCK — TODAS LAS ÁREAS

ACTIVIDAD/ PRODUCTO /PROCESO: PRODUCCION DE BLOCK

DEPARTAMENTOS INVOLUCRADOS: DIRECCIÓN, VENTAS, COMPRAS, PLANTA DOSIFICADORA DE CONCRETO, ASEGURAMIENTO DE CALIDAD, MANTENIMIENTO

EQUIPO DE TRABAJO: — 001 — HOJA: 1 2

PROCESO / ACTIVIDAD/ PRODUCTO	PELIGROS	RIESGOS	CANT./ VOLUMEN./ REPETICIONES	SEVER	CAUSA DEL RIESGO	OCURRENC	MECANISMOS ACTUALES PARA PREVENCIÓN DEL RIESGO Y/O SU CAUSA POTENCIAL	MECANISMOS ACTUALES DE CONTROL DEL RIESGO Y/O SU CAUSA POTENCIAL	REGULACIÓN DEL CRITERIO LEGAL	DEMANDA	REQUIS LEGAL	NPR	Grado del impacto	ACCIONES RECOMENDADAS P/ PREVENIR EL ASPECTO Y/O SU CAUSA POTENCIAL	ACCIONES RECOMENDADAS P/ DETECTAR EL ASPECTO Y/O SU CAUSA POTENCIAL	RESPONSABLES Y FECHA OBJ.	RESULTADOS DE ACCIONES: ACCIONES TOMADAS	CANT/ PRESU	SEV	OCUR	REGUL
a)	b)	c)	d)	e)	f)	g)	h)	i)	J)	K)	L)	m)	n)	o)	p)	q)	r)	s)	t)	u)	x)
*Programación de producción *Requisición de compra	Carga excesiva de trabajo Bull ying	**Estrés**	**2**	**3**	Largos periodos de trabajo (horas extras)	**5**	Rotación de personal	Rotación de personal	**1**	**1**	**1**	**30**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
	Mala postura Equipo y/o instalaciones anti ergonómicas	**Lesiones Ergonómicas**	**6**	**3**	Falta de cultura	**8**	Rotación de personal	Rotación de personal	**1**	**1**	**1**	**144**	**4**	NO REQUIERE ACCIÓN INMEDIATA	NO SE REQUIEREN	A. Gómez					
	Contacto con agentes transmisores Inhalación de partículas	**Transmisión de enfermedades**	**1**	**3**	Falta de cultura en prevención	**1**	NO HAY	Incapacidad	**1**	**5**	**5**	**75**	**4**	NO REQUIERE ACCIÓN INMEDIATA	NO SE REQUIEREN	A. Gómez					
*Producción *Salida e inspección de producto terminado	exposición continua y prolongada a sustancia químicas Inhalación de partículas	**Enfermedades crónicas**	**1**	**3**	Exceso de partículas en el aire	**3**	NO HAY	Utilización de EPP y faja	**1**	**1**	**5**	**45**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
	suelo húmedo Instalaciones eléctricas expuestas	**Descarga eléctrica**	**1**	**10**	Fugas de agua por descuido de operadores y falta de precaución	**1**	NO HAY	Señalamientos de Precaución	**1**	**1**	**5**	**50**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
	Carga excesiva de trabajo Intimidación	**Estrés**	**2**	**3**	Largos periodos de trabajo (horas extras)	**6**	Rotación de personal	Rotación de personal	**1**	**1**	**1**	**36**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
	Contacto con agentes transmisores Inhalación	**Transmisión de enfermedades**	**1**	**3**	Falta de cultura en prevención	**1**	NO HAY	Chequeo Medico	**1**	**1**	**5**	**15**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
	Mala postura Equipo y/o instalaciones anti ergonómicos	**Lesiones Ergonómicas**	**6**	**3**	Falta de cultura	**8**	NO HAY	Utilización de EPP y faja	**1**	**5**	**5**	**3600**	**3**	Cumplir con los lineamientos de la norma	Realizar estudio ergonómico	A. Gómez					
	Maquinaria sin protección Vehículos en movimiento Caída de objetos suspendidos Ruido Excesivo	**lesiones y/o fracturas**	**1**	**3**	Falta de cultura y descuido	**3**	NO HAY	Utilización de EPP y faja	**1**	**1**	**5**	**45**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
*Clasificación de producto terminado *Desecho de producto terminado *Entrega de producto terminado a almacén	exposición continua y prolongada a sustancias químicas Inhalación de partículas	**Enfermedades crónicas**	**1**	**3**	Exceso de partículas en el aire	**3**	NO HAY	EPP y Mascarilla para Polvos	**1**	**1**	**5**	**45**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
	suelo húmedo Instalaciones eléctricas expuestas	**Descarga eléctrica**	**1**	**1**	Fugas de agua por descuido de operadores y falta de precaución	**1**	NO HAY	Ayudas Visuales	**2**	**1**	**5**	**10**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
	Carga excesiva de trabajo Bull ying	**Estrés**	**2**	**3**	Largos periodos de trabajo (horas extras)	**5**	Rotación de personal	Rotación de personal	**1**	**1**	**1**	**30**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
	Contacto con fluidos corporales Inhalación	**Transmisión de enfermedades**	**1**	**3**	Falta de cultura en prevención	**1**	NO HAY	Chequeo Medico	**1**	**1**	**5**	**15**	**5**	NO SE REQUIEREN	NO SE REQUIEREN	A. Gómez					
	Mala postura Equipo y/o instalaciones anti ergonómico	**Lesiones Ergonómicas**	**6**	**3**	Falta de cultura	**8**	NO HAY	Utilización de EPP y faja	**1**	**1**	**5**	**720**	**4**	NO REQUIERE ACCIÓN INMEDIATA	NO SE REQUIEREN	A. Gómez					
	Maquinaria sin protección Vehículos en movimiento Caída de objetos suspendidos Ruido Excesivo Obstáculos en el área de trabajo	**lesiones y/o fracturas**	**1**	**5**	Falta de cultura y descuido	**1**	NO HAY	EPP	**3**	**1**	**5**	**75**	**4**	NO REQUIERE ACCIÓN INMEDIATA	NO SE REQUIEREN	A. Gómez					

Table 1. FMEA Block production area

4.4 Matrix of legal requirements

The regulations contained in this matrix refer to the Official Mexican Standards (NOM) regarding OHS. For the elaboration of the Matrix, the guide for evaluation of compliance with the normativity in occupational health and safety prepared by the Ministry of Labor and Social Security (STPS) was used.

The compliance matrix is a tool that allows a complete revision of the NOMs that are applicable to the company, and based on the progress in compliance, it is determined the type of preventive or corrective action to be implemented in the company for the due compliance with regulations. As preventive actions are considered to preserve, improve and update, with scores of five, four and three units, respectively. As corrective actions, to complement, correct and perform, with scores of two, one and zero points.

In addition, the starting and ending dates should be specified for each preventive and corrective action, as well as the person responsible for its execution, in order to be part of the OHS program.

The final score for the evaluation of compliance with OHS regulations is obtained by summing up the scores assigned to each of the preventive or corrective measures to be established that result from the conformity assessment.

4.5 Internal Work Regulations

The internal work regulations were elaborated; which provides in chapter VII the obligations and provisions relevant to occupational health and safety applicable to all personnel who perform work for the company, in order to preserve their physical integrity.

5. CONCLUSION AND RECOMENDATIONS

Many times, companies decide not to invest in security to reduce costs, such situation is a serious mistake since the worker is the most valuable asset of any organization, besides that safety is every worker´s right.

The process of implementing the OHS Management System is long; However, the benefits that can be gained are many since they elevate the organization to a new level of competitiveness. In order to implement it, it is a fundamental requirement to obtain the commitment of the personnel who, duly trained and motivated, provide ideas and points of view that facilitate adaptation to changes.

The implementation of the occupational health and safety management system is important because in addition to ensuring that there are procedures that allow the company to control occupational safety and health risks, it also potentially reduces downtime and associated costs to these, in addition to contributing to continuous improvement.

While the measures adopted are effective in preventing occupational accidents and diseases, a greater awareness of the importance of OHSMS is required, and a firm commitment, as the efforts to solve these problems are often scattered and fragmented, Therefore, they do not have the necessary coherence to produce a real impact. It is therefore recommended that OHSMS is given a higher priority at managerial level and to involve all workers in the establishment and maintenance of the system for continuous improvement.

Employee training programs should be developed to increase awareness of the importance of their participation in all activities related to occupational health and safety since it not only brings benefits to the company but also improves their working conditions.

Perform preventive maintenance on the machines used and periodically review the jobs, in order to prevent accidents, incidents and unintended events, ensuring a good working environment that encourages the motivation of employees and in this way increase productivity.

6. REFERENCES

Arévalo Pinilla, Nelcy; Molano Velandia, Jorge Hernando; (2013). De la salud ocupacional a la gestión de la seguridad y salud en el trabajo: más que semántica, una transformación del sistema general de riesgos laborales.

INNOVAR. Revista de Ciencias Administrativas y Sociales, Enero-Marzo, 21-31.

British Standards Institution (BSI). (2007). *OHSAS 18001:2007*. Recuperado el 10 de junio de 2015, de BSI Sitio web: http://wwwisis.ufg.edu.sv/wwwisis/documentos/TE/662.1-A472p/662.1-A472p-Capitulo%20II.pdf

Congreso de los Estados Unidos Mexicanos. (2014). *Reglamento Federal de Seguridad y Salud en el Trabajo.* Recuperado el 1 de mayo de 2016, de Diario Oficial de la Federación Sitio web: http://www.dof.gob.mx/nota_detalle.php?codigo=5368114&fecha=13/11/2014

Congreso de los Estados Unidos Mexicanos. (2015). *Ley Federal del Trabajo*. Recuperado el 1 de mayo de 2016, de Diario Oficial de la Federación Sitio web: http://www.diputados.gob.mx/LeyesBiblio/pdf/125_120615.pdf

Carral Couce, L.; Iglesias Rodríguez, G.; Fraguela Formoso, J. A; Castro Ponte, A.; Rodríguez Guerreiro, M. J.; (2011). La integración de los sistemas de gestión. necesidad de una nueva cultura empresarial. *Dyna*, Sin Mes, 44-49.

European Agency for Safety and Health at Work. (2013). *Aspectos generales de Seguridad y Salud en el Trabajo*. Recuperado el 30 de abril de 2016, de OSHwiki Sitio web: https://oshwiki.eu/wiki/Aspectos_generales_de_seguridad_y_salud_en_el_trabajo_(SST)#cite_ref-13

Pozo, José M.; Rodríguez, Zoe; (2012). Los sistemas de gestión integrados: reto y necesidad de la empresa cubana. *Economía y Desarrollo*, Enero-Junio, 203-212.

Secretaría del Trabajo y Prevención Social. (2016). *Normas Oficiales Mexicanas*. Recuperado en mayo de 2015, de Diario Oficial de la Federación Sitio web: http://www.stps.gob.mx/bp/secciones/conoce/marco_juridico/noms.html

Solis Carcaño, R., & Sosa Chagoyán, A. (2013). Gestión de riesgos de seguridad y salud en trabajos de construcción. *Revista Educación en Ingeniería, 8*(16), 161-175.

Stewart, J. (S.f.). *Higiene Industrial*. Recuperado el 2 de mayo de 2016, de OIT Sitio web: http://www.insht.es/InshtWeb/Contenidos/Documentacion/TextosOnline/EnciclopediaOIT/tomo1/30.pdf

CONCORDANCE EXPLORATION OF THE PERCENTAGES INDICATED BY LIBERTY MUTUAL TABLES, FOR LIFTING TASKS, REGARDING MEXICAN YOUNG MEN

Jesús Rodolfo Guzmán Hernández, Joaquín Vásquez Quiroga, Rafael Hernández Leon

Program of Industrial Engineering and Systems
Universidad de Sonora, Unidad Regional Norte, Campus Caborca
Ave Universidad e Irigoyen s/n
Caborca, Sonora, México
rguzman@caborca.uson.mx, jovaqui@caborca.uson.mx, rafa@caborca.uson.mx

Resumen: Esta investigación se realizó con la intención de verificar la aplicación de las Tablas Liberty Mutual para levantamiento de cargas en la población laboral de Caborca, Sonora, Mex. Se realizó con jóvenes estudiantes del programa de Ingeniería Industrial y de Sistemas adoptando el planteamiento de que pudieran formar parte de la mano de obra de las empresas establecidas en la región y también para involucrarlos en trabajos de investigación académica. El experimento se limitó a: levantamiento vertical en hombres, frecuencia uno por minuto, cajas de 34 cm. distancia desde el cuerpo, distancia de movimiento 51 cm., tres niveles de elevación, baja, que corresponde al levantamiento entre el suelo y la altura de nudillos, medio, de altura de nudillos a altura de hombros y alto, de la altura de los hombros al brazo extendido. Como resultado del experimento se observó que la información de percentiles de las Tablas Múltiples de la Libertad para el levantamiento de carga para situaciones similares a las de este experimento son cuantitativas mayores, pero no hay evidencia estadística suficiente para afirmar que son divergentes.

Palabras clave: levantamiento de cargas, cargas mujeres, levantamiento manual, método psicofísico.

Abstract: This investigation was realized by the intention of verifying the application of the Liberty Mutual Tables for lifting in the labor population of Caborca, Sonora, Mex. It was realized with young students of the program of Industrial Engineering and of Systems adopting the approach of which they could be a part of the workforce of the companies established in the region and also in order to involve them in works of academic investigation. The experiment was limited to vertical lifting in men, frequency of one per minute, boxes of 34 cm. of wide (distance since the body), distance of movement 51 cm., in three levels of lifting, low, that corresponds to lifting among the floor and the height of knuckles, medium, of height of knuckles to height of shoulders and high, of height of shoulders to arm extended. As a outcome of this experiment It was observed that the information of maximum acceptable weight the Liberty Mutual Tables for similar situations to those of this experiment they are quantitativement greater but not sufficient statistical evidence exists to affirm that they are divergent.

Keywords: lifting of loads, women loading, manual lifting, psychophysical method

1. INTRODUCTION

Is very common to listen, of people that suffer pain in the region of the low back, great part of these situations they are caused for the inappropriate management of loads, chiefly in the labor sector. These affections represent, for the families and/or for the businesses, considerable wastes of time and money. On a worldwide basis has been recognized like a great problem the lumbago associated with work of manual lifting of loads, is the costliest wound in the industrial world and this has favored that they have themselves carried out great quantity of investigations on the matter. Among the more disclosed they are found carried out in the United States. The National Institute for the Security and Employment Health (NIOSH) in 1981 form a committee of experts to revise this problem and to develop a tool for identify the risks of associated lumbago to lifting of physical load to that were submitted the workers and to recommend a weight of acceptable maximum lifting. Thus same, the business Liberty Mutual has worked in the development of guides and manuals for evaluation and design of manual management of loads, in a intent by attending the industrial sector in the lumbago injuries control, reducing the incident, the duration of the incapacity and the recurrence.

These studies and the respective conclusions, of all the investigations performed, they have been generated from experimental data obtained of labor populations of countries developed and the results and their recommendations apply in Mexico without considering that they were obtained without including data of the characteristics and the physical capacities of the Mexican Population.

1.1 Lifting loads

The need to determine how the tasks of lifting load affecting the worker has led conducting research using different methods to determine. Some of them have been using biomechanical criteria that have to make it clear that this type of task forces and appear moments mechanical compression of the spinal column, specifically on the union of the lumbar vertebral segments 5 - sacral 1 (disk L5/S1) giving rise to a heightened stress lumbar. Of the forces of compression, torsion and cutting appearing, it is considered the compression of the disk as a primary cause of L5/S1 risk of low back pain. Through biomechanical models, and using data collected in studies on resistance of these vertebrae, it was considered one strength of 3.4 kilo Newton (kN) force as 350Kg compression limit for the appearance of risk of low back pain. Since then was published the practice guide for the Survey of handling tasks which contains the Niosh equation. Another approach is the Physiological, although there is little data showing that fatigue increases the risk of muscle-skeletal injury, it has been widely recognized that the uprisings repetitive tasks can easily exceed the capabilities of normal power of the worker, causing a premature decrease in their resistance and increasing the likelihood of injury. The Committee for the National Institute for Occupational Safety and Health of the United States (1991) put limits on the amount of exercise a person can develop without running out of breath and call Maximum Capacity Aerobics, to be used in the calculation energy expenditure. In repeated uprisings, the maximum aerobic capacity will be lifted to 9.5 kcal / min. Thus, in surveys that requires lifting the arms more than 75 cm. not exceed 70% of maximum aerobic capacity. Not exceed 50%, 40% and 30% of maximum aerobic capacity to calculate energy expenditure task duration of 1 hour, 1 to 2 pm and from 2 to 8 hours respectively. Another approach used is the psychophysical; this approach is based on the participant, motivated by an incentive, select the maximum weight load or force that can sustain for a working day of 8 hr., based on the perceived sensations. By this method the company Liberty Mutual made publishing what is known as Guidelines for the handling of loads Liberty Mutual Tables.

2. OBJETIVE

To collate the maximum weight of acceptable lifting in the repetitive manual handling of loads of the labor population of the region of Caborca, with the Liberty Mutual Tables using psychophysical criterion.

3. FRAME OF REFERENCE

3.1 Liberty Mutual Tables or Snook Tables

These tables were developed by the Insuring Company Liberty Mutual and published by Snook and Ciriello in 1991 in an attempt to develop manuals or guides for evaluation and design of manual handling of loads. These tables were based on controlled experiments using psychophysical evaluations, and are used to find the percentage (percentile) of the industrial population capable to bear the efforts that listed, for tasks of lifting, lowering, pushing, pull and carrying. The present investigation was focused solely in the task of lifting by men, with boxes of 34 cm. wide (distance from the body), movement distance 51 cm. in three levels, from floor to height of knuckles (low), from the height of knuckle to acromial height (medium) and from the acromial height to extended arm (high), for frequencies of 1 per minute. The Percentages and maximums acceptable weights (MAW) indicated by the Table Liberty Mutual for men are the following one:

Table 1 Maximum acceptable weight MAW (Kg)

Percentil	Level		
	Low	Médium	High
90	16	17	16
75	23	22	21
50	31	28	26
25	39	34	32
10	46	40	37

3.2 Psychophysical criterion

The experiment was made using psychophysics’ approach. This approach requires that subject is motivated by an incentive and taking his own sensations he selects the maximum weight for the load or force that guess can maintain for a day of 8 work of hr. According to Shoaf (1997), the greater hypothesis of the psychophysical method is that in a given time, fit to 40 min., a person is able to predict the weight or forces maximums that could manipulate during an 8 period of hr., Mital (1983) affirms that the people can consider the amount of weight who can raise comfortably in 8 hr., based on the fatigue which they experiment in 25 min. and the weight selected by the subject is hoped that will be same, if the continuous person doing it by 8 hr; Also it asserts that does not exist evidence in Literature to validate this affirmation. Under this criterion, basically, the control of the weight of the load is gave it to the subject. All the other variables of the task as they are: frequency, weight of the initial charge, distance of movement, etc. are controlled by the experimenter. The subject will be monitoring his own sensations of effort or fatigue and fits the weight to which he considers could support in a day of 8hr. The details of the experiment used are in publications of Ciriello and Snook (1983), Ciriello et al (1990), Snook and Ciriello (1991).

4. METODOLGY

4.1 Participants

The participant people in the experiment were 15 males young, between 19 and 22 years, students of University level who are part of the labor force in the region of Caborca. All of them she asked for herself to them to point out in writing that they were free of lumbar damage and they did not have cardiovascular suffering. The dress and the footwear were the one that normally dress the young people that are shoe type tennis, jeans and t-shirts.

4.2 Training

During four days consecutive were made lower lifting tasks (of floor to height of knuckles), for that the subjects were learning to recognize her own sensations. During the first and second day, each subject done tasks of 10 min with light and heavy load, respectively, the third day two tasks of 10 min tasks each one with light and heavy load respectively, the fourth day two tasks of 15 min each one with light and heavy load respectively; all this with the intention of which the participant to gain experience in fitting the weight of the load, all the tasks were for lifting of 1 per minute to a distance of 51 cm. Ciriello and Snook (1983). The fifth day was for data collection; that day were made two 20 tasks of min each one, without period of rest, the first segment with a heavy initial charge and another one with a light initial charge.

4.3 Equipment

For the experiment were used rigid polypropylene boxes of 55 cm inner length (distance between hands), 34.17 cm wide (distance from the body) and 17 cm of height. The handles were located to half of the distance from the body and 15 cm from the bottom of the boxes. The box included a false bottom in which I am placed a light load or heavy whose weight was selected randomly, Ciriello and Snook (1990). This weight was not known by the participant in an attempt to diminish the visual effect.

4.4 Tasks

The tasks that the subject made, were vertical lift, doubling the knees and maintaining the back straight, without turns neither twists, nor hauling and nor pushing the load; Each task lasted 40 minutes divided in two periods of 20 minutes each one without rest between periods. In each stage of the experiment the task established were lifting of 51 cm of high, beginning with load heavy of between 32 and 45 kg and later a load lighter between 2 and 18 kg, selected randomly, Snook (1991). The subject increases, or diminishes the load, according to their own perceptions, making effort themselves but without arriving to reach a state of unusual fatigue, weakening, overheating or to remain out of breath, until I represent the Maxima, that they could lift, during a turn of 8 hr. At the end of the task, if the load weight of the second period was within 15% of first are take like good and like weight average of participant, otherwise is made a new test. Each one participant repeats the same set of task to each three levels of lifting that marks the Liberty Mutual table, that is to say: low rank < 77 cm. (from floor to knuckles height), the medium rank 77 to 142.5 cm (height of knuckle to acromial height) and high rank 142.4 cm and more (acromial height to extended arm).

4.5 Randomness of loads

For each level of lifting were randomly select 15 heavy loads with gross weight between 32 and 45kg, from this weight be rest 3 kg, that corresponds to the tare of the container, from this new data, was select, randomly, the load for the hidden compartment and finally was calculate the complement that is the visible load. Same procedures were made to 15 light loads between 2 and 18 kg.

5. ANALYSIS OF RESULTS

5.1 Analysis of results in lifting low level

In agreement with the hypothesis of work raised in this investigation, the averages obtained from the participants set (Experimental average weight (EAW) must match with the distribution of maximum acceptable weight (MAW), for each one of the percentile of the Liberty Mutual Tables. In the next table it made the comparison:

Table 2. Hypothesis test for low level lifting

percent	MAW (Kg)	Null hypothesis	Alternative hypothesis	n-1	EAW (Kg).	Standard deviation	t	α	decision
90	16.00	$\mu_0 = 16$	$\mu_1 \neq 16$	14	25.79	7.77	4.72	0.0003	se rechaza H_0
75	23.00	$\mu_0 = 23$	$\mu_1 \neq 23$	9	25.82	8.31	1.02	0.3350	se acepta H_0
50	31.00	$\mu_0 = 31$	$\mu_1 \neq 31$	6	25.71	9.69	-1.34	0.2300	se acepta H_0
25	39.00	$\mu_0 = 39$	$\mu_1 \neq 39$	3	24.49	9.46	-2.66	0.0776	se acepta H_0
10	46.00	$\mu_0 = 46$	$\mu_1 \neq 46$	1	29.05	10.68	-1.59	0.3580	se acepta H_0

As can be seen, only Ho = 16 is rejected, which could conclude that for low level if the percentiles of the liberty mutual table coincide with the values obtained in the experiment.5.2 Analysis of results in lifting mean level

Same that analysis of results in lifting low level in agreement with the hypothesis of work raised in this investigation, the EAW, must match with the distribution of maximum acceptable weight (MAW), for each one of the percentile of the Liberty Mutual Tables. In the next table the comparison is made.

Table 3.- Hypothesis test for medium level lifting

percent	MAW (Kg)	Null hypothesis	Alternative hypothesis	n-1	EAW (Kg).	Standard deviation	t	α	decision
90	17	$\mu_0 = 17$	$\mu_1 \neq 17$	14	19.85	6.259	1.70	0.1105	se acepta H_0
75	22	$\mu_0 = 22$	$\mu_1 \neq 22$	9	21.35	6.787	-0.29	0.7804	se acepta H_0
50	28	$\mu_0 = 28$	$\mu_1 \neq 28$	6	21.30	7.308	-2.25	0.0658	se acepta H_0
25	34	$\mu_0 = 34$	$\mu_1 \neq 34$	3	23.23	9.084	-2.05	0.1323	se acepta H_0
10	40	$\mu_0 = 40$	$\mu_1 \neq 40$	1	26.00	12.587	-1.11	0.4662	se acepta H_0

As can be seen all null hypotheses are accepted, it can be concluded that the percentiles of the liberty mutual table coincide with the values obtained in the experiment.

5.3 Analysis of results in lifting high level

Same that analysis of results in previous lifting levels in agreement with the hypothesis of work raised in this investigation, the EAW, must match with the distribution of maximum acceptable weight (MAW), for each one of the percentile of the Liberty Mutual Tables. In the next table it made the comparison

Table 4.- Hypothesis test for high level lifting

percent	MAW (Kg)	Null hypothesis	Alternative hypothesis	n-1	EAW (Kg).	Standard deviation	t	α	decisión
90	16	$\mu_0 = 16$	$\mu_1 \neq 16$	13	15.44	4.39	0.46	0.6532	se acepta H_0
75	21	$\mu_0 = 21$	$\mu_1 \neq 21$	9	15.45	4.69	3.55	0.0062	se rechaza H_0
50	26	$\mu_0 = 26$	$\mu_1 \neq 26$	6	15.76	5.66	4.43	0.0044	se rechaza H_0
25	32	$\mu_0 = 32$	$\mu_1 \neq 32$	3	15.43	7.07	4.06	0.0269	se rechaza H_0
10	37	$\mu_0 = 37$	$\mu_1 \neq 37$	1	20.00	7.85	2.17	0.2754	se acepta H_0

As it is can note in H_0=16 and 37, the two α are not significant to reject the null hypothesis, only that in the case of H_0=37 this it probably must to that the sample is too small and the very great standard deviation.

5.4 Comparison general of results

Finally, in the next table can be seen that the MAW from the liberty mutual table and the EAW, compared in a comprehensive manner, differ considerably; In the data of MAW is note an appreciable dispersion between percentile, which denotes that the capability of the workforce from where the information was collected, has a wide range, while the EAW, between percentile, tended to be around an average with very small dispersion. In other hand, between the levels of lifting, in both cases, if it appreciates decrease in the amount of cargo but the decrement is to a greater on the data from the experiment.

Table 5. Comparison general of results between MAW of the Liberty Mutual Tables and EAW

MAW (Kg)				EAW (Kg)			
	level				level		
Percentile	low	mean	high	Percentile	low	mean	high
90	16	17	16	90	26	20	15
75	23	22	21	75	26	21	15
50	31	28	26	50	26	21	16
25	39	34	32	25	24	23	15
10	46	40	37	10	29	26	20

6. CONCLUSIONS AND RECOMMENDATIONS

The intention of this investigation was the verification of the application of the Liberty Mutual Tables for lifting of loads, in the population labor of Caborca, Sonora, Mexico, for vertical lifting, men, frequency of one per minute, 34 cm wide boxes, 51 cm distance of lifting, in three levels low, mean and high. As result of this experiment we can conclude that does not exist to sufficient evidence to affirm that the information of the MAW of the Liberty Mutual Table for lifting of load, under conditions similar to those of this experiment, are different from the average weights from experiment for what, there is not statistical evidence to affirm that is not applicable to the population of Caborca.

Given the magnitude of the injuries of the low back as a result of the workings of lifting load in Mexico is necessary to make a big investigation, with a sample sufficiently ample with Mexican workers of different ages and with greater experience and remunerated work for verify that the maximum recommended weight, normally estimated for Mexican out work force, are really applicable for Mexican work force

7. REFERENCES

Hidalgo J., Genaidy A., Karwowsky W., Christensen D., Huston R., Stambough, 1997, A comprehensive lifting model: beyond the Niosh lifting equation. Ergonomics journal 40(9): 916-27.

National Institute for occupational and health (Niosh), 1981, Work practices guide for manual lifting.

National Institute for occupational and health (Niosh), 1991, Scientific support documentation for revised 1991 Niosh lifting equation.

National Institute for occupational and health (Niosh), 1993 Revised Niosh equation for the design and evaluation of manual lifting tasks.

Putz Anderson, V. (1994) Cumulative Trauma Disorders. A manual for musculoskeletal diseases of the Upper, Limbs, Taylor & Francis, London

Instituto Mexicano del Seguro Social, (2004), Revista médica IMSS, 42(1): 79-88

http://www.imss.gob.mx/dpm/dties/produc/CdTecnicos/El_IMSS_en_cifras/SCDo_02.pdf, visited October 20, 2006.

Snook S.H. 1987 cited for Ciriello V.M. and Snook S.H. 1991, Ergonomy, the design of manual handing tasks, Reviewing tables maximum acceptable weight and strength.

Temple R and Adams T. 2000, Ergonomic analysis of a multi-task industrial lifting station using the Niosh method, Journal of industrial technology vol. 16, 2.

Webster and Snook (1994) cited for Ciriello V.M. and Snook S.H. S. 1997, Inspection of the tasks of manual handling of loads, International Journal of Industrial Ergonomics 23 (1999) 149D156.

RISK EVALUATION TO DETERMINE IF PUSH OR PULL A CART LOADED WITH MATERIAL IS CAUSING BACK PAIN

Martha R. Contreras-Valenzuela, Roy Lopez-Sesenes, Alber E Duque-Alvarez, Lucero I. Mendoza-Toledo

Facultad de Ciencias Químicas e Ingeniería
Universidad Autónoma del Estado de Morelos
Avenida Universidad 1001 Col. Chamilpa, Cuernavaca, Morelos CP 62209
Corresponding author's e-mail: marthacv@uaem.mx

Resumen: La presente investigación se centra en el estudio de caso para determinar si cargar, descargar y empujar un carro cargado con material es la causa de lumbalgia, para ello se aplicó un estudio antropométrico que proviene de varias mediciones en diferentes centros de trabajo en el Estado de Morelos. Para análisis de posturas durante la carga y descarga del material se práctico un estudio REBA para el área de trabajo, finalmente se determinó la fuerza ejercida por el trabajador al manipular la carga utilizando un método analítico. Del diagnóstico y análisis del método de trabajo se determinó que un trabajador carga y descarga en un carro 3 productos que pesan 90 kg en promedio 12 veces al día, el carro vacío pesa 79.35 kg, finalmente la fuerza inicial ejercida por el trabajador al empujar es de 792 N con el carro vacío, 4365.56 N con el carro lleno y 400.22 N por cada vez que manipula un producto. Dando como resultado un alta probabilidad de que la sintomatología presentada por los trabajadores sea derivada de la tarea realizada.

Palabras clave: Ergonomía, Antropometría, Evaluación del nivel de riesgo

Abstract: The present research is focused in a study case about loading, unloading and pushing a cart with material is the cause of low back pain. For that, an anthropometric study was implemented which was established using data from some other companies at Morelos State. The posture analysis was made using the REBA method moreover a PLIBEL method was implemented to analyze the working area. Finally, the force exerted by the worker when manipulating the load was determined using an analytical method. From the diagnosis and work method analysis the results were as follow: a worker loads and unloads a cart with 2 to 5 products weighing 90 kg each one, 12 times by shift, the empty cart weighs 79.35 kg. Finally the initial force exerted by the worker in pushing an empty cart is 792 N, a full cart 4365.56 N, and for each manipulated product 400.22 N. Resulting in a high probability that the symptomatology presented by the workers was derived from the task performed.

Keywords: Ergonomics, Anthropometrics, Risk Level Evaluation.

Relevance to Ergonomics: The main objective of this paper is show an ergonomic preliminary study to determine if pushing a cart with materials is causing back pain. A study method of working area is proposed and the anthropometric data come from some other companies at Morelos Estate.

1. INTRODUCTION

The ergonomics concept has two domains; the first one, a scientific discipline that studies the system effects of human interaction (International Ergonomics Association, 2017), and the second one, as set of techniques directed at the adequacy between the work system and people, optimizing the human well-being and the overall system performance (International Organization for Standardization, 2004). On the other hand, the anthropometric studies in Mexico are important because there are few works about it. Thus, the definitions of workers anthropometric characteristics are showed in the table 1, the set of design limits for the 5 and 95%ile range as Pheasant recommendation (Pheasant 2003) were determined. In our country the male workers of the industrial sector has many problems in their workstations caused by the wrong designs, as a result of this, the operators suffer multiple professional diseases. One example of this is the low back pain, which is possible to avoid doing better design using appropriate anthropometric data in support of the productive sector. As a part of the research project called “Methodology development for improving processes and their work environments", We are conducted a study to determine whether pushing a car with materials as daily work in production areas is causing back pain in workers. Anthropometry basically decides ergonomically conditions, is for that reason the anthropometric studies should be specialized in a single sector, hence the interest in the production workers from Pharmaceutical Company in order to improve the work environment.

2. METHODOLOGY

The structure was taken from the Six Sigma Methodology. Nevertheless, the focus approach for resolving quality problems was modified for ergonomic purposes as follow:

1. The work system diagnosis by REBA
2. Anthropometric study
3. The measure work system and determine anthropometric data. The equations used in this work are the follow:

$$F = ma + m mg \qquad (1)$$

Where
F = object weigh, a= acceleration, m friction coefficient, g= gravity force, q is work position angle

$$F = \frac{ma + m mg}{\cos q + m \sin q} \qquad (2)$$

4. Analyzing risk level
5. Improving the work system

3. RESULTS AND DISCUSSION

The task consisted of translate rolls of plastic from warehouse to production area. The rolls weight 90 kg and they were taken from a rack, to load and unload a cart with 2 to 5 products as is showed in Figure 1 a) and b) for that the worker used his strength. After that, the material was transported around 0.50 m. The movements developed by the worker that were analyzed during the diagnosis were: Lifting and lowering material and push and pull the cart 12 times by shift see Figure 1 c) and d), the empty cart weighs 79.35 kg

a) b) c) d)

Figure 1. Example of work method

The diagnosis results from the work area made possible to develop a classification of the ergonomic risk factors. The risks where classified using a Pareto chart, the result is showed in Figure 2. Thus, The opportunity area for improvement was the rolls manipulation activity of which involve force and loads as principal risk factor for the workers during a shift. Other factors such as distance between the cart handle with respect to the back and hands position were identified. The PLIBEL analysis determines that the body parts under risk were wrist, arms and back.

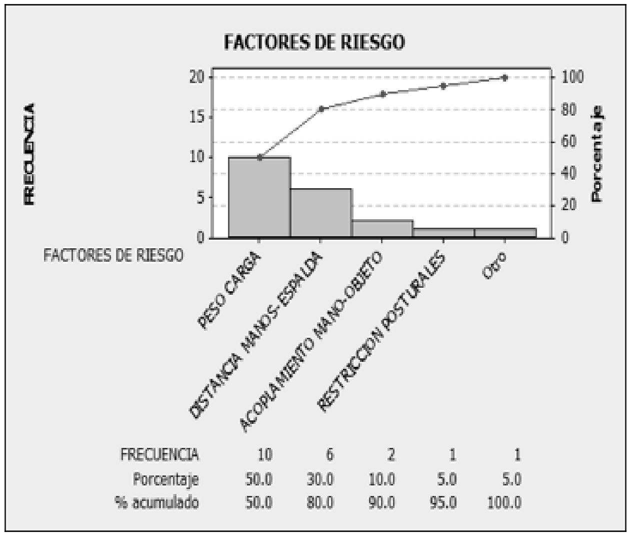


Figure 2. Example of work method

The anthropometric study was applied to 27 workers from the area, they represent the 100% of the population occupationally exposed. A special sheet for recording the data and the result of the survey were developed. Approximately 35 body measurements were collected from the workers organized in two data sets a) measures on foot and b) measures on sitting. The anthropometric results needed for the present work are showed in Table 1. The equipment used for this activity were:

a. Metric tapes of 1.5 mts.
b. Anthropometer Lafayeffe with range of 60 cm.
c. Anthropometer Lafayeffe with range of 30 cm.
d. Scale Tanita WB-3000
e. Anthropometric seats

Table 1. Anthropometric results in meters for male workers in Morelos State

	Height	Chest height	Shoulder height	Grip height
Percentile 5	1.47	1.15	1.24	1.02
Mean	1.61	1.25	1.36	1.16
Percentile 95	1.76	1.36	1.48	1.27

The REBA evaluation for diagnosis were implemented only when the worker was in front of the cart in push position before starting the movement and 1 or 2 seconds during the worker starts push, the activity give a level of eight based on the risk established by this methodology, rated as high in this scale, considering that it is a postural evaluation, it was established that the weight of the car without load is 79.35 kg, the worker must apply a force of 80.88 Kgf to move only the car. They are placed in the platform of the car between three and five rolls to move, evaluated the same force to apply with the weight of three rolls, with a weight of 369.65Kg, the worker must apply a force of 445.46 Kgf to move the loaded car with 3 rolls. Some of the factors besides the weight that increase the level of strength developed were the obstruction in the start of the trajectory of the movement and the bad state of some elements of the car and the friction between the material of the wheels and the floor. See Figure 3.

Figure 3. REBA evaluation

An example of the work done by the workers is showed in the Figure 4, where is possible stablished an analogy between the body segments and the loads through a vector system (Figure 3 a) and b)). The rolls charge that the worker has to move is compound by a vector system of four components in the x and y axis such as force (F), friction (f), mass (m) and acceleration (a). The result of the analysis is showed in Table 1, which make evident an excess of load during a shift. Based on this analysis, a redesign proposes is necessary with the aim to improve the work condition under which the worker does his activities.

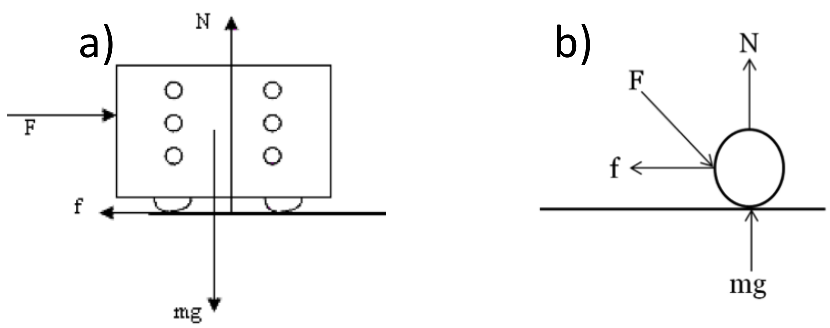


Figure 4. Analogy and interpretation of applied forces

Data and results from the equations:

Push empty cart	Push full cart (3 rolls)
m= 79.35 Kg	m= 369.65Kg

d= 0.43m
t= 1.54s
μ= 1 (rubber-concrete)

d= 0.51m
t= 1.61s

Force developed by the worker when push the cart empty

$$F=(79.35\,Kg)(0.18\,m/s^2)+(1)(79.35\,Kg)(9.81\,m/s^2)$$

$$F= 792.7\ N = 80.88\ Kgf \quad (3)$$

Force developed by the worker when push the full cart

$$F=(369.65\,Kg)(2\,m/s^2)+(1)(369.65\,Kg)(9.81\,m/s^2)$$

$$F= 4365.56\ N = 445.46\ Kgf \quad (4)$$

Force developed by the worker when unload a roll

$$F=\frac{(0.4\,m/s^2)(90\,Kg)+(0.45)(90\,Kg)(9.81\,m/s^2)}{\cos(33.37°)+(0.45)\sin(33.37°)}$$

$$F= 400.22\ N = 40.83\ Kgf$$

(5)

4. CONCLUSIONS

The measurement results showed in the table 1, indicate that the maximum forces that can performed the workers are exceeded, so we conclude that the stresses generated in this activity are the cause of low back pain. Moreover the work method has to be analyzed too, and the results were: the back pain was caused by the repetitive action and by movements bad executed.

5. REFERENCES

Pheasant P. (2003). Bodyspace: Anthropometry, Ergonomics and the design of work. Second Edition. Taylor & Francis Inc.

International Ergonomics Association (2017). Definition and domains of ergonomics. Available at http//www.iea.cc/whats/index.html.

International Organization for Standardization (2004). International standard 6385:2004(E), Ergonomic principles in the design of work systems. Second edition.

VALIDATION OF A REGRESSION MODEL.

Gerardo Meza Partida[1], Enrique Javier de la Vega Bustillos[1]
Francisco Octavio López Millan[1], Jaime Sánchez Leal[2], Manuel Rodríguez Medina[2].

[1]Instituto Tecnológico de Hermosillo, Ave. Tecnológico s/n
Hermosillo, Sonora, Mx. 83170
Email del autor: ge_meza@ith.mx

[2]Instituto Tecnológico de Ciudad Juárez. Ave. Tecnológico #1340.
Ciudad Juárez, Chihuahua, Mx. 32500

Resumen: El análisis de modelos de regresión es una técnica estadística para investigar y modelar la relación entre diversas variables. Para hacer uso de estos modelos, se debe tener la seguridad de que su comportamiento será adecuado a las condiciones naturales de operación. Por lo tanto es necesario realizarle pruebas para su evaluación y en base a los resultados poderlo validar.

En la presente investigación se propone el uso del método de validación mediante la obtención de nuevos datos, llamados también corridas de confirmación, a un modelo de regresión obtenido previamente y en base a los resultados poder determinar si es buena la predicción que proporcione al modelo de regresión.

Palabras claves: Validación; Modelos de Regresión; Análisis de regresión.

Abstract: The analysis of regression models is a statistical technique to investigate and model the relationship between several variables. To make use of these models, you must be assured that your behavior will be appropriate to the natural operating conditions. Therefore it is necessary to perform tests for its evaluation and based on the results can validate.

In the present research the use of the validation method is proposed by obtaining new data, also called confirmation runs, to a previously obtained regression model and based on the results to be able to determine if the prediction that provides the model of regression.

Keywords: Validation; Regression models; Regression analysis.

1. INTRODUCTION.

The use of regression models is common for prediction or estimation, data description, parameter estimation and control. Frequently regression models are used by a person other than who developed it, so it is important to make an evaluation for its validity. The validation of a model focuses on determining whether it will function properly in an environment appropriate to its operation.

The techniques for the validation of a regression model are as follows:

- Analysis of model coefficients and predicted values.
- Collection of new data.
- Division of data.

The most effective method to validate a regression model is to collect new data and to directly compare model predictions with that data. If the model produces accurate predictions for new data, we will have more confidence in both the model and the process of obtaining it.

2. OBJETIVES.

General: Validate the results of a previously obtained regression model by analyzing new data and comparing them directly, using least squares adjustment prediction errors.

Individuals:

- Validate a regression model, which represents the grip strengths that are made in the manufacturing industry based on the regressors age, time, height and width of the hand.
- Get a robust adjustment with the application of new data.
- Use statistical tools for data processing.
- Describe the manual force that can be generated based on the factors described above over time

3. METHODOLOGY.

For this study, participants were asked to apply the maximum manual grip force that they consider acceptable for an 8-hour work day, taking into account that due to the nature of the operation, it will be necessary to be applying force in shape Repeated, thus simulating a work station where the application of force of grip for the elaboration of electrical components is required.

For this research, a group of 10 operators, with work experience and daily activities in the manufacturing industry, in the community of Hermosillo, were randomly selected. Test subjects underwent medical examination to prevent injury. A study of anthropometry was made to test subjects, in order to obtain their physical measurements and to be able to characterize them based on them. The laterality of the participants was considered to give preference to the same during the study of the grip strength. The age range of the operators group is between 21 and 30 years, you will get your average age, height and width of the hand.

3.1 Data Collection.

Dynamometers were used to measure the manual grip force. The test subjects were instructed to stand in front of a structure that held the dynamometer to a height that formed a right angle with its elbow. The wrist was held in a neutral position with the hand resting on the dynamometer. The test subjects were instructed to perform a manual grip force on the dynamometer. Three manual grips were performed at the beginning, at the middle and at the end of the working day, for five weeks. The test subjects were instructed to apply their maximum acceptable force, assuming that the grip level they selected can be sustained repeatedly.

3.2 Data Processing.

The data were recorded on an electronic sheet for easier handling. The peak force was recorded for each insertion with the dynamometers.

3.3 Statistic Analysis.

For the development of this procedure, 150 new observations were made, in table 1 the first 10 observations are represented. The equation for the adjustment model was obtained in equation 1:

$$\hat{y} = -43.08 + 11.45(\mathit{ancho\ de\ la\ mano}) - 2.48(\mathit{Tiempo}) + 0.124(\mathit{estatura}) + 0.148(\mathit{edad}) \quad (1)$$

Table 1 shows the new observations and the corresponding predicted forces and least squares adjustment prediction errors using equation 1 (columns 6 and 7) are shown.

For the robust adjustment, the 150 new observations are considered, in addition to the previously obtained observations. With this we obtain the equation 2 of the robust adjustment:

$$\hat{y} = -40.2 + 11.45(\mathit{ancho\ de\ la\ mano}) - 2.61(\mathit{Tiempo}) + 0.112(\mathit{estatura}) + 0.142(\mathit{edad}) \quad (2)$$

The corresponding predicted forces and the least squares robust prediction errors are shown in columns 8 and 9 of Table 1.

Table 1. Prediction Data Set.

Obs	(1) Force y	(2) X1	(3) X2	(4) X3	(5) X4	(6) Adjustment	(7)	(8) Robust Adjustment	(9)
						ŷ	y-ŷ	ŷ	y-ŷ
1	63	6	21	161	8.1	57.628	5.372	58.304	4.696
2	64	6	21	161	8.1	57.628	6.372	58.304	5.696
3	63	6	21	161	8.1	57.628	5.372	58.304	4.696
4	62	6	21	161	8.1	57.628	4.372	58.304	3.696
5	62	6	21	161	8.1	57.628	4.372	58.304	3.696

6	59	7	21	161	8.1	55.108	3.892	55.694	3.306
7	59	7	21	161	8.1	55.108	3.892	55.694	3.306
8	60	7	21	161	8.1	55.108	4.892	55.694	4.306
9	58	7	21	161	8.1	55.108	2.892	55.694	2.306
10	58	8	21	161	8.1	52.588	2.892	58.304	4.696

4. RESULTS.

With the mean squared prediction errors of the adjustment model we have:

$$\frac{\sum_{i=1}^{150}(yi-\hat{y}i)^2}{150} = \frac{1516.49}{150} = 10.11$$

When the percentage of variability of the adjustment model is obtained, one has:

$$R^2 \text{ Predicción} = 1 - \frac{\sum_{i=1}^{150}(yi-\hat{y}i)^2}{\sum_{i=1}^{150}(yi-\bar{y}i)^2} = 1 - \frac{1516.49}{6531.67} = 0.78$$

When calculating the average squared prediction error of the robust adjustment obtained in columns 8 and 9 of Table 1, we obtain:

$$\frac{\sum_{i=1}^{150}(yi-\hat{y}i)^2}{150} = \frac{1456.33}{150} = 9.71$$

Similarly, the R^2 for robust fit prediction is:

$$R^2 \text{ Predicción} = 1 - \frac{\sum_{i=1}^{150}(yi-\hat{y}i)^2}{\sum_{i=1}^{150}(yi-\bar{y}i)^2} = 1 - \frac{1456.33}{6531.67} = 0.80$$

5. CONCLUSIONS.

It can be seen that this value is slightly higher than the corresponding value of the least squares model. Collecting new observations, it has been seen that least squares adjustments such as the robust, produce reasonably good prediction equations. There is some evidence that the robust fit is a bit better than the least squares.

The new 150 observations help us to have a reliable assessment of model prediction efficiency. In cases where two or more alternative regression models are developed, comparing the efficiency of the prediction with new data can serve as a basis for selecting the final model.

6. REFERENCES.

Draper, N. and Smith, H. (1981), Applied Regression Analysis. Segunda edición. Ed. John Wiley & Sons. Inc.

Kutner, M., Nachtsheim, C., Neter, J. and Li, W. (2005). Applied Linear Statistical Models. Mc Graw Hill Irwin, Fifth Edition, New York.

Montgomery, D. et al (2004), Introducción al análisis de regresión lineal. Tercera edición. Ed. Cecsa.

Wackerly, D. et al. (2008). Estadística matemática con aplicaciones. Séptima edición. Ed. Cengage learning.

ERGONOMIC ANALYSIS OF THE WHEAT FLOUR PACKING PROCESS IN 44 KG.SACKS

Mayra Edith Romero Gomez, Jose Ignacio Aguilar Carrasco, Roberto Arvizu Acosta, Fausto Neftaly Martinez Martinez, Nicolas Villa Quintero

División de Ingeniería Industrial, Instituto Tecnológico Superior de Cd. Constitución, Marcelo Rubio Ruiz s/n entre Márquez de León y Pablo L. Martínez, col. 4 de Marzo, Cd. Constitución Baja California Sur,
jaguilar@itscc.edu.mx

Resumen: Contar con un análisis ergonómico donde se identifiquen las áreas de oportunidad para realizar mejoras ergonómicas es trascendental para asegurar y mantener la eficiencia de cualquier empresa. En este sentido, la identificación de riesgos ergonómicos en una línea de producción es una actividad que busca brindar propuestas para asegurar el bienestar de los colaboradores, para ello, se realizaron mediciones antropométricas del personal involucrado en el proceso de empaque de harina de trigo en costales de 44 Kg para contrastarlas con las dimensiones de la distribución física de los elementos de trabajo. Se identificaron áreas de oportunidad en función de los resultados obtenidos, creando asi un análisis detallado que sirva para tomar medidas en vista de mejorar las condiciones de trabajo, reduciendo el riesgo de sufrir lesiones en corto y mediano plazo.

Palabras clave: Análisis ergonómico, linea de empaque.

Abstract: Having an ergonomic analysis where identify opportunity areas to make ergonomic improvements is crucial to ensure and maintain the efficiency of any company. In this sense, the identification of ergonomic hazards in a production line is an activity that seeks to offer proposals to ensure the well-being of the collaborators, for that, anthropometric measurements of the personnel involved in the process of packing wheat flour in sacks Of 44 Kg to contrast them with the dimensions of the physical distribution of the working elements. Areas of opportunity were identified based on the results obtained, thus creating a detailed analysis that serves to take measures to improve working conditions, reducing the risk of injuries in the short and medium term.

Keywords: ergonomic analysis, work item and packaging line.

Relevance to Ergonomics: Ergonomics today is a topic that deserves special attention in companies, especially at managerial and operative levels, where not only must the worker be given the tools necessary for the development of his activities, but also analyze the conditions under which work, interaction with its machinery and tools; the environment, including factors such as temperature, noise, vibrations, etc .; their ability to carry out a task; the postures and movements that are made; labor relations; the mental burden, as well as their emotional and economic situation; among others (Mondelo et al., 1999).

INTRODUCTION

The evolution of industrial society in recent centuries has been demanding from ergonomics and production engineering a joint and continuous effort towards the supply of solutions through concepts, methods, techniques and tools, in order to satisfy the needs of Modern societies (Gomes, 2014).

Actually the study of occupational ergonomics is a little developed activity in the different industries dedicated to the transformation, the lack of quantitative data referring to the anthropometric aspects of the operative personnel is sometimes a secondary problem that does not affect at first glance the labor productivity, However, the identification, analysis and measurement of these aspects may represent a solution to the existing complications related to muscular fatigue affecting work performance. Lopez, Marin and Alcala (2012) mention the relevance of the application of ergonomics in industrial companies, in order to promote the reduction of occupational health and safety costs while boosting workers' productivity.

The application of ergonomics has been able to correct and reduce work risks when already detected harmful consequences for the operator, it is intended to bring ergonomics to a level capable of preventing damages and continuously improving working conditions (Mondelo,GregoriandBarrau, 1999). Thus, even in terms of certification, it has introduced the term to raise awareness of organizations in the valuation of their human capital, managing to greatly reduce the expenses incurred from injuries and simultaneously achieving the productive growth of the company.

It is well known that work-related problems due to poor ergonomic conditions cause deterioration of health status and unnecessary suffering affecting individuals. In this sense, ergonomics uses anthropometry, whose purpose is to know the dimensions of human beings, a determining factor for a correct linking of people with the work elements used in their tasks.

Taking into account the dimensional aspects of people, the necessary space can be provided without compromising the technical requirements of the design. Nowadays, the use of reliable anthropometric data and the application of an ergonomic analysis, become indispensable tools for the dimensional adaptation of the products, the machines and the protection equipment, that interact with the people in theirdailylife favoring the conditions for their performance, as well as their safety and well-being (Tomasiello and Del Rosso, 2008).

Ergonomic studies allow an appropriate and fair view of workers' risks, a somewhat subjective but necessary verification in every institution. This analysis can contribute to (informed) decision making to improve safety systems, work efficiency. For the present investigation is considered that the analysis of the problems related to the postures in the work activities developed in the area of packing of sacks of 44 kg in the company Molinera de México S.A. of C.V., is not a frequent activity, this situation causes a lack of knowledge about the reasons that give rise to various physical discomforts that decrease the capacity of work of the individual and consequently the productivity. In thissense, it is important for this company to know the ergonomic risk factors that can affect the health of its employees.

OBJECTIVES

GENERAL OBJECTIVE
Determining if the machinery and work equipment distribution and dimensions are adequate depending on the anthropometric variables of the personnel involved.

SPECIFIC OBJECTIVES

- To obtain anthropometric measurements of the operators.
- Make the measurements corresponding to the used machines and equipment.
- To compare operator vs machines measurements to elaborate improvement proposals to the company.

METHODOLOGY

The first activity was the observation of work operations in the line of packaging involved in a period of time provided by the plant manager, so as not to generate distractions on employees during their work shifts. Once work elements such as conveyor belts, hopper and others were identified, the work operations performed by the employees on the production line during the morning and evening shifts were identified to identify which could lead to injuries Muscles.

Some of the risks that these operators may suffer are:

• Movement: repeating the same activity for 8 hours of work.

• Trunk postures: when loading the sacks tilt the back to help support the weight of the sack.

• Arms and wrists: the operator who fills the sacks must place the sack in the mouth of the hopper and, once filled, stop so that the sack does not fall abruptly on the conveyor belt.

To perform an effective ergonomic analysis it was necessary to make measurements to the equipment involved in the process using a flexometer, for it was considered the following variables related to machinery and equipment:

• Height to floor that has the raised band
• Height to floor to conveyor belt
• Height between the belt and the flour hopper
• Distance between hopper and sack cooker for flour
• Distance between conveyor and sewing belt
• Distance between the sack carrier and the flour hopper
• Height of the computer where the weight records are made
• Distance between the belt and the table

As well as measuring the equipment, anthropometric measurements were also carried out on five workers using an anthropometer and flexometer, the analyzed anthropometric variables are listed below:

• Height
• Height to elbow

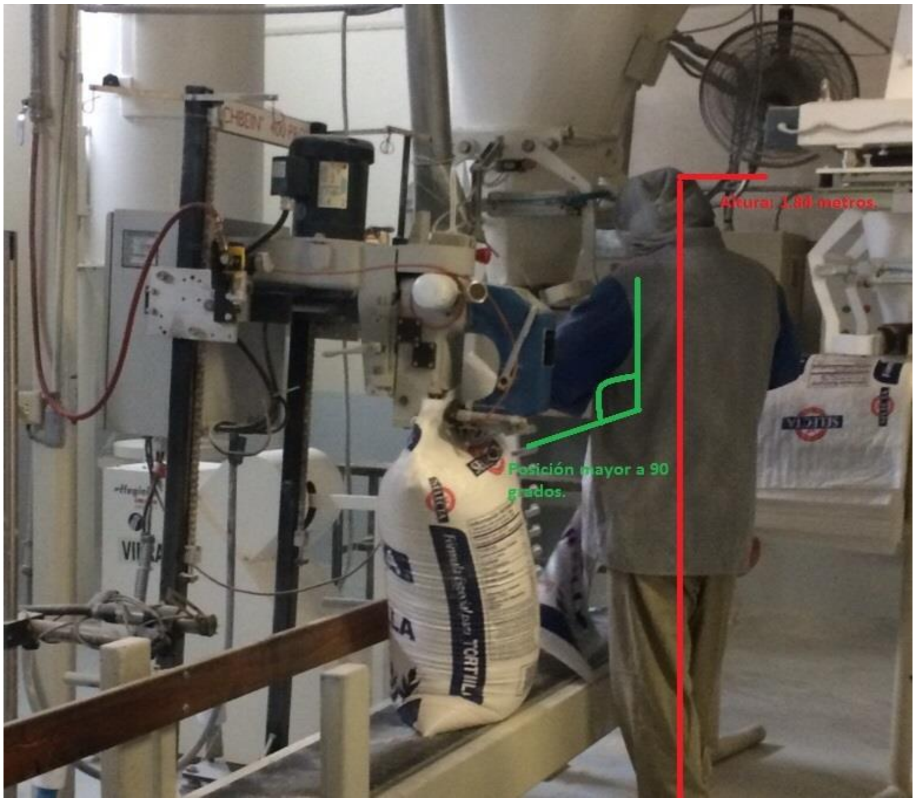


Figure 1. 44 kg sacks packing workstation.

- Shoulder height
- Height to pelvis
- Height to eyes
- Shoulder Width
- Hip width
- Elbow-Shoulder Distance
- Abdominal depth
- Elbow-wrist distance

The last step of the ergonomic analysis is to compare the results of the measurements made in the work elements against the anthropometric variables obtained, contrasting the lengths of the machinery and equipment with the variables that are directly related, in this way it is tried to know if the Distribution and the dimensions of the elements are appropriate to the body dimensions of the operators involved.

RESULTS

To perform an organized comparison between anthropometric measurements and those of machinery and equipment are grouped into tables where each measured variable can be identified and obtain a result that can indicate if the dimensions of the work elements are in function or are adequate to the Body dimensions of operators.

The following table shows the comparisons of the anthropometric measurements of each operator against the measurements of the height of the raised belt, which is where the sack of flour is transported to the final height where the operator holds it on his shoulder for his Subsequent accommodation on pallets. The height of the flour hopper is also presented where the second operator of the packing line holds the sacks to be filled with flour and later to be transported by the belt:

Table 1. Comparison between shoulder height vs elevated belt height and flour hopper, (cm)

<table>
<tr><th>Worker</th><th>ShoulderHeight</th><th>High conveyorbeltheigth</th><th>Hopper height</th></tr>
<tr><td>1</td><td>158</td><td rowspan="5">148</td><td rowspan="5">150</td></tr>
<tr><td>2</td><td>137</td></tr>
<tr><td>3</td><td>143</td></tr>
<tr><td>4</td><td>136</td></tr>
<tr><td>5</td><td>150</td></tr>
</table>

In the table above it is observed that only one operator has shoulder height greater than the hopper, this indicates that the rest of the workers are performing tasks above the shoulders situation that affects the operators because besides being repetitive the movement is a greater effort where the weight of the sack falls on the shoulders causing physical fatigue.

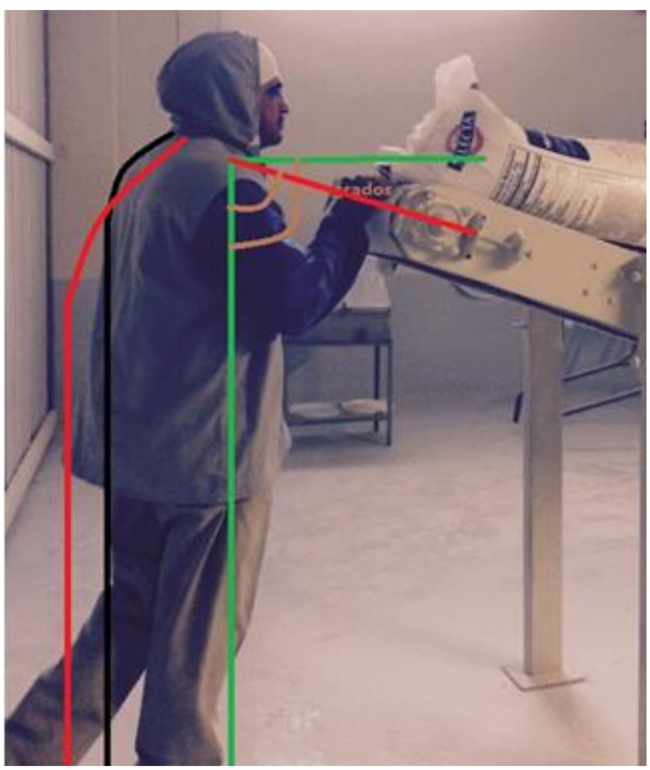


Figure2.Workerreceiving sack at raised belt.

In the raised belt, where the workers wait for the sack to be placed on their shoulder, three of them are below the height of the end of the belt so the weight of the sack falls on them and there is no need to lean to place the sack on his shoulders. Operator number 5 has a difference of 2 cm greater, for what is considered a minimum effort at the moment of inclination to receive the sack and the operator number 1, who has the highest shoulder height has to lean significantly to receive the sack and then raise his back to begin to accommodate the sack and place it later on the scale. Therefore the operator number five may present greater fatigue, pain in the back and shoulders due to the repetitive actions of this operation.

The next comparison is the width of shoulders and hip against the width of the aisle (the distance between the 44kg band and the 10kg band). This is to know if the workers have the necessary space to walk and move down the aisle as next to the packing machine of 44 kg there is the flour packing of 5 and 10 kilograms.

Table 2. Comparison of dimensions that make up the trunk vs. width of the corridor of the packing area (cm)

Worker	Shoulderwidth	Hip width	Abdominal depth	Corridorwitdth
1	53	42	36	58
2	47	38	30	
3	43	36	30	
4	40	32	19	
5	50	42	31	

With the measures taken it is observed that 4 of the operators can move without any problem, however there is an operator whose margin is 5 cm, 2.5 cm on each side, one of the recommendations would be to separate a little more machines, so that there is more space for operators to move without worry and this can avoid incidents in the work area. It is identified that the abdominal depth does not affect any of the operators, so they can be in front of the hopper and band without touching the back band.

The next factor to be compared is the distance between elbow-wrist and shoulder-elbow against the distance that exists between the hopper and the seeder and the hopper and the portacostal.

Table 3. Comparison of arm dimensions vs distances between hopper and sewing machine (cm)

Worker	Shoulder-elbowdistance	Elbow-wristdistance	Distance Hopper-sewing machine
1	41	33	78
2	31	30	
3	33	27	
4	31	26	
5	34	30	

According to data from the distance between the hopper and the sewing machine, it is clearly shown that it is bigger the distance between the place where the workers are placed when the sack falls on the conveyor belt towards the hopper. Sewing of sacks, this originates workers tend to move or tilt their body to reach to place the sack, so that the seamstress begins to do their job. This is reduced to the fact that the operator strives so that he suffers physical fatigue by unnecessary movements.

Another aspect to consider in this ergonomic analysis is the comparison that exists between the height to the eyes of the operators and the height of the computer.

Table 4. Comparasion between eyes and elbow height vs computer station height (cm)

Worker	Eyesheight	Elbowheigth	Computerstation top height	Computerstationlowerheight
1	182	122	150	107
2	159	104		
3	161	109		
4	152	104		
5	171	114		

The top distance of the computer was taken based on where the eyes should be looking when each operator is in front of the screen.
Four of the workers over pass the top of the computer so they tend to lean, hunch or crouch to reach to see what appears on the screen, causing knee flexion and stooped back giving rise to muscle pains, effort by the operators and pain in the lower back by the bend.

The lower height of the computer was taken based on the height where the keyboard and computer mouse is located which is 107 cm and can be compared with the elbow height of each operator. Looking at Table 4, it can be seen that two of the workers have a higher height so they tend to lower their arms by placing them at an approximate angle of 70 degrees by seeing the angle open from the side of the leg upwards. Health risks arise such as tendon wear, radial tunnel syndrome, among other conditions.

The following points explain the results of the comparisons made between the anthropometric measurements and the dimensions of the work elements:

- In the high band, 40% of the operators are in a situation of suffering muscle injuries because they adopt bad postures to receive the sack with flour on their shoulder.
- 60% of workers have trouble placing the sack in the flour hopper, since it is at a higher elevation than the height of their shoulders causing more physical wear and tear by raising the arms to a greater height.
- All workers do not have problems moving within the workstation.
- The distance between the hopper where the sacks are filled with flour and the sewing machine is greater than the reach of the arms of the totality of workers so that all have to move to sew the sack.
- It can be stated that 80% of workers are significantly inclined to observe the computer screen at the weighing station.

CONCLUSIONS

It was possible to determine that the dimensions and distribution of the work elements in general terms are not totally adequate to the majority of the operators. Areas of improvement were found to prevent risks of physical injuries that could be caused by the inadequate dimensions of the conveyor belt distribution, the height of the belt and also the weight recording station.

Thanks to the analysis, the blind spots in the packing line of 44 kg of wheat flour were determined in terms of ergonomics, and the results obtained are very useful for the plant manager since he did not know the ergonomicconditions in which the operator was in relation to the studied anthropometric variables, giving rise to generate improvements in this respect.

In order to reinforce the ergonomic analysis it is recommended to the company in question to address the following aspects to promote the prevention of physical injuries originated by any of the situations that were found in the comparisons made in the development of the investigation:

A. Introduce workers through training or conference related topics on ergonomics and how good work practices can prevent injuries.

B. Raise the height of the computer approximately 15 cm, so that operators do not have to stoop to see what appears on the monitor.

C. Decrease the distance between the floor and the hopper by 6 to 10 cm to prevent operators raising their arms above shoulder height.

D. Decrease by 15 cm the distance between the hopper and the sewing of sacks, to avoid that the operators make unnecessary movements and do not have to extend the arms more than allowed.

E. Extend the distance between the 44 kg band and the 10 and 5 kg band by 10 to 15 cm. This to avoid roses or shocks of the operators against the machines.

F. Prevent operator from working repetitively in the raised belt and for the rest of the workers to verify that the work movements are done in the best possible way to avoid injuries and cause discomfort in the lower back or shoulders.

G. In addition to ensuring the use of safety equipment to prevent injury risks, it is recommended to use lumbar support belts for all employees involved in the 44 kg wheat flour sacks packaging line.

REFERENCES

Gomes, J. (2014). *El papel de la ergonomía en el cambio de las condiciones de trabajo: perspectivas en América Latina*. Rev. Cienc. Salud. vol. 12 (Especial): pp 5-8

Mondelo, R. P., Gregori, E., &Barrau, P. (1999). *Ergonomía I Fundamentos*. Tercera edición. México, D.F. Alfaomega.

López, V. G., M. E. Marín Y M. C. Alcalá. (2012). *Ergonomía y productividad: Variables que se relacionan con la competitividad de las plantas maquiladoras*. Ingeniería industrial. Actualidad y nuevas tendencias Año 5, Vol.III, No 9.pp. 17-32.

Tomassiello, R., Del Rosso R. (2008). *El diseño desde las medidas humanas*. Huellas, Búsquedas en Artes y Diseño, no 6, 56-67

ERGONOMIC EVALUATION IN THE PROCESS OF PRODUCTION OF A PROCESSING COMPANY OF FISH

Grace Erandy Báez Hernández[1], Miguel Ahumada Felix[1] Viridiana Humarán Sarmiento[1] and Claudia Selene Castro Estrada[2]

[1] Department of Industrial Engineering
Instituto Tecnológico Superior de Guasave
Carretera a Brecha S / N, Ej. Burrioncito
Guasave, Sinaloa, CP.81149
E-mail del autor correspondiente:
Gracebaezh@gmail.com

[2]Department of Engineering in Quality Systems
Universidad Intercultural del Estado de Sinaloa
Juárez 39 Mochicahui, El Fuerte, Sinaloa 81890
Klaudy_00@hotmail.com

Resumen: En el sector pesquero existen muchas condiciones inseguras para los trabajadores, las actividades son repetitivas y presentan una rotación de personal constante. Tiene como objetivo Realizar una evaluación ergonómica para detección de lesiones musculoesqueléticas y caracterizar los factores de riesgos que se presentan el proceso de producción en una procesadora de pescado Se delimito el trabajo en una procesadora de pescado ya que existen problemas latentes por presentar un trabajo repetitivo con jornadas de 8 horas seguidas, y con 1000 trabajadores. La metodología que se aplico fue el método Rula (Rapid Upper Limb Assessment) y el Corlett & Bishop (Mapa de Molestias) para detectar los riesgos ergonómicos a los que están expuestos los trabajadores y encuestas de ambientes laborales. Como resultado se tuvo dos métodos reportan que existen molestias en diferentes partes del cuerpo. Así como riesgos moderados y alto que puede ocasionar DTA´s, principalmente en espalda, cuello, mano y muñecas. Después de analizar los resultados se presentó una propuesta de rediseño y mejoras de las condiciones de trabajo.

Palabras clave: Método Rula, Lesiones musculoesqueléticas, procesadora de pescado.

Abstract: In the fishing sector there are many unsafe conditions for workers, activities are repetitive and have a constant turnover of personnel. It aims to perform an ergonomic evaluation for the detection of musculoskeletal injuries and characterize the risk factors that are presented in the production process in a fish processor. The work in a fish processor is delimited since there are latent problems to present a repetitive work with 8-hour days, and with 1000 workers. The methodology applied was the Rula (Rapid Upper Limb Assessment) method and the Corlett & Bishop (Nuisance Map) method to detect the ergonomic hazards to which workers are exposed and surveys of work environments. As a result we had two methods report that there are discomforts in different parts of the body. As well as moderate and high risks that can cause DTA's, mainly in the back, neck, hand and wrists. After analyzing the results, a proposal for redesigning and improving working conditions was presented.

Keywords: Rula Method, Musculoskeletal Injuries, Fish Processor

Relevance to the Ergonomics: The contributions are very significant because the methods were applied in real cases and from the Ergonomics significant contributions were made to the production lines where they clean the fish.

1. INTRODUCTION

In Sinaloa the triggering activities of the economy are Agriculture, Livestock and Fisheries. This last activity is present in 6 municipalities. According to a registry of the Ministry of Economy in 2011, indicates that there are 113 companies engaged in fish processing. In this industry there are many problems with the personnel, since the work done in the fishing industry is very heavy and 90% of the activities are manual. The participation of the workers is a primordial axis since they are present from the capture, cleaning, cooking and packaging of the product. Particularly a fish processor has had constant problems in the production line, since the turnover of personnel, low productivity, loss of product and a high fatigue index in the workers.

From this it is intended to perform an ergonomic evaluation for the detection of musculoskeletal injuries and characterization of the risk factors to which the workers are exposed. In the company is processed different fish, the line that was served was the line that is responsible for cleaning the tuna. With 1000 workers in the production line of 18 to 60 years all women. With a day of 6 days of week and 1 day of rest in days of 8 hours.

2. OBJECTIVE

Perform an ergonomic evaluation for the detection of musculoskeletal injuries and characterize the risk factors presented in the production process in a fish processor.

3. METHOLOGY

In the fish processing company to carry out the evaluation, the production line with the largest number of workers was considered and the one that presented a greater number of problems of fatigue and turnover of personnel. The study was structured in two phases:

The first part consisted of knowing the facilities to visually detect operations and processes that have the production line and perform a work environment survey (stress and conditions that mark STPS) and evaluated the performance with the proposal of personal protection equipment To carry out its activities.

The second phase focused on the application of ergonomic evaluation methods, RULA and Corlett & Bishop. And the measurements corresponding to the workstations and the production line.

The third phase was the analysis of the work environment survey and what indicates the legal framework of the STPS. As well as analyzing the results of the Rula and Corlett & Bishop methods.

4. RESULTS

The results of the research were developed in phases. In the first one detected several anomalies from the route, all the people that work in the line are women of 18 to 60 years, with a day of 8 hours daily every day.

4.1. First phase

Work environment survey. For the application of the survey 30 people were taken because there is a constant rotation in that production line and we select the people who have more than 6 months working in the processor.

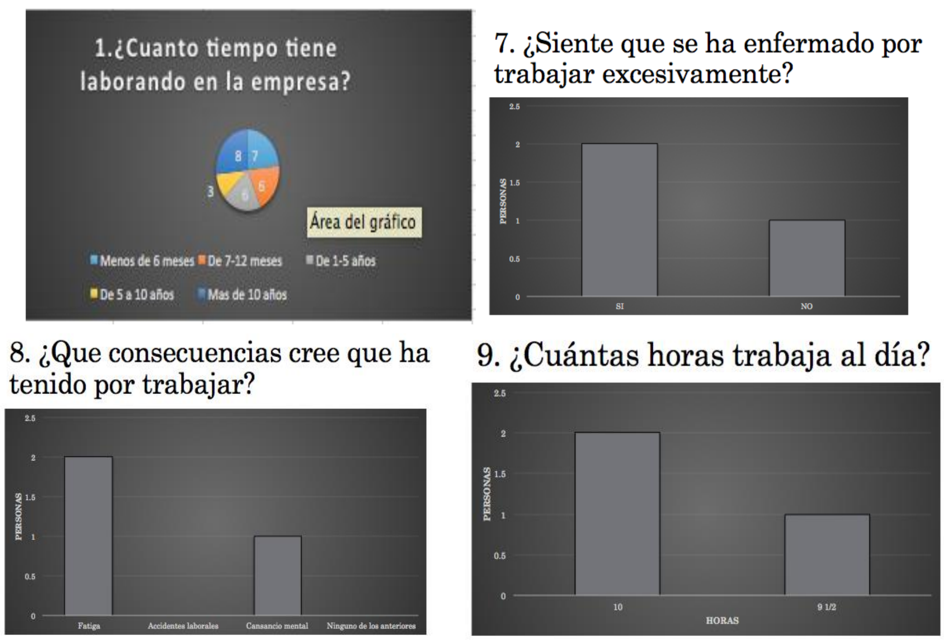
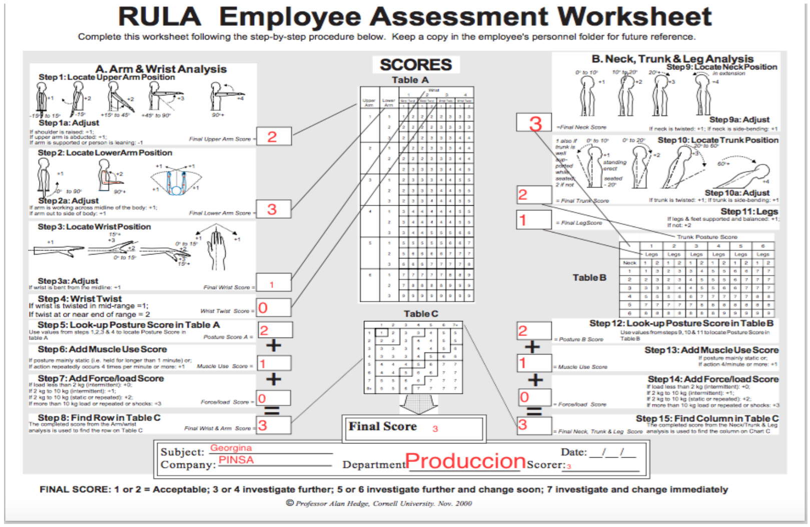


Table 1 Workplace Survey Charts

4.2 Second Phase

In the production line, it took 3 workers who had more than 6 months working in the company. And they have different anthropometric characteristics, to represent the percentiles of the 95%, 50% and 5% line. Once identified, the Rula method was applied.


RULA Employee Assessment Worksheet

Complete this worksheet following the step-by-step procedure below. Keep a copy in the employee's personnel folder for future reference.

A. Arm & Wrist Analysis

Step 1: Locate Upper Arm Position

Step 1a: Adjust

Step 2: Locate Lower Arm Position

Step 2a: Adjust

Step 3: Locate Wrist Position

Step 3a: Adjust

Step 4: Wrist Twist

Step 5: Look-up Posture Score in Table A

Step 6: Add Muscle Use Score

Step 7: Add Force/load Score

Step 8: Find Row in Table C

SCORES

Table A

Table C

Final Score 3

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position

Step 9a: Adjust

Step 10: Locate Trunk Position

Step 10a: Adjust

Step 11: Legs

Table B

Step 12: Look-up Posture Score in Table B

Step 13: Add Muscle Use Score

Step 14: Add Force/load Score

Step 15: Find Column in Table C

Subject: Georgina

Company: PINSA

Department Produccion

Date: __/__/__

Scorer: 3

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately

© Professor Alan Hedge, Cornell University. Nov. 2000

Table 2 Results of the application of the RULA Method

4.3 Third phase

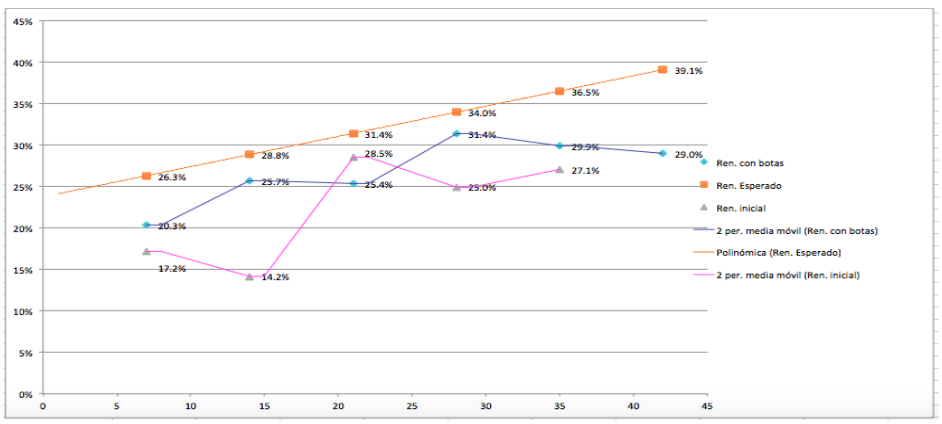


Table 3. Performance Comparison Chart with Ergonomic Boots and Ergonomic Rug.

As a results of the application of the RULA method, it indicates that a future investigation has to be done, because the workers present problems of injuries in the shoulders, arms, neck, upper and lower back and legs. With the application of the Corlett method And Bishop found that the parts that should have greater attention for the constant pains that are presented are high back, lower legs, shoulders, arms, neck and head.

5. CONCLUSIONS

When performing the ergonomic analysis, it was possible to detect the activities with greater occupational risk as well as the most effective personal projection equipment for cleaning tasks in the production process in the processor. Through the methods of ergonomic evaluation the cumulative trauma disorders that have the workers of the line were detected as well as the postures not suitable for the process.

Recommendations were made to the company's health and safety department for future production line and process design.

5. REFERENCES

Abepro M. et al. (2011), Ergonomia: Trabalhoadequado e eficiente, Brasil,: ABDR.

Buzzanca C, (1996), Ergonomia del trabajo, Madrid, España,: Reverte.

Castillo J. (2010), Ergonomía fundamentos para el desarrollo de soluciones ergonómicas, Bogotá D.C. Colombia,:Universidad del Rosario.

Cruz Gómez et al. (2004), Principios de Ergonomía, Bogotá D.C. Colombia,: Fundación Universidad de Bogotá.

Cuno P, et al. (1993), Estrategia empresarial: cómo implementar la estrategia en la empresa Madrid, España,: Ediciones Díaz de Santos.

Fuente D. (2008), Ingeniería de organización en la empresa: Dirección de Operaciones, Madrid, España,: Universidad de Oviedo.

Fabio S. et al, (2008), Rehabilitación en salud, 2.a edición, Colombia, :Universidad de Antioquia.

Galán José, (2014), Diseño ergonómico industrial, Madrid, España,: Ediciones Paraninfo, S.A.

García E. (2013), Procesos de producción: Una visión holística, Bogotá, Colombia,:Ilineata Publishing.

Gill J. et al, (2007), Ergonomía, Buenos Aires, Argentina,:Ediciones Granica S.Aç

Gil M, (2010), Ergonomía Industrial, Pozuclo de Alarcón, Madrid, España,:ESIC Editorial.

González D. (2007), Ergonomía y psicosociología, Buenos Aires, Argentina,:FC Editorial.

Llorca José et al. (2016), Manual de ergonomía aplicada a la prevención de riesgos laborales, Madrid, España,:Ediciones Pirámide.

Peñalba Sergioet al. (2002), Diseño: Teoría y Reflexión. Buenos Aires, Argentina,: Ediciones Díaz de Santos

Quiñonez Alberto, (2010), Estudio de tiempos y movimientos, México, D.F,: Asimag Servicios Empresariales.

Martínez D et al, (2005), La elaboración del plan estratégico y su implantación a través del cuadro de mando integral, Madrid, Espana,:Ediciones Díaz de Santos.

Mastretta G. (2004), Administración de los sistemas de producción, México D.F,:Editorial Limusa.

Mayer F, (2000), Estudios de tiempos y movimientos, California, Estados Unidos: Pearson Educación.

STATIC BIOMECHANICAL MODELS FOR POSTURE ANALYSIS IN PAINTING, SCULPTING AND ENGRAVING TASKS

Patricia Eugenia Sortillón González[1], Enrique Javier de la Vega Bustillos[2]

[1]Departamento de Ingeniería Industrial
Universidad de Sonora
Avenida Rosales S/N CP 83000
Hermosillo, Sonora, México
Corresponding author's e-mail: psortillon@industrial.uson.mx

[2]Instituto Tecnológico de Hermosillo
División de Estudios de Posgrado e Investigación
Avenida Tecnológico, Col. El Sahuaro
Hermosillo, Sonora, México
Corresponding author's e-mail: e_delavega@yahoo.com

Resumen: El propósito de este trabajo es plantear los modelos biomecánicos estáticos para el plano sagital de las tareas desarrolladas por los ejecutantes de las artes plásticas en las áreas de pintura, escultura y grabado, a propósito poder de realizar un análisis postural cuantitativo.

Palabras clave: Modelo, biomecánico, postura, arte

Abstract: The intention of this work is to develope the biomechanical models at the sagittal plane of the body, for the tasks performed by plastic artists in the areas of painting, sculpting and engraving, in order to provide an approach to perform a quantitative posture analysis.

Keywords: Biomechanical, model, posture, art

Relevance to Ergonomics: This work provides the static biomechanical models for a specific group of tasks: painting, sculpting and engraving, which are a basis to perform quantitative posture analysis.

1. INTRODUCTION

Body postures, refers to a set of body segments in a period of time (Chaffin et al, 1984), during the activities developed in an art activity, especially in those focused on painting, sculpting and engraving we observe a diverse posture, which can be explained by a static biomechanical model.

A static biomechanical model provides a quantitative evaluation of loads imposed by the body itself, as well as those imposed by the segment posture and its angular position, and also by the external forces acting on the body, due that the use of tooling.

A model that includes internal forces, is more complex, however, that complexity can be reduced if the analysis is focused on one spacial plane, as the saggital body plane. The biomechanical models for the painting, sculpting and engraving posture proposed in this work deals just with sagittal plane due the fact that most artists are right handed, so most posture is demanded in that side of the body.

Biomechanical models require to establish certain anthropometric variables, which includes: segment weight, segment mass-center, segment length, segment weight, body weight, body length, segment rotation angles, and the external forces acting over body.

2. OBJECTIVE

The objective pursued in this research is to develop the static biomechanical models for the tasks performed by artists from three different areas: painting, sculpting and engraving.

3. METHODOLOGY

In order to figure out the model, it was first performed an observational process of each area, for detecting all activities developed during art performance.

They were found the following tasks by area:

Painting: preparation of canvas, making the wood structure for canvas, painting any theme over canvas.

Sculping: preparation of ceramic mixes, making of molds, making of wood, ceramic sculptures.

Engraving: Engraving of a wood surface, press of engraved designs.

The described tasks were selected considering the time cycle and the frequency of realization of all observed activities in all areas as well as the tasks where a high frequency of load lifting was observed.

All selected activities were registered and tasks fully described, as well as, various positions taken during the development of task.

They were found six body segments which acts in all art tasks: neck, arm, underarm, trunk, hand and thigh. The first five are for the painting and engraving tasks and the six sets of body segments are suitable for performing the posture analysis on sculpting tasks.

The rotation angles of body segments considered for model have as reference the body vertical and they are measured counterclockwise.

Another important variable in the model is the rotation center, which is obtained by the projection of two adjacent body segments. Rotation center is known as body joint and it is shown in Figure 1:

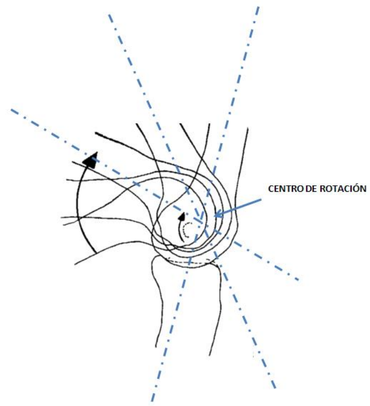


Figure 1. Rotation center

In the body we can find several rotation centers, as per Figure 2:

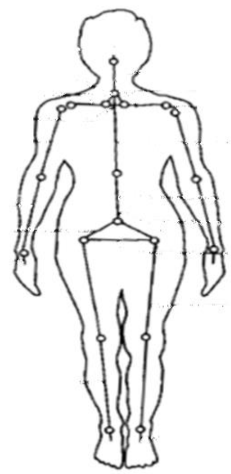


Figure 2. Rotation Centers in the Human body
(Occupational Biomechanics, John Willeys & Sons, Inc, 1984, USA)

The segment length can be estimated (2) using the following scheme, shown in Figure 3:

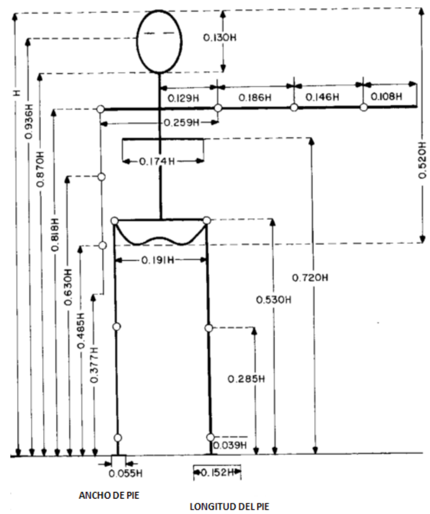
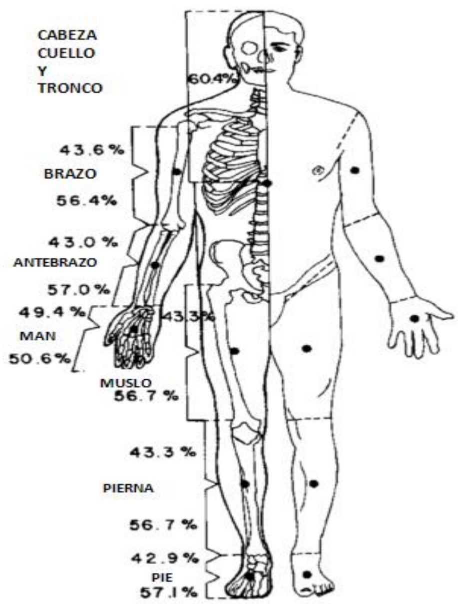


Figure 3. Standard Segment Lenghts
(Occupational Biomechanics, John Willeys & Sons, Inc, 1984, USA)

The segment length is estimated trough the percentages of human height (Drillis, 166), by multiplying the factor in the scheme by body height.:

Mass center, another variable in the biomechanical model is estimated using the figure No. 4 developed by Dempster (1955):



1

Figure 4. Mass Center Estimation
(Occupational Biomechanics, John Willeys & Sons, Inc, 1984, USA)

Scheme from Figure 4 shows the mass-center position for each body segment, so the relative position can be obtained according to percentages of segment length.

Segment weight can be calculated by multiplying approximate density values from Table 1 by volume and gravitational acceleration.

Table 1 Approximate Segment Density values
(Occupational Biomechanics, John Willeys & Sons, Inc, 1984, USA)

Segmento	Densidad (Harless 1860) g/cm3	Densidad (1955) g/cm3
Cabeza y cuello	1.11	1.11
Tronco	-	1.03
Brazo	1.08	1.07
Antebrazo	1.10	1.13
Mano	1.11	1.16
Muslo	1.07	1.05
Pierna	1.10	1.09
Pie	1.09	1.10

3.1Equipment and Materials

In order to do a deep observational process, it was required to make a 30 hours video for every art area, it was used a Sony HD video recorder HDRC405 handycam camcorder with floor support.

A 2.3 m by 3 m white screen, with a blue grill was placed behind the artist, and used as a support for blocking other ambiance elements, and in this way have a precise task observation.

All camera files were split into screen frames in order to perform a sagittal profile of tasks.

4.RESULTS

Two static biomechanical models were developed, one for painting and engraving and the other one for sculpting.

The two models are explained by using the same model variables, however, the model developed for sculpting includes the values associated for thigh.

Biomechanical model for painting and engraving is shown in figure 5:

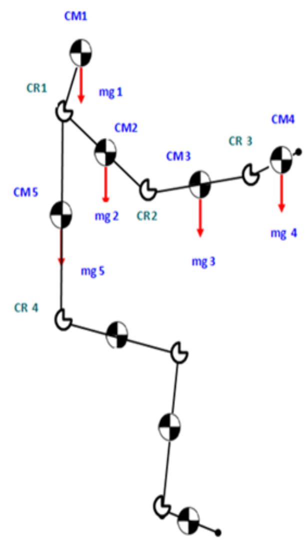


Figure 5. Biomechanical Model for Painting and Engraving Tasks

Biomechanical model for painting and engraving tasks considers five variables: mass center (CM), rotation center (CR), segment weights (mg), segment rotation angle and segment lenght, and there are five possible values for each variable, due to the five segments considered in painting and engraving tasks modeling.

Biomechanical model for sculpting includes the same five variables, but there are six possible values, due the fact, that for this model, there is another body segment: thigh, as shown in figure 6.

The sixth body segment has been included due to the fact that the sculpting tasks demand posture where there is a need for lifting heavy objects.

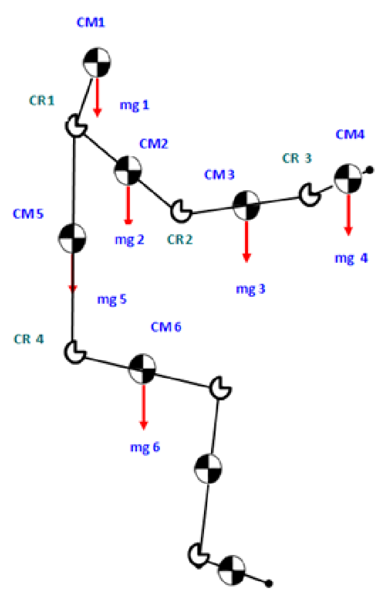


Figure 6. Biomechanical Model for Sculpting Tasks

5.CONCLUSIONS

Proposed models for painting, sculpting and engraving tasks, provide a quantitative approach to perform postures analysis. The results obtained open a new area of investigation for ergonomics, that is poorly studied, due that the fact that most researchs are focused on industrial labor than the art field, however, muscle-skeletal disorders has been found in artists labor and this a good reason to study. Ergonomics needs to open its study field to other labor areas such those related to art activity.

6. REFERENCES

Chaffin, Don B, Andersson, Gunnar B.J. (1984). *Occupational Biomechanics*. EE. UU.: John Willeys & Sons, Inc.

Dempster, W.T., (1955). Space Requirements of seated Operator, WADC-TR-55-137, Aerospace Medical Research Laboratories.

Drillis, R., R. Contini, (1966).Body segment parameter. New York University, New York: BP 174-945, *Tech. Rep. No.1166.03*, School of engineering and science.

Kroemer, H.E., Roebuck, J.A. , Thomson, W.G. (1975). Engineering Anthropometry Methods**,** *Wiley-Interscience, New York*, 77-128.

ERGONOMIC ANALYSIS FOR THE IDENTIFICATION OF CUMULATIVE TRAUMA DISORDERS IN COMPANY WORKERS OF FROZEN PRODUCTS IN GUASAVE SINALOA

Grace Erandy Báez Hernández, Jocelyne Murillo Pulido, Karla Y. Rivera Lugo, César O. Sandoval Cota

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

Corresponding author's e-mail: gracebaezh@gmail.com,jo_c_elyne@hotmail.com

Resumen: En el presente trabajo se muestran los resultados de un análisis ergonómico que se realizó en un proceso de producción de una empresa de productos congelados en Guasave, Sinaloa. Las actividades principales de la empresa es la elaboración de paletas de hielo y congelados. El estudio tiene como objetivo analizar las actividades del área de trabajo para la identificar los desórdenes de trauma acumulativo (DTA´s). Se analizaron los principios ergonómicos, así como la normatividad referente a las condiciones físicas del lugar. Todo esto con el propósito de identificar los riesgos y los DTA´s a los que están expuestos los trabajadores, y proponer soluciones a dichas problemáticas, para obtener un mejor ambiente de trabajo que proteja la integridad física y psicológica del trabajador. En la realización del estudio se contó con la participación directa del personal de la paletería, a los cuales se les aplicó distintos métodos de análisis ergonómicos, como el método *Corlett & Bishop*, en el cual se detectó las áreas del cuerpo donde los trabajadores presentaban dolores y molestias, así como un test de fatiga laboral. Se utilizó un software de simulación antropométrico llamado *Jack and Process Simulate Human,* para realizar un diseño propuesto del área de trabajo y observar como actuaría el trabajador en estas nuevas condiciones de trabajo.

Palabras claves: riesgos, ergonomía, congelados, trauma.

Abstract: The present work shows the results of an ergonomic analysis that was carried out in a production process of a frozen products company in Guasave, Sinaloa. The main activities of the company is the development of ice and frozen pallets. The study aims to analyze the activities of the work area to identify cumulative trauma disorders (DTAs). The ergonomic principles were analyzed, as well as the normative referring to the physical conditions of the place. All this in order to identify the risks and the DTAs to which the workers are exposed, and propose solutions to these problems, to obtain a better work environment that protects the physical and psychological integrity of the worker. In the realization of the study, there was a direct participation of the staff of the pallet, who were given different methods of ergonomic analysis, such as the method Corlett & Bishop, which detected areas of the body where workers presented pain And discomfort, as well as a labor fatigue test. An anthropometric simulation software called Jack and Process Simulate Human was used to make a proposed design of the work area and observe how the worker would act in these new working conditions

Keywords: risk, ergonomics, frozen, trauma.

Relevance to Ergonomics: Ergonomics contributes significant to the health of the workers thanks to the methods of ergonomic evaluation can achieve a significant improvement in production processes, greater productivity in workers. Achieving a safer working environment, reducing costs and above all improving the working environment. And the productivity of the workers.

1. INTRODUCTION

The productivity of workers is one of the most important factors when evaluating the productivity of the company (Móndelo, 2001). Ergonomics is about this, adapting work to the worker, and the use of ergonomic methods seeks to minimize injuries and ergonomic risks to have an optimal performance to develop their activities.

The Corlett & Bishop method is one of the ergonomic methods used in our analysis, we made revisions in the workers of our company at the beginning and the end of the work day, this to know how the employee feels, if he presents any discomfort, Pain or injury to determine the areas where these points are presented and thus to know if the worker already comes with some discomfort or stress from home or develops it during working hours.

2. OBJECTIVE

Analyze work area activities to identify workers cumulative trauma disorders (DTAs). Presenting a proposal for design improvement.

3. METHODOLOGY

The Company analyzed the work areas and identified cumulative trauma disorders, through the application of ergonomic principles and ergonomic evaluation methods. The research participants were two people, because they are on the ground and work up to 9 hours from Monday to Sunday. The study was developed in 3 phases:

The first part consisted of touring the facilities to visually detect the operations and processes that can lead the DTA's. As well as compliance with ergonomic principles.

The second phase focused on the application of a fatigue questionnaire and evaluation methods: CORLETT & BISHOP for two weeks.

The third phase was the analysis of methods and the application of general survey. Describing the physical characteristics of the workers, and detecting those activities that can impose excessive demands, a design proposal was presented in a simulation software of Jack and Process Simulate Human.

4. RESULTS

The results of the different methods used and the design proposal of the work area of this research.

4.1 First phase:

Ergonomics principles	Terms
Keep everything within reach	Not met, The materials are very separate. Because of not having a good distribution is wasted a lot of time in the process. Stretching is generated
Use elbow height as a reference	It is not fulfilled, since the height is 10 cm above the height of the elbow, and has many hours of work in that position.
Grip reduces effort	Fails. The grip of the tools and instruments of work are not appropriate generating excessive efforts in the wrists and fingers
Find the right position for each job	They do not fulfill, they do not correct positions crouching, and constant, with movement of load, like raising molds full of products. For long period
Minimize fatigue	They do not meet, because the establishment has several operations that are constant, handling loads and repetitive work and be exposed to low temperatures. And long hours.
Adjustment and change of posture	They do not comply, because you can not change the postures because it is part of the production process, with the proposed workstation design can remove one or two positions not suitable for the worker that cause DTAs.

Table 1. Table of results of Ergonomics principles that do not meet the conditions

4.2 Second Phase

Methods of Corlett &Bishop.

The Corlett & Bishop analysis was used for all workers in the Company to identify pain or discomfort, as Wells as a fatigue questionnaire.

	Entry of the worker 1	Entry of the worker 2	Exist of the worker 1	Exist of the worker 2
A	M		M	
B	M		M	
G	D	M	D	M
H	D	M	D	M
I	D	M	D	M
L	M	M	M	M
M	M	M	M	M

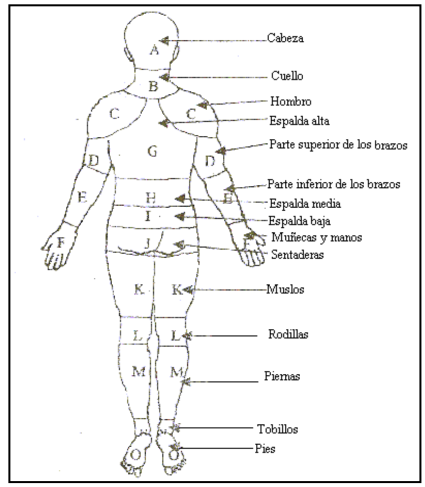


Table 2. Table of the results the Corlett & Bishop methods (Corlett & Bishop, 1976)

Figura1

Observations: Worker 1, with more seniority presented more pain, besides being the oldest.

Table 3. Table of results of work fatigue test.

	Workers 1	Workers 2
Sex	Male	Male
Working days per week	6 days	6 days
Study and work	No	No
Tiredness during work	yes	No
Age	60	30
Overworked condition	yes	yes
Type of ailment	Fatigue	Fatigue
Working hours	8-12	8-12
Working hours	8:00 am a 8:00 pm	8:00 am a 8:00 pm
Food before work	yes	No
Conveyance	Car	Car
Time to get to work	30 min	20 min

4.3. Third Phase

Based on the results of the tests carried out, a proposal for improvement was designed for the design of the work area using the Jack and Process Simulate Human software.

Figure 2. (Simulation of the proposed work area)

1. Posters
2. Better distribution of materials
3. Tables of greater height
4. Support in the liquid container
5. Air Extractor

5. CONCLUSIONS

It is know that the application of ergonomic methods and techniques in a Company is of great help, since with them they detect the possible risks and problems in the different areas of work, in which actions are taken to prevent them from occurring and affecting the Workers and that they can carry out their activities with the greatest possible confort. By having all these precautions the Company can save a lot of expenses that happen not to apply ergonomic principles or techniques like Corlett & Bishop, would have a higher productivity in their workers and therefore a higher quality in their processes.

6. REFERENCES

Barrientos-Gutiérrez, Tonatiuh, Martínez-Alcántara, Susana, & Méndez-Ramírez, Ignacio. (2004). Validez de constructo, confiabilidad y punto de corte de la Prueba de Síntomas Subjetivos de Fatiga en trabajadores mexicanos. Salud Pública de México, 46(6), 516-523. Consultado el día 14 de octubre del 2016. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0036-36342004000600006&lng=es&tlng=es

Idoate, García, V. (s.f.). *Aeeq*. Obtenido de Aeeq: www.aeeq.net/ponencias/m2_vmidoate http://www.ergocupacional.com/4910/99701.html

Móndelo P. "Ergonomía 3. Diseño de puestos de trabajo". Alfaomega grupo editorial, D. F. México. 2001

Nogareda, Cuixiart, S. (2001). *INSHT*. Obtenido de INSHT: http://www.insht.es/InshtWeb/Contenidos/Documentacion/FichasTecnicas/NTP/Ficheros/601a700/ntp_60.pdf

SEGOB. Norma de ventilación. Consultada el 06 de Noviembre del 2016. Recuperado de: http://dof.gob.mx/nota_detalle.php?codigo=4761393&fecha=19/07/1993

VALLEJO, José. Principios ergonómicos para el diseño de áreas de trabajo. Consultado el 26 de Noviembre del 2016. Recuperado de:

CONCIERGES OF SCHOOLS IN THE CITY OF LOS MOCHIS, SINALOA. A STUDY ON POSSIBLES CUMULATIVE TRAUMA DISORDERS (CTD'S)

José Alfredo Leyva Astorga, Alberto Ramírez Leyva, Gilberto Espinoza Moreno, Denisse Alejandra Rosas Cota.

Industrial Engineering department
M.I.E. Engineer and Professor
Institute Technologic of Los Mochis
Los Mochis, Sinaloa
jala641031@hotmail.com

Resumen: El trabajo desde la antigüedad constituye una de las áreas del desarrollo del ser humano, por lo tanto las condiciones en que esté inmerso el trabajador van a ser determinantes en su bienestar. Hoy en día las máquinas realizan más trabajos. Pero hay tareas que se deben hacer manualmente y que requieren un gran esfuerzo físico. Una de las consecuencias del trabajo manual, además del aumento de la mecanización, es que cada vez hay más trabajadores padecen dolores músculo-esqueléticos.

Las actividades que realizan los conserjes en las escuelas son distintas y el desempeño de sus labores se ha ido llevando a cabo de un modo intuitivo. Muchas de las tareas que realizan los conserjes requieren estiramientos, movimientos repetitivos, posturas incómodas y esfuerzos excesivos por sobrecarga de los miembros inferiores. Por ello el objetivo de la presente investigación, es identificar la exposición a los principales riesgos ergonómicos por ocupación y condiciones de empleo de los conserjes para evaluar si tienen o han desarrollado algún tipo de desorden de trauma acumulado (DTA´S).

Abstract: The Work from ancient times is one of the areas of human development, therefore the conditions in which the worker is immersed will be decisive in their welfare. Today the machines perform more jobs. But there are tasks that must be done manually and require great physical effort. One of the consequences of manual labor, in addition to increased mechanization, is that more and more workers are suffering pains musculoskeletal.

The activities that performed by concierges in schools are different and the performance of their work has been carried out in an intuitive way. Many of the tasks performed by concierges require stretching, repetitive motion, awkward postures and overexertion by overload of the lower limbs. Therefore the aim of this research is to identify the exposure to the main risks ergonomic by occupation and employment conditions of concierges to assess whether they have or have developed some kind of cumulative trauma disorder (CTD's).

Keywords: Ergonomics, risk factors, conditions working, physical exertion, and musculoskeletal disorders.

Relevance to Ergonomics: The research that has been done is important as providing ergonomic data of concierges from the city of Los Mochis, Sinaloa, is intended to determine control measures, and provide data obtained from the subjective method of Corlett and Bishop . That is why this article should be published as it contributes greatly to strengthen the main objective of ergonomics through its essential principles.

1. INTRODUCTION

The work performed by the concierges, is a monotonous and very tiring work, in which the body is forced; because they have to perform activities heavy of mopped, mapped, and cleaning in general, which leads to awkward postures, inadequate positions, among others. It is for this reason that evaluate the concierges of school in order to determine if they have or had some kind of CTD's.

2. OBJECTIVES

2.1 General objectives

Identify the exposure to the main ergonomic hazards by occupation and employment conditions of concierges to assess whether they have or have developed some kind of CTD's.

2.2 Specific objectives

- Identify symptoms and discomfort in the concierges.
- Analyze the work area and the conditions that affect the generation of injuries and CTD's

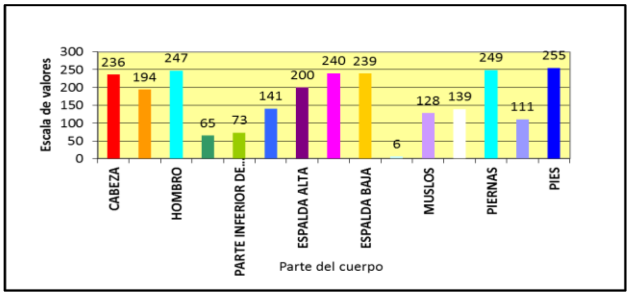
3. METHODOLOGY

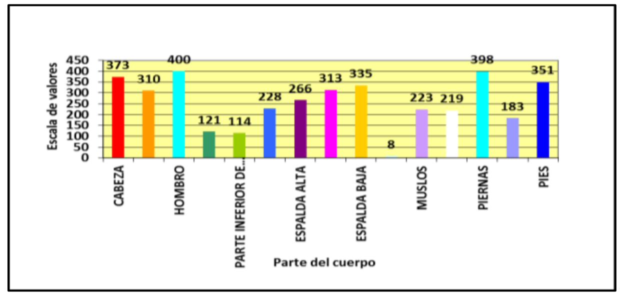
In the realization of the studyIn They are harvested data so directly collected by field research, through the method subjective of Corlett and Bishop, which will help the diagnosis of the risk level to confirm or rule out repetitive motion injuries also called cumulative trauma disorder (CTD's), with order to determine control measures, and obtain results that could be the basis for the development of the project.

To successfully achieve planned is selected a sample of 32 concierges of schools. The evaluation method Corlett and Bishop, was held at the start and end of the working day for a period of three weeks, finally It performeda general survey of the work activities to observe the influence that have the activities outside to workplace . Considering his age, sex, family, hours worked per day, antiquity, among others. Also, the workload will be analyzed.

4. RESULTS

After performing the evaluation methods Corlett and Bishop, it was observed that the areas of the body where concentrated greater pain are on the shoulders, legs, feet, upper back, middle and low, neck and head , being stronger at the end of the workday.

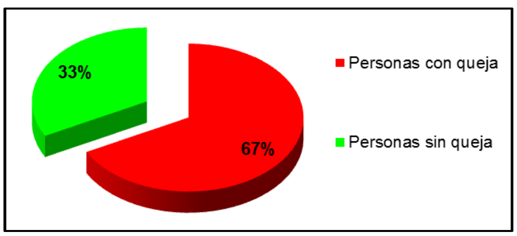




Graph 1. Number of complaint generals in time of entry.

Graph 2. Number of complaint generals in time of depart.

67% of the sample selected present complaints by discomfort and pain somewhere in your body, and 33% do not have present any complaints.



Graph 3. Percentage of general complaints within 3 weeks

The discomforts remain, in their majority, one day, but if nothing is done can result in a decline in job performance; without rest is this more exposed the pain increases and be more constant, this can bring serious consequences in the future as formations CTD's .

5. CONCLUSIONS

It can be concluded that the working tools are poorly designed, as they cause awkward postures, repetitive actions, among others, generate problems that can be solved quickly and at a low cost, because sometimes the changes ergonomic, however small, can greatly improve comfort, health, safety and worker productivity.

5.1 Recommendations

For reduce the risks ergonomics is required incorporating equipment and tools to help a the concierges, to make her tasks with less risk, since it was observed that almost always the person has to carry his things of work to other areas, it requires something essential that is the staff training in matter of ergonomics, handling and lifting loads, as well as conditioning the tools. This approach can help prevent injuries and physical or psychological diseases caused by lack of attention to the principles of the ergonomic.

6. REFERENCES

David J. Oborne. Ergonomía en acción: la adaptación del medio del trabajo al hombre, Ed. Trillas.

Formación: Caso de los conserjes del área metropolitana de caracas: Dayelis Daniela Ramirez, Inaki Mendizabal, Carascas.15 de octubre de 2009: De http://biblioteca2.ucab.edu.ve/anexos/biblioteca/marc/texto/AAR7080.pdf

Llaneza, F. J. (2006). Ergonomía y Psicosociología aplicada. España. Lex nova.

EFFECT ON THE INSERTION OF PUSH PINS WITH FULLY THICKNESS USING PSYCHOPHYSICS METHODOLOGY

Delcia Teresita Gamiño Acevedo[1], Enrique Javier de la Vega Bustillos[1], Ing. Alejandro Iván Coronado Ríos[2], Francisco Octavio Lopez Millan[1]

[1]Departamento de Ingeniería Industrial
Instituto Tecnológico de Hermosillo
Av. Tecnológico y Periférico poniente s/n
Hermosillo, Sonora 83170
Correo electrónico del autor: delciagam@gmail.com

[2]Planta FORD de estampado y ensamble
Hermosillo, Sonora
Mexico

Resumen: Se realizó un estudio donde se aplicó la metodología psicofísica a 14 mujeres, con una edad promedio de 20 años, 1.62 metros de altura y 64 kilogramos de peso, las cuales previamente estuvieron bajo entrenamiento de 4 días, realizando pruebas de inserciones, utilizando el dedo pulgar en jornadas de 8 horas a manera de entrenamiento, y un 5to día ya en conocimiento aplicado.

El objetivo del presente estudio fue determinar la máxima fuerza aceptable en la inserción de 1 a 4 componentes de sujeción (Push-pins) utilizando una férula de pulgar. Durante la investigación se analizaron 14 estaciones donde se realizan inserciones de push pins, en las cuales más del 90% están por encima del límite de esfuerzo aceptable, el cual es de 10 lb sin férula aplicando de 1 – 7 push pins y 7 lb de 8 – 12. La realización de este proyecto es para estudiar si la utilización de una férula para el dedo pulgar ayuda a aumentar la fuerza aceptable de inserción de 10 lb de 1 a 7 sujetadores push pins.

La metodología de investigación que se está utilizando, es la misma que ha estado utilizando Snook y Ciriello en sus investigaciones previas, que es por medio de una metodología psicofísica, en la que las personas que se van someter al experimento son entrenadas para que sean capaces por medio de percepción determinar cuál es la fuerza máxima que pueden soportar trabajando con la inserción de sujetadores, bajo ciertas condiciones en un periodo de 8 horas, sin que se sientan cansados, estresados, extenuados, fuera de aliento o débiles al final de un turno completo de actividad laboral.

Se pretende demostrar también la importancia de la utilización de férula al reducir lesiones y evitar gastos, permitiendo realizar un trabajo saludable y exitoso, en base a datos de referencia de fuerzas máximas aceptables.

Palabras Clave: Metodología psicofísica, fuerza máxima

HANDLING LIFTING MATERIAL, SPECIFIC FROM FLOOR TO WAIST, ITS BIOMECHANICAL IMPACT REDUCTION IN SPINE.

Lamberto Vazquez Veloz, Daniel Hurtado Laborin, Alejandra Francisca Valenzuela Gomez, Paul Alberto Munoz Luevano, Jose Gonzalo Valenzuela Gomez

Industrial Engineering Department
Instituto Tecnologico de Agua Prieta
Ave. Tecnologico and Road to Janos Chihuahua
Agua Prieta, Sonora, 84200
drlamberto@gmail.com, dlaborin2015@gmail.com

Resumen: Los sistemas de producción intermitentes por línea, mantiene un flujo operativo secuencial, que establece un ritmo cronológico de en la producción, lo que en conjunto a las exigencias en cuanto a calidad, flexibilidad en los productos, respuestas rápidas a cambios repentinos en las preferencias de los clientes y los vertiginosos avances en las tecnologías de información y comunicación, generan un conjunto de variables exógenas a los sistemas hombre – máquina, de un alto impacto negativo a la estructura anatómica, fisiológica y psicológica en el trabajador que desempeña su labor en este tipo de sistemas de producción.

Aunado a lo anterior, los trabajos que en su operatividad diaria requieren del levantamiento manual de cargas, en específico los que están relacionados con la altura definida como piso a la cintura, llevan consigo una mayor posibilidad de generar un Desorden Músculo Esquelético, debido principalmente a la mínima capacitación que se da en el levantamiento manual de materiales, a la alta repetitividad que se presenta en estas tareas, a la cantidad de peso que se requiere levantar y a la dinámica competitiva que se presenta en las industrias maquiladoras y manufactureras de exportación establecidas en el noroeste el Estado de Sonora.

La presente investigación establece un procedimiento que minimiza el efecto negativo del manejo manual de materiales, al proponer un mecanismo de acción pragmática, que perfila de manera correcta la alineación de la columna vertebral del trabajador y con ello se reduce la compresión de los discos intervertebrales afectados en el levantamiento manual de cargas.

Palabras clave: Biomecanica, levantamientos, piso-cintura.

Abstract: Intermittent production systems by line, keeps a sequential operating flow, which establishes a chronological rhythm in the production, that altogether the requirements in terms of quality, flexibility in products, quick responses to sudden changes in the preferences of customers and the rapid advances in information and communication technologies, generate a set of exogenous variables to systems man - machine , a high negative impact to the anatomical, physiological and psychological structure in the worker, which plays its role in this type of production systems.

In addition to the above, work which in its daily operations require the manual lifting of loads, in particular those who are related to the height defined as floor - waist, they carry with them a greater chance of generating a muscle skeletal disorder (DME´s), mainly due to the minimum training that is given in the manual lifting of materials, to high repetitiveness that occurs in these tasks the amount of weight that is required to lift and the dynamic competitive arising in the maquiladora industries and manufacturing of export established in the northeast of the State of Sonora.

This research establishes a procedure that minimizes the negative effect of the manual handling of materials, to propose a mechanism for pragmatic action, which outlines proper alignment of the spine of the worker and thereby reduces the compression of the intervertebral discs in the manual lifting of loads.

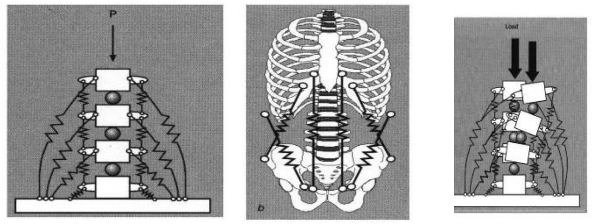
The results developed in the work are supported by the experiential analysis of the operations of uprising, direct observation of the object of study and of the statistical basis of the comparisons in the results. Presenting the substantial improvements in the decompression of the intervertebral discs of the workers who applied the procedure.

Key words: Biomechanics, lifting, floor-waist.

Relevance to ergonomics: This research establishes a procedure that reduces the impact Biomechanics of manual lifting materials, specific to the height defined as floor - waist. The above keeps ergonomic relevance since the procedure carries with it the decompression of the intervertebral discs of the worker, reducing the possibility that presented a skeletal muscle disorder and increase operator productivity. Guidelines aimed at improving the operations of the human factor that impacts and interacts consistently with the pragmatic objectives of ergonomics.

1. INTRODUCTION

The human spine is a rigid structure, which allows to support pressures, and elastic which gives a wide range of mobility (Mihaila and Slicaru, 2014). These two concepts are competing, but over evolution have convoluted, and the result is a suitable balance to support and mobility needs. This almost perfect balance is achieved by muscular, aponeurotic and mixed systems of protection. When the column is no longer stable and the pain these systems should be checked and is normally observed that one or more are failing, picture 1 shows schematically the alignment and misalignment of the spine.



Picture 1: Scheme of the spine aligned and when misalignment occurs (Mihaila and Slicaru, 2014).

Postural load that keeps the spine consists of a multi-factorial set that includes the weight of the person, the burden of lift or transport, shape and structure of load, posture in which develop the task the operator and among others the repetitiveness of movements you make. This produces a compression of the intervertebral discs of irregular shape. What causes that it referred to as intervertebral pad, loses hydration and strength, being thus able to generate a herniated disk and cause pressure on nerves system.

The manual lifting of materials, which develops from the floor - waist, establishes an impact negative biomechanical spinal cord of workers, reflected mainly in the lumbar area, and maintains a high possibility is presented a skeletal muscle disorder (DME´s), this is mainly due to the posture, strength and frequency that carry this type of tasks.

The main effect that arises is axial misalignment of the trunk, causing an asymmetrical compression pad intervertebral, generating a pressure of the nucleus pulposus on the Tash fibrous ring with a greater intensity in one area, resulting in premature wear in its elasticity and functionality. The objective of this research is to design an alignment procedure non-invasive that reduces the impact of the manual lifting of materials, those related to the height of the floor - waist of the operator. It applies the pragmatic action of an ergonomic machine to decompress the intervertebral disc and a procedure that measures the deviations of the backbone of the workers on its central axis of rotation. Statistical analysis of measurements includes two stages, one before the action of the machine and the other then compared through statistical procedures the discrepancies between the first and second measurement. Of this to see the effect of the action of the machine.

1.1 General objective:

Designing an alignment procedure non-invasive that reduces the impact Biomechanics of the materials, manual lifting those related to the height of the floor - operator waist.

1.2 Specific Objetives:

1. Develop the theoretical framework of research from the study of the impact Biomechanics of manual lifting materials, specific height-related floor - waist; epidemiological evidence of the DME´s, with greater emphasis on

the lumbar area; risk factors and alternatives for the alignment of the spine.
2. Developing phases of the procedure alignment noninvasive that reduce the impact Biomechanics of the materials, manual lifting height-related floor - waist.
3. Validate the procedure from concurrent evaluation of measurements developed statistical methods.

2. DELIMITATION

The investigative work was developed in the maquiladora industry and export manufacturing, located in the northeast of the State of Sonora, specifically in those production lines flashing with flows into line, as per their own requirements was of incipient need the manual lifting materials, in those referenced to the floor height - waist.

At the same time, the preliminary study developed manages to identify that tasks that carry with them the need for a manual lifting of materials and that these are made in the distance between the floor and the waist, maintain a high probability of generating a skeletal muscle disorder in the lumbar area of the spine.

Research generates a data platform, which found a variety of complex situations for the health of the operator and the yield of the workstation. This is caused mainly by the impact biomechanical generated in the spinal column manual lifting materials.

The proposal is to conduct pragmatic action of a machine developed for the decompression of the intervertebral disc, which reduces significantly the negative impact of the rising and generates an axial alignment of the column. With this operator reduces the possibility of generating a lumbar injury.

3. METHODOLOGY

The application of the procedure in the field was developed as the figure 1, being structured in 3 steps, then developed methodological action:

The first step establishes the characteristics and requirements for the ergonomic design of the machine, required for decompression of the intervertebral disc. This process includes analysis of the anthropometric characteristics of the population under study, the structure Biomechanics of interaction between operator and machine, the aspects relating to the mechanics of the movement of the machine and the permissible limits of the movement.

The conditions that characterize how ergonomic machine include four important aspects: the position that must be the operator for the decompression of the intervertebral disc and the maximum time allowed. The range of motion that the user of the machine must have to achieve the goal of decompression. The repetitiveness with which the movement for decompression should be. The levels of adjustment required so to minimize the distance between the position of the operator and the neutral position of the same, to achieve a positive effect in decompression. The machine with the central objective for the decompression of the intervertebral disc of the study population was designed with these features.

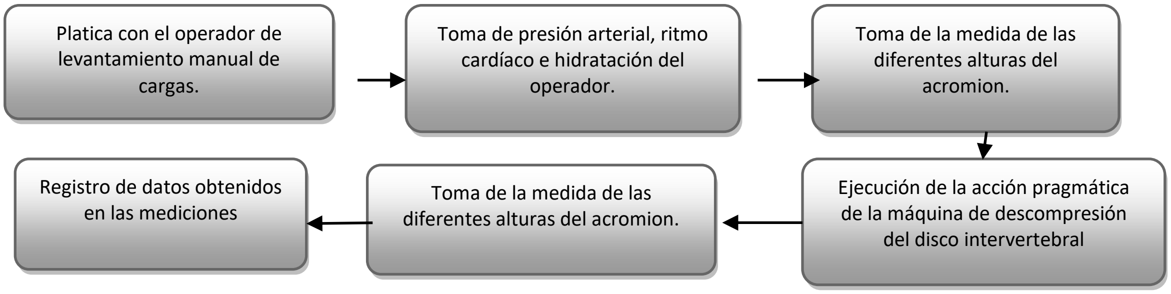


Figure 1: Flow of action for the implementation of the procedure for decompression.

In the second step of the methodological development is established a mechanism of measuring deviation of the spine on its axis of rotation. This mechanism is addressed with the scientific principles of the posturology evaluation (Vazquez, 2016). Picture 2 shows the measurement procedure.

Pic 2: Measurement and procedure template to measure the spine deviation.

Once developed measurement and pragmatic action of decompression machine processes, analyzes the workstations where carry out tasks of manual lifting of materials and make its height from the floor to the waist of the operator. Picture 3 shows the pragmatic action of intervertebral disc decompression machine.

With this information, it carries out measurement of the heights of the acromion's of the operators that perform the lifting, back to this, the pragmatic action takes place from the machine and again measurement of the heights of the acromion's, at the same time establishing a relationship between this type of work and the skeletal muscle lesions, referenced to the lumbar area of the worker.

Pic 3: Action of the machine for decompression of the intervertebral disc (patent pending).

The third step is to establish the mechanism for validation of the results that this procedure.

4. Results

So far, there have been 30 applications of the procedure, of which 84% showed a decrease of misalignment of the heights of the acromion with respect to the horizontal reference axis and only the remaining 26% presented an absolute increase of axial deviation of the acromion. Table 1, shows the results obtained in the implementation of the procedure.

Table 1: Data obtained in the application of the procedure for decompression of the intervertebral discs.

ALINEACIÓN DE LA COLUMNA INTERVERTEBRAL EN PROCEDIMIENTO PISO-CINTURA												
DATOS DEL PACIENTE						ANTES DEL PROCEDIMIENTO			DESPUES DEL PROCEDIMIENTO			RESULTADO
EDAD	ALTURA	PESO	sexo	FRECUENCIA	PESO DE LEVANTAMIENTO	ACROMION IZQUIERDO	ACROMION DERECHO	DIFERENCIA	ACROMION IZQUIERDO	ACROMION DERECHO	DIFERENCIA	ACROMION - ACROMION
22	1.76	73	M		30	1.9	2.1	0.2	1.6	1.6	0	0.2
20	1.74	79	M		30	1.6	2.6	1	3.5	4.5	1	0
21	1.69	94	M		40	0.3	0.8	0.5	0.7	0.9	0.2	0.3
20	1.65	72	F		16	1.5	2.8	1.3	2	3	1	0.3
22	1.9	82	M		30	2.5	2.9	0.4	2.6	3.5	0.9	0.5
58	1.67	79	m		30	2.9	0.7	2.2	3	2.5	0.5	1.7
51	1.73	205	m		40	1.8	2.9	1.1	2	1.8	0.2	0.9
24	1.72	85	m		50	0.5	-1	1.5	0	0.5	0.5	1
34	1.72	72	M		50	0	2.2	2.2	0	1.7	1.7	0.5
45	1.66	88	M		50	1.8	-0.5	2.3	1.8	0.3	1.5	0.8
26	1.76	96	M		50	2.7	2.3	0.4	2.3	2.3	0	0.4
23	1.7	73	M		30	1.5	2.3	0.8	1.5	1.5	0	0.8
51	1.8	105	M		40	0.3	0.6	0.3	0	0.6	0.6	0.3
33	1.73	83	M		30	3	3.4	0.4	3.5	3.6	0.1	0.3

To sustain statistically differences in measurements, a set of tests were conducted to verify the existence of a statistically significant difference between the two measurements (Meaney and Moineddin, 2016). The first test that was conducted, is to verify if the two data sets behave in a normal way in its distribution, the test was performed with a confidence level of 95%. Table 2 shows the normality test applied to the two objects of study populations. The test statistics show that they are higher than those established by the error condition, defined as 0.05, which statistically valid that the two populations behave normally. This is ability to generate the statistical test that allows us to recognize that population has not been applied to which action of the machine maintains a greater difference in the height of the acromion`s, that that has been the action of the machine.

It is important to mention that statistical tests were performed considering that populations are paired (paired), because of the way in which were in the experimental preparation.

Table 2: test of normality for the two populations under study.

	Kolmogorov-Smirnov test			Shapiro-Wilk		
	Statistic	Mexico City	*GIS.*	Statistic	Mexico City	GIS.
Difference of acromion's before the action of the decompression machine	.107	30	.200	.965	30	.423
Difference of acromion's after the decompression machine action	.156	30	.061	.945	30	.122

For the statistical test raises the null hypothesis H_0: there is no significant difference between the population prior to the implementation of the procedure and after the application of the procedure. Being the alternative hypothesis H_1: the population before the application of the procedure maintains a greater difference in the heights of the acromion's that after the implementation of the procedure. It is important to mention that the statistical test is defined as evidence of a single queue, since we are looking for statistical evidence that a population is higher before than after the application of pressure relief. Figure 2 shows the results of the statistical tests and critical values of rejection and acceptance.

Paired T-Test and CI: Diferencia de ac, Diferencia de ac

```
Paired T for Diferencia de acrominoes antes - Diferencia de acromion después
                      N      Mean      StDev     SE Mean
Diferencia antes     30   0.946667   0.864125   0.157767
Diferencia después   30   0.516667   0.563905   0.102954
Difference           30   0.430000   0.643884   0.117557
        95% lower bound for mean difference: 0.230257
T-Test of mean difference = 0 (vs > 0): T-Value = 3.66  P-Value = 0.001
```

Figure 2: Results of the statistical tests performed to study populations.

Statistical tests show its Pvalue that H_0 is rejected and accepted H_1, by what is defined statistically that the two populations are different and at the same time the population has not been applied which pragmatic action of the machine maintains a greater misalignment in the acromion, the population that was applied pressure relief.

This reflects the positive effect of the action of the machine on the compression of the intervertebral disc of the workers who carry actions of manual lifting of loads, in particular at the height of floor - waist and at the same time emphasizes the reduction of the impact Biomechanics of the manual lifting on the spine of the worker.

5. CONCLUSIONS

In Mexico, the effort to decrease muscle skeletal disorders of occupational origin, mainly focused on preventive, corrective, ergonomic measures procedures ergonomic for the handling of loads, the use of lumbar supports and the maximum permissible weight calculations it has not had the necessary effect, on the other hand, it marks a trend in the increase of this type of complications. For what it is necessary to complement these strategies with a focused procedure to occupational therapy non-invasive, which together present a substantial improvement of the position of the worker, from the intervertebral disc decompression.

The procedure established in the present investigation intervertebral disc decompression, carries three important moments, the first is measured where the existing misalignment between the two acromion’s of the worker who carries in its daily work the manual lifting of loads; a second moment is the pragmatic action of the so-called machine JVC Shaking; a third time where again is the measurement of the heights of the two acromion’s with respect to the horizontal and the comparison between the first and second measurement is conducted.

The application of the procedure is carried out in production processes with workflows online, specifically in the manual lifting of materials at the height of the floor - waist. Finding that this kind of task generates a misalignment of the spine and a higher compression of the nucleus pulposus on a specific area of the Tash fibrous ring. What keeps a high possibility of generating a DME´s.

The action of the procedure has been validated through a set of statistical evidence that allows us to establish, that the pragmatic action of the machine generates a considerable decrease in the misalignment of the acromion’s, thereby generating a lower and equal compression of the vertebrae on the intervertebral discs. With the previous support is set to the alignment procedure not invasive reduces the impact Biomechanics of the manual lifting of materials at the height of the floor - waist.

6. REFERENCES

Meaney, Ch and Moineddin R. (2016). "Text mining describes the use of statistical and epidemiological methods in published medical research". Journal of clinical epidemiology , 74, 124-132.

Mihaila, Roxana; Slicaru Adina. (2014). "Spine Functionality - General Methodological Problems and Electromyography as a Method of Investigation". Procedia-Social and Behavioral Sciences, 117, 588-596.

Vazquez, L. et al. (2016, April). "Analysis and measurement of intervertebral discs deviation caused by manual material handling". In book of memories XVIII International Congress of ergonomics, ergonomics occupational research and applications, 9, 389-393. ISBN 978-0692-66972-3. Tijuana, BC.

Vazquez, Lamberto. (2012). "Contribution to the evaluation of the productive performance and health of the worker, in the manual Assembly of the maquiladora industry in northeastern Sonora, Mexico". Director: José Manuel Pozo. Thesis of doctorate, Universidad de La Habana, Ciudad de La Habana.

DIAGNOSIS OF THE MECHANICAL RISK FACTOR

Javier Nava García, Raquel Muñoz Hernández

[1]*División de Ingeniería Industrial*
Tecnológico de Estudios Superiores de Coacalco,
Avenida 16 de Septiembre 54, Cabecera Municipal,
Coacalco de Berriozábal, México, C.P. 55700

[2]*División de Ingeniería Industrial y de Sistemas.*
Universidad Politécnica del Valle de México.
Av. Mexiquense s/n, Col. Villa Esmeralda,
C.P. 54910, Tultitlán, Estado de México

[1]*javinavag@hotmail.com,* [2]*jael2222@hotmail.com*

Resumen: Los accidentes en el trabajo con máquinas pueden ser por contacto o atrapamiento en partes móviles y por golpes con elementos de la máquina o con objetos despedidos durante el funcionamiento de la misma, de aquí que las lesiones sean, principalmente, por alguno de estos motivos: aplastamiento, cizallamiento, corte o seccionamiento, arrastre, impacto, funcionamiento, fricción o Abrasión y proyección de materiales. Un riesgo es la probabilidad de ocurrencia de un evento, que pueda causar daño en la salud de una persona y/o en los procesos de producción de una industria, cuando no existen o fallan los mecanismos de control. En cualquier proceso de producción que implique el uso de maquinaria se generan riesgos mecánicos al personal, por lo cual es de vital importancia eliminar la probabilidad de ocurrencia de estos y de esta forma asegurar la salud e integridad del personal de las industrias. En muchas ocasiones las personas que trabajan, sufren lesiones y mutilaciones en su cuerpo e incluso llegan a perder la vida a causa de las interacciones de trabajo con sus máquinas o equipos.

Palabras clave: *Máquinas, riesgo, accidentalidad.*

Relevancia para la Ergonomía: Se puede concluir que la oportuna intervención de la Ergonomía es de vital importancia, ya que lo primordial es la integridad de los seres humanos, además de que al brindarle mejores condiciones de seguridad, los empleados se sentirán más motivados a trabajar y mejoraran su productividad en las plantas de producción.

Abstract: Accidents at Work machines can be contact or entrapment in moving parts and blows with machine elements or fired during the operation of the same objects, hence the lesions are mainly for one of these reasons: crushing, shearing, cutting or sectioning, dragging, impact, performance, friction or abrasion and projection of materials. A risk is the likelihood of an event that can cause damage to the health of a person and / or production processes of an industry, or fail when there are control mechanisms. In any production process involving the use of machinery mechanics personnel risks arise, so it is vital to eliminate the probability of occurrence of these and thus ensure the health and integrity of the staff of industries. Often people who work, suffer injuries and mutilations in your body and may even lose their lives because of interactions working with machinery or equipment.

Keywords: Machines, risk, accident.

Relevance to Ergonomic: It can be concluded that the timely intervention of Ergonomics is vital because the bottom line is the integrity of human beings, besides that provide better security, employees will feel more motivated to work and improve their productivity production plants.

1. INTRODUCTION

The project is developed in a ceramic product company with high dimensions, where the workers must carry out the packing of the pieces manually and only have hand tools, and have had the highest accident rates; So I called the attention to the area of packaging for presenting the highest risks within the company object of this study, having within the risks the placement of tacks and staples using the mouth generating mechanical risks.

Mechanical risk is understood as the set of physical factors that can give rise to an injury by the mechanical action of elements of machines, tools, pieces of work or projected materials, solid or fluid. (Rodríguez, 1991).

The machine concept comprises all those sets of elements or installations that transform energy with a view to a main or auxiliary productive function. It is common for machines to have at some point or zone concentrations of energy, either kinetic energy of moving elements or other forms of energy (electric, pneumatic, among others). (UC3M, 2017).

We can differentiate the whole of a machine into two parts: Transmission system: set of mechanical elements whose mission is to produce, transport or transform the energy used in the process. This part of the machine is characterized in that the operator must not penetrate them during production operations. Operating area (or point of operation): This is the part of the machine on which the useful work on a part is executed, by means of the energy.

That the transmission system communicates to the active element of the machine. This zone is characterized in that the operator must penetrate in it in the normal operations of feeding, extraction of pieces, or if it is automatic process, to correct deficiencies of operation. (UC3M, 2017).

The elementary forms of mechanical risk are the danger of shearing: this risk is located at points where the edges of two objects are moved close enough to one another to cut relatively soft material. Many of these points cannot be protected, so be especially careful when operating because in many cases the movement of these objects is not visible due to the high speed of the same. The resulting injury is usually the amputation of a limb. (UC3M, 2017).As can be seen in Figure 2.

Figure 1. Packing area
Source: Own creation propia.

Danger of entrapment or drag: It is due to zones formed by two objects that move together, of which at least one, rotates as is the case of feed cylinders, gears, transmission belts. The parts of the body that are most at risk of being trapped are the hands and the hair, it is also a cause of the trapping and dragging of the work clothes used, so to avoid it you must wear tight clothing to avoid being caught and Protect the areas close to rotating elements and you should wear your hair collected. (UC3M, 2017).

Crush Hazard: Crush hazard areas occur mainly when two objects move one over another, or when one moves and the other is static. This risk mainly affects the people who help in the hooking operations, being trapped between the machine and implement or wall. Hand and finger injuries are also often injured. (UC3M, 2017).

Solid: Many machines in normal operation expel particles, but among these materials can be introduced strange objects such as stones, branches and others, which are launched at high speed and could hit the operators. This risk can be reduced or avoided with the use of shields or baffles. (UC3M, 2017).

Of liquids: The machines can also project liquids as those contained in the different hydraulic systems that are able to produce burns and reach the eyes. To avoid this, hydraulic systems must have adequate preventative maintenance which includes, among other things, checking the condition of pipes to detect the possible presence of pores in them. The projections of fluid under pressure are very common. (UC3M, 2017).

Other types of mechanical hazards produced by the machines are the danger of cutting, disconnection, hitching, impact, punching, punching and friction or abrasion. (UC3M, 2017).

The mechanical risk generated by parts or parts of the machine is fundamentally conditioned by its shape (sharp edges, sharp parts), its relative position (since when parts or machine parts are in motion, they can cause areas of entrapment, crushing, Shear.).

Its mass and stability (potential energy), its mass and velocity (kinetic energy), its mechanical resistance (at break or deformation) and its accumulation of energy (by springs or pressure deposits) Of this risk, a gun operated under compressed air pressure, which exerts the functions similar to those of a staple of tacks, as shown in the following figures, as can be seen in Figure 2.

Figure 2. Packing area.
Source: Own creation .

It was also possible to detect that in the internal part of the warehouse there are electrical installations like light meters, which had a short circuit, due to the energy cuts caused by the rains and floods, and there is a risk of greater intensity due to the quantity Of flammable chemicals such as tinner and turpentine used in the wood material with which the products are packaged and that at that time they were in place. (Ramirez, 2010).

2. OBJECTIVES

Diagnosis of the mechanical risk factor, recommendations and design of solution alternatives at the system level of the most critical machines in the metalworking companies.

3. METHODOLOGY

3.1. Characteristics of the study

It is observed that for the risks noise, dust, forced positions and manual movements of load it is necessary to evaluate the ergonomic conditions to later implement corrective and preventive measures.

It is observed that short-term prevention measures need to be implemented for illumination, falling objects and people, kinks, cuts, blows, electricity, entrapment, eye injuries, explosions and fires. (Zinchenko, 1985).

The development of the project begins with the identification of the respective machines to work in each one of the sections that are at the moment with a high degree of mechanical risk. In identifying the machines, the identification of the needs of the operators and the company is continued; For this, activities such as operator interviews, accident information in companies, risk assessment and diagnosis of each machine are carried out. (Salmerón, Fajardo & Cañas, 2004).

Subsequently begins the stage of generation, testing and selection of concepts that are based on the analysis obtained in the identification of needs and general ideas of solution. Finishing with the environmental assessment.

It is also very important to analyze the environmental conditions in which people perform their daily tasks, for which a survey was also carried out.

The information obtained will help to understand and detect that sector of the company that needs more attention.

3.2. Method

Ergonomic risk assessments were carried out through the METRIX System to determine the level of risk to which workers are exposed with the following methods:

1.- PLIBEL
2.- GME
3.- NIOSH
4.- FCD

It was also observed that the greater the inexperience, the greater the accidents, so that the evaluation of the Learning Curve was carried out, for the adequate distribution of the tasks.

Likewise, the environmental conditions were measured, finding the ones with the most relevance and impact in the performance of the functions and that can cause health risks or accidents.

4. RESULTS

A continuación se muestran los Reportes por Método arrojados por el Sistema METRIX VR:

GME
Gasto Metabólico de Energía

Metrixx VR

DATOS GENERALES
Tarea: Cortadora
Descripción de la tarea: Cortadora de varilla de acero
Analista: Equipo ergonómico
Fecha: 02/02/2017

MEDICIÓN Y VARIABLES
SEXO: MASCULINO **EDAD:** 30 años **DURACIÓN DE LA TAREA:** 1.3 min
MOVIMIENTO DE BRAZOS Y MANOS: Dentro de los 50 centímetros
DISTANCIA PROMEDIO CAMINADA POR MINUTO: 0 m

EJECUCIÓN DE LA TAREA
PESO DEL OBJETO: 450 kg
CICLOS POR MINUTO: Menos de 2 ciclos por minuto

TAREA EMPUJAR/JALAR/CARGAR
FUERZA PROMEDIO EN KGS: 5 kg
DISTANCIA PROMEDIO CAMINADA POR MIN: 0 m

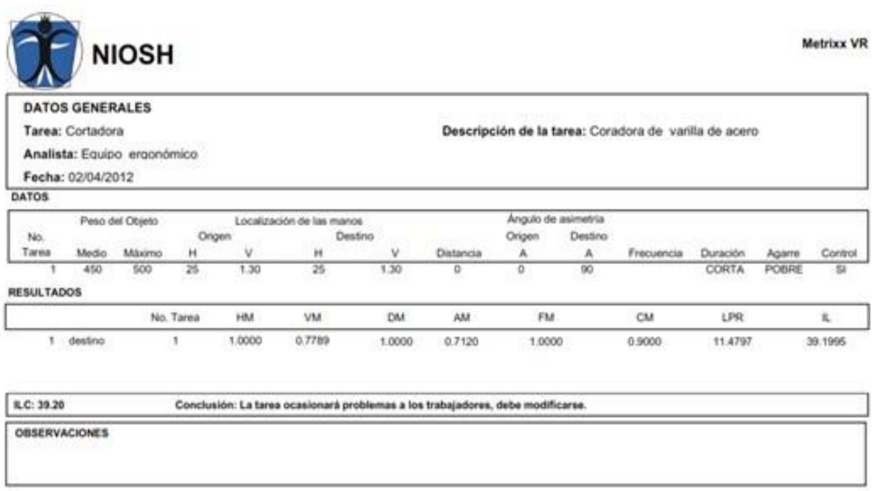
RESULTADOS

GASTO METABÓLICO REQUERIDO POR EL TRABAJO:	2.59 kcal/min
CAPACIDAD DEL TRABAJO FÍSICO DEL TRABAJADOR:	20.38 kcal/min
TIEMPO MÁXIMO ANTES DE QUE EL TRABAJADOR SE FATIGUE(MIN):	0 minutos
TIEMPO DE RECUPERACIÓN REQUERIDO POR EL TRABAJADOR (MIN):	0 minutos

RECOMENDACIONES
Que el método de trabajo no se modifique, ya que no representa ningun riesgo para el trabajador.

OBSERVACIONES
Debido a que la pieza en la que realiza el corte, es muy ligera, realmente no representa algun riesgo para el trabajador.

Figura 3. Método GME.
Fuente: Creación propia.



NIOSH

Metrixx VR

DATOS GENERALES
Tarea: Cortadora
Descripción de la tarea: Coradora de varilla de acero
Analista: Equipo ergonómico
Fecha: 02/04/2012

DATOS

No. Tarea	Peso del Objeto Medio	Peso del Objeto Máximo	Localización de las manos Origen H	Origen V	Destino H	Destino V	Distancia	Ángulo de asimetría Origen A	Destino A	Frecuencia	Duración	Agarre	Control
1	450	500	25	1.30	25	1.30	0	0	90		CORTA	POBRE	SI

RESULTADOS

		No. Tarea	HM	VM	DM	AM	FM	CM	LPR	IL
1	destino	1	1.0000	0.7789	1.0000	0.7120	1.0000	0.9000	11.4797	39.1995

ILC: 39.20 **Conclusión: La tarea ocasionará problemas a los trabajadores, debe modificarse.**

OBSERVACIONES

Figura 4. Método NIOSH.
Fuente: Creación propia.

FCD
Fuerza compresión de disco

Metrixx VR

DATOS GENERALES
Tarea: Cortadora — **Descripción de la tarea:** Cortadora de varilla de acero
Analista: Equipo ergonómico
Fecha: 03/04/2017

DATOS

PESO DE LA PERSONA	73 kg.
ESTATURA DE LA PERSONA	1.73 m.
PESO DEL OBJEO	.450 kg.
ÁNGULO DEL TRONCO	20 grados
ÁNGULO DEL BRAZO	61 grados
ÁNGULO DEL ANTEBRAZO	95 grados

RESULTADO

FUERZA COMPRESIÓN DE DISCO	132.43 kg.

CONCLUSIONES
EL LEVANTAMIENTO NO ES RIESGOSO PARA EL OBRERO

OBSERVACIONES
De acuerdo a los resultados obtenidos, el operador no realiza esfuerzo de FCD, ya que el peso del objeto es poco.

Figura 5. Método FCD
Fuente: Creación propia.

PLIBEL
Evaluación de puestos de trabajo

Metrixx VR

DATOS GENERALES
Tarea: Cortadora — **Descripción de la tarea:** Cortadora de varilla de acero
Analista: Equipo Ergonómico
Fecha: 10/04/2017

PUNTUACIONES

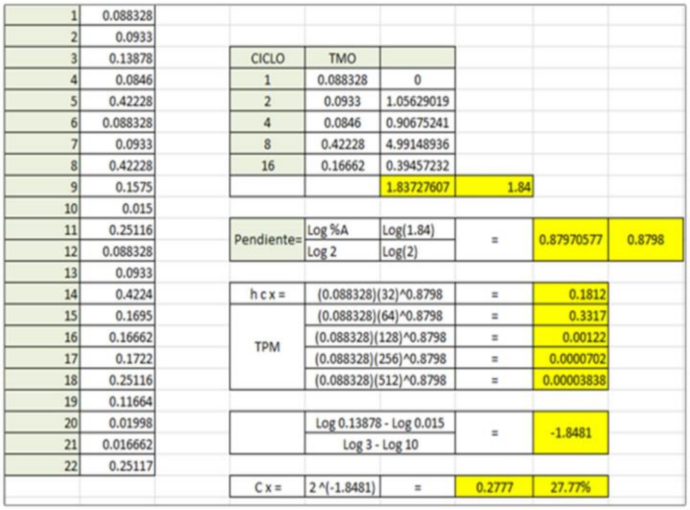
	CUELLO, HOMBRO Y PARTE ALTA DE LA ESPALDA	CODO, ANTEBRAZOS Y MANOS	PIES	RODILLAS Y CADERAS	ESPALDA BAJA
TOTAL SI'S	18	5	2	2	12
PORCENTAJE	69 %	56 %	25 %	25 %	57 %

CONCLUSIONES
Total de Si's: 39 ,mientras mas Si's obtenga mas riesgoso es el trabajo, debe tratar de disminuir el número de Si's en su trabajo para evitar lesiones.

OBSERVACIONES
En esta operacion se efectuan movimientos repetitivos, en las que el operador se encuentra de pie, es recomendable utilizar un tapete de descanso, ya que permanece asi largos periodos de trabajo. Tambien es importante concider ar la distancia que tiene del material hacia la maquina, es

Figura 6. Método PLIBEL.
Fuente: Creación propia.

.



1	0.088328							
2	0.0933							
3	0.13878		CICLO	TMO				
4	0.0846		1	0.088328	0			
5	0.42228		2	0.0933	1.05629019			
6	0.088328		4	0.0846	0.90675241			
7	0.0933		8	0.42228	4.99148936			
8	0.42228		16	0.16662	0.39457232			
9	0.1575				1.83727607	1.84		
10	0.015							
11	0.25116		Pendiente=	Log %A	Log(1.84)	=	0.87970577	0.8798
12	0.088328			Log 2	Log(2)			
13	0.0933							
14	0.4224		h c x =	(0.088328)(32)^0.8798		=	0.1812	
15	0.1695		TPM	(0.088328)(64)^0.8798		=	0.3317	
16	0.16662			(0.088328)(128)^0.8798		=	0.00122	
17	0.1722			(0.088328)(256)^0.8798		=	0.0000702	
18	0.25116			(0.088328)(512)^0.8798		=	0.00003838	
19	0.11664							
20	0.01998			Log 0.13878 - Log 0.015		=	-1.8481	
21	0.016662			Log 3 - Log 10				
22	0.25117							
			C x =	2 ^(-1.8481)	=	0.2777	27.77%	

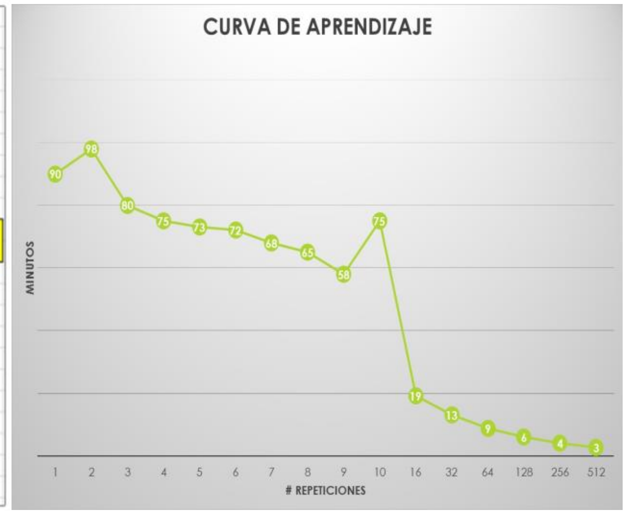


Figura 7. Curva de Aprendizaje.
Fuente: Creación propia.

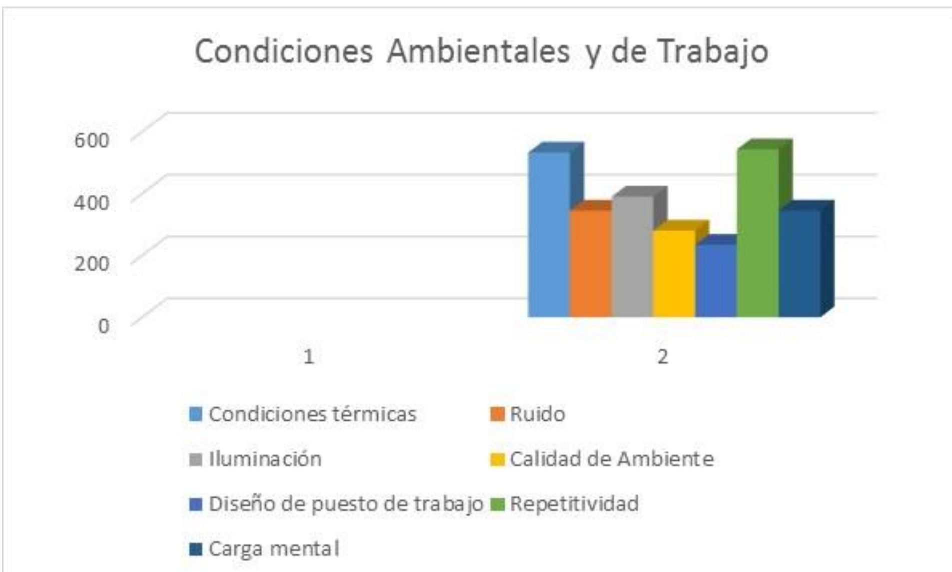


Figura 8. Condiciones Ambientales
Fuente: Creación propia.

5.CONCLUSIONS

A mechanical risk is something that can be easily presented in any production plant, since all machinery is equipped with moving elements that constitute a source of risk. By means of Ergonomics and the application of different protocols and inspection standards, a correct identification of the sources of risk that represent the greatest danger to the integrity of employees at any production plant can be achieved.

According to the results of the analysis in the workstation we can see that a specific area of work can be optimized with the help of times and movements, ergonomic methods and with a good implementation of a workstation, where the worker can carry out his activities Without any wear and tear, with a greater use of the available tools and materials, permanently measuring their progress with the Learning Curve. (Belloví, 2013).

Establish the method for the investigation and analysis of incidents generated within the plant, and generate corrective and preventive actions to prevent it from happening again.

The company will have the necessary cleaning elements in all the jobs.
Keep the passage and exit areas clear of obstacles.
Collecting accidental spills, whether liquids, solids or powders at work stations immediately, another person may suffer an accident.

Keep your workplace clean and tidy. Remember that "cleaning is fine but not getting dirty is better".

When the workplace generates waste, use suitable containers.
Remember that there is "a place for everything and everything in its place".
Do not throw papers anywhere in your work center.

5.1. Technical solutions and / or corrective measures

- Combat risks at source.
- Adapt the work to the person, in particular as regards the conception of jobs, as well as the choice of equipment and methods of work and production, with a view, in particular, to attenuate monotonous work And repetitive and to reduce the effects of it on health. (Osorio, 2008).
- Take into account the evolution of the learning curve.
- Replace dangerous with little or no danger.
- Adopt measures that put collective protection before the individual.
- Give proper instructions to workers.

Under no circumstances should the speeds recommended by the manufacturer be exceeded.
Use automatic roller feeders when curved parts and feeders cannot be used.
Check the perfect sharpening of the tools.
Avoid deep stapling, always giving successive and progressive stapling.

6. REFERENCES

Belloví, M. B. (2013). *Análisis coste beneficio en la acción preventiva* (I): bases conceptuales. Notas Técnicas de Prevención.: Instituto Nacional de Segurida e Higiene en el Trabajo. España

Osorio, J. (2 de 11 de 2008). *La Rentabilidad de la Ergonomía* . El Portal de la Seguridad, Productor, & El Portal de la Seguridad, la Prevención y la Salud Ocupacional de Chile. Recuperado el 5 de julio de 2016, de http://www.paritarios.cl/: http://www.paritarios.cl/ergonomia.htm

Prokopenko, J. (1989). La Gestión de la Productividad. Manual Práctico. *Revista OIT*. Ginebra: Organización Internacional del Trabajo.

Ramírez, C. (2010). Ergonomía, productividad y calidad. México: Limusa.

Rodríguez, J. (1991). *Indicadores de Calidad y Productividad en la Empresa*. Venezuela. Nuevos tiempos.

Salmerón, L., Fajardo, I., & Cañas, J. (2004). Sobre la relación entre la ergonomia y psicologia cognitivas. *U. d. Barcelona, Anuario de Psicologia*, Vol. 35), pp. 507-519.

Zinchenko. V, V. M. (1985). *Fundamentos de Ergonomía*. Editorial Progreso. Moscú., Rusia: Progreso.

DIAGNOSTIC STUDY OF PSYCHOSOCIAL FACTORS IN THE AUTOMOTIVE INDUSTRY IN MEXICO

Martha Estela Díaz Muro, Martha Cecilia Terán Contreras, Carmen Adolfo Rivera Castillo

Tecnológico Nacional de México/Instituto Tecnológico de Hermosillo
División de Estudios de Posgrado e Investigación
Ave. Tecnológico S.N
Colonia El Sahuaro
Hermosillo, Sonora 83170
Corresponding author's e-mail: diazmuro@yahoo.com.mx

Resumen. Este trabajo de investigación busca diagnosticar a partir del análisis de los factores psicosociales la situación de riesgo en la que se encuentra la Industria Automotriz considerando los cambios en la reglamentación federal sobre la seguridad y salud en el trabajo, vigentes a partir del mes de febrero de 2015, que incluye a los factores de riesgos psicosociales.

Para la evaluación de los FRPS se utilizó el cuestionario CoPsoQistas21, una versión del Copenhagen Psychological Questionnaire adaptado al español y que ha sido traducido a 25 idiomas. Se aplicó a un grupo de trabajadores de una empresa del ramo de la industria automotriz, divididos en tres turnos.

Los resultados coinciden con la visión de la presión del tiempo, el factor de riesgo de mayor presencia es el ritmo de trabajo mencionado en el reporte de la OSHA Europa, seguido del conflicto de rol y de la inseguridad sobre el empleo.

En los resultados se vislumbra con posible afectación el factor doble presencia, relacionado con la interacción de los aspectos familiares y personales con los aspectos relativos al trabajo.

Abstract. This research seeks to diagnose from the analysis of the psychosocial factors the risk situation in which the Automotive Industry is considering the changes in the federal regulations on occupational safety and health, effective as of February of 2015, which includes psychosocial risk factors.

For the evaluation of FRPS, the questionnaire CoPsoQistas21 was used, a version of the Copenhagen Psychological Questionnaire adapted to Spanish and translated into 25 languages. It was applied to a group of workers of a company of the branch of the automotive industry, divided into three shifts.

The results coincide with the view of time pressure, the risk factor of greater presence is the work rate mentioned in the OSHA Europe report, followed by the role conflict and insecurity about employment.

In the results, the double presence factor, related to the interaction of the family and personal aspects with the aspects related to work, is possible to be affected.

Keywords: Psychosocial, risk factors, automotive industry

Relevance to Ergonomics: Psychosocial risk factors has been associated with the prevalence of work muscle-skeletal disorders and it is important to study this relationship in automotive industry.

1. INTRODUCTION

Psychosocial risk factors (RRF) and their negative effects related to work have been extensively studied. In several countries, there are regulations, decrees, and regulations aimed at reducing exposure to risks and their consequences on the health of workers. FRPs have been associated in industries governed by continuous flow production systems, organized by the concepts of the system just in time and requiring great flexibility in their structures of work organization to maintain a competitive level according to the requirements of the Globalized markets, distinctive of the automotive industry of high-volume production and product catalogs almost available to the customer.

FRPs can have a decisive impact on companies if the specific characteristics of each worker are considered to have different outcomes when exposed to adverse psychosocial factors. The needs, expectations, tolerance to the different levels of exposure to stress and frustration in the work, can influence the adaptation of the employee to his work scope and strongly determine the intensity and nature of the behavior that presents itself to the own problems of the organization.

For the company, it is essential to generate strategies to detect factors and psychosocial risks that may arise in the daily work not necessarily can be generated by the same organization since the worker is exposed to a number of situations that can decrease his capacity of resistance in such a way that, a situation that for others is not important, can trigger a crisis in another worker.

2. BACKGROUND

It has sought to classify the various risks that the worker can face in order to identify the most common forms in which these adverse conditions present themselves both to the individual and to the organization. According to ILO studies (1984), they are considered adverse factors linked to health overwork, lack of control, misuse of powers worker, authority issues, and poor distribution of wages, lack of security Work, problems in labor relations, shift work and physical danger. The European Agency for Safety and Health at Work indicates, among others, 6 organizational factors that lead to psychosocial risks: excessive workloads; Contradictory requirements and lack of clarity in the functions of the post; Lack of participation in decision-making affecting the worker and lack of influence in the way the work is carried out; Ineffective communication, lack of support from management or colleagues; Violence by third parties and psychological and sexual harassment.

Other studies of psychosocial risks (Cox et al, 2003, Velázquez, 2007) include the content, pace and work program, control, environment and equipment, organizational culture, interpersonal relationships at work, role in company development Professional and interrelation between the organization and the worker's house.

Although it is difficult to determine the main psychosocial risks, the studies (ILO, 2014, Moreno and Báez, 2010) allow us to identify some of the most important risks:

Stress.

Internal and external factors and constant technological change in which the organization operates, demanding maximum effort to meet the demands that the environment determines, or counterclockwise, inefficient use of the skills of workers in their jobs, generates behavior change negatively affecting their work performance, motivation and quality of life, and reduce its capacity for creativity and stagnation of professional development impacting decisively on organizational effectiveness (Schabracq et al., 2000).

Stress is caused in part by the imbalance between the demands and pressures to which the worker is facing in the post and on the other, the skills and knowledge that this has (WHO, 2004). When the needs of the environment exceed the capabilities of the worker can trigger adverse effects on physical and mental health such as exhaustion, depression to the detriment of their quality of life and productivity, even reaching contract recession.

The characteristics of the position, volume, rhythm and work schedules as well as the company's participation and control are triggers of stressors in the company, mismanagement, poorly designed processes and demanding work shifts are red lights that must Be considered when establishing strategies of improvement within the organization and that are aimed at developing the skills and competencies of the worker in a work environment that fosters creativity, motivation and productivity.

Burnout or professional burnout

Broadly related to stress, the term burnout was used in the decade of the 70's after analyzing the behavior of some police at that time, according to data from the portal of work stress, were the psychologists C. Maslasch And S. Jackson, who in 1976 identified burnout as a "syndrome of emotional exhaustion, depersonalization, and less personal accomplishment, which often occurs more frequently in jobs that merit attention to third parties by physically and mentally disabling the employee. Develop their work efficiently and increase the levels of stress that in the long run can affect their behavior. "

Work shifts

The agitated dynamics of organizations in industrialized countries has led to the need to incorporate a system of shifts that cover the 24 hours to attend to the demands of the market, considering for this, the fragmentation of the production scheduled in shifts that include Sundays and holidays provoking that These work rhythms generate physical and mental imbalances in the worker. According to the Foundation for the Prevention of Occupational Risks, sleeping by day does not allow the body to adapt easily as when sleeping at night (see figure 3), sleep provides a uniform state of rest of the body characterized by low levels of Physiological activity which comprises two phases; One of slow sleep allowing the physical recovery of the body and the other of fast sleep that helps the psychic recovery. It is necessary to sleep at night about 7 hours to be able to walk through all phases of sleep and obtain physical and mental recovery.

Why it is important to consider psychosocial factors in AI?

The establishment of Transnational Corporations in Sonora since 1984 has generated a strong boost to the automotive industry in Sonora, providing solidity to the regional economy by not depending exclusively on local or national investments.

According to the Economic Commission for Latin America and the Caribbean (ECLAC, 2004), the incorporation of these transnational corporations has led to a strong demand for high standards of efficiency and productivity, with an impact on labor intensification.

In the OSHA Europe Report, three very important factors in the intensification of work are mentioned: radical changes in the use of time, production systems "Just in Time" and flexibility as a requirement.

The first factor refers to the urgency to finish each cycle of work in time, in the AI the production rate is established by the assembly line, either by the movable bases or by carousel type supports where the unit is not In contact with the floor. The operator has the cycle time to travel the distance assigned to the workstation, this represents the production speed, time in which the distance is traveled. Added to this is the importance of the analysis of value-added activities at each station, where "waste" times are transformed into productive times, increasing the efficiency in the allotted time.

The use of information technologies has facilitated the application of the "just in time" production system, which is increasingly used in the search for waste disposal (Womack et al, 1992). This system of production, the second factor, exerts some additional pressure on the operators, especially in the sense of the scarce possibility of delaying in the execution of the work assigned to be fulfilled in the allotted time, and as it states the Report has repercussions on delays to The production chain and consequently incur additional costs due to errors in the execution of the activity, delays or due to the malfunction of the system.

The third factor: Flexibility is based on the need to reduce inventories by increasing the complexity of the work caused by the various options that demand higher requirements for adaptation and execution of the activity depending on the cycle times of each workstation.

The report mentions that in addition to the presence of musculoskeletal disorders or injuries associated with work intensification, the effects of psychosocial risks are also associated with the manifestation of stress due to work.

Considering the above, it is that psychosocial factors should be considered in AI, especially at this time of its boom in Mexico, because of its relation with the intensification of work, as mentioned in the Report of the European Risk Observatory (2007), Distinguishing two basic trends in the world of work; The perception of the deterioration of the working conditions and the negative increase of the effects of the work on the health, manifesting itself through the musculoskeletal injuries and the psychosocial risks. The concept of intensification of work is not directly related to the organization of production, however, it is present in the current conditions of high volume production AI, for example, the synchronization of continuous work. In practice, it has been observed the need for organizations to increase the use of human resources by allocating more activities per cycle while increasing the efficiency of work. The production rhythms in the middle of the last decade were of maximum 40 units per hour, currently have production rates of between 50 to 73 units per hour, translated in time represent cycles of 49 to 72 seconds per cycle, that is to say, the Time available at each workstation for the assignment of activities.

2.1 Description of AI

The manufacturing industry, in particular, the automotive industry (IA), is fundamental for the development of the economy at a global level, according to data from the International Organization of Automobile Manufacturers (OICA, 2015), the world production of automobiles, Family vehicles and light vehicles in 2014 reached the figure of 89, 747,430 units. The same source mentions that the AI represents the incorporation of more than twelve million workers for the manufacture of the total of cars, plus considering approximately 5 additional jobs for each direct job, the total approaches the 60 million jobs related to the automotive industry.

The IA is somewhat different from the pattern of the export manufacturing industry, has been located with a greater presence in the central region of the country and the trend continues, the state of Guanajuato has established itself as the main attractor of the industry. In the distribution of AI already considered the new investments and the new brands that will be established in the country but does not consider the complementary industry of auto parts, only the manufacture of auto parts belonging to the automotive brand.

The production of automobiles for the years 2014 and 2015 up to the month of June is concentrated in table 1. The production considers cars and light vehicles, according to the classification of the OICA these are passenger vehicles in both cases, the definition is Relating to motor vehicles with at least four wheels and can carry up to eight passengers in addition to the driver. The data correspond to the Automotive Industry established in Mexico and the total mentioned is the production of passenger vehicles. The table also shows the variations in the volumes produced in the two years.

Table 1. Production of passenger vehicles in Mexico.

MARCA	**JUN-15**			**JUN 2014**		**JANUARY - JUN**		
Autos	Ligeros	Total	Total	Var. %	2015	2014	Var. %	
FCA MÉXICO	1,885	42,195	44,080	41,575	6	254,775	243,262	4.7
FORD MOTOR	44,423	0	44,423	42,107	5.5	235,668	231,771	1.7
GM	12,566	46,877	59,443	55,870	6.4	342,325	353,712	-3.2
HONDA	1,774	10,995	12,769	11,293	13.1	90,260	48,224	87.2

MAZDA	18,629	0	18,629	6,766	175.3	101,915	25,466	300.2
NISSAN	60,791	12,788	73,579	73,615	0	414,108	412,312	0.4
TOYOTA	0	7,934	7,934	6,241	27.1	41,741	34,404	21.3
VOLKSWAGEN	45,837	0	45,837	49,877	-8.1	246,765	248,443	-0.68

Source: AMIA, 2015.

The total production for the period January-June 2015 was 1,727,557 units which, compared to production for the same period of the previous year 1,597,594 units, represents an increase of 8.1%. In the case of Mazda, the increase is very noticeable, but it is explained by the fact that the production started already advanced in 2014. The trend to the rise places Mexico in the first seven places of production of light vehicles worldwide. In the year 2013, the total production was 2, 933,465 units.

According to INEGI data, in 2013, the total number of employees employed in the manufacture of light vehicles was 45, 356 people, its impact on the total generation of jobs is greater than that reported by OICA, in Mexico the proportion is Of 14.5 jobs per direct job, this represented a total of 668,456 total jobs. The total number of hours worked in the IA in 2013 was 1, 507,011 of which 174,095 corresponded to the manufacture of light vehicles.

In the same source, the value of production is mentioned at 575, 980,649 (thousands of pesos); however, the proportion in the same employment trend is not maintained, the production value is only 50% of the total AI , 1,201,005,209 (thousands of pesos). In total income with respect to wages, the AI contributed with 81,992,754 (thousands of pesos), that is an average of 122,660 pesos per year.

2.2 Legislation in Mexico

On November 13, 2014, the Federal Regulation on Occupational Safety and Health (RFSST) has been published in the Federal Official Gazette, according to the provisions of the first of the transitory articles, there is a period of Three months for the entry into force of this regulation, that is, from February 13, 2015.

Emphasis is given to the inclusion of article 42, referring to ergonomic risks in workplaces and article 43, referring to psychosocial risk factors in workplaces. According to the RFSST as psychosocial risk factors, "Those that can cause anxiety disorders, non-organic sleep-wake cycle and severe stress and adaptation, derived from the nature of the functions of the job, the type Of working hours and exposure to severe traumatic events or acts of Labor Violence, for the work developed. "

Article 43 states that "employers shall":
I. Identify and analyze the jobs with psychosocial risk by the nature of their functions or the type of working day;
II. Identify workers who were subjected to severe traumatic events or acts of Labor Violence, and to assess them clinically;

III. Adopt the necessary preventive measures to mitigate the Psychosocial Risk Factors;
IV. Practice examinations or clinical evaluations to Occupationally Exposed Persons to Psychosocial Risk Factors, as required;
V. Inform workers about possible alterations to health due to exposure to Psychosocial Risk Factors, and
SAW. Keep records on the preventive measures taken and the results of clinical examinations or evaluations.

Understanding also the need to have a program of safety and health at work to avoid risks in work centers. The process of identification of psychosocial risks must start from a diagnosis of health and safety at work and consequently establish the set of actions aimed at prevention and correction.

Because of the very nature of the risk and the methods for its evaluation, it is anticipated that identification and diagnosis should be applied to each individual in the workplace representing an AI universe of 668,456 workers. Here it is important to anticipate and establish the strategy to carry out the process of diagnosis and identification of psychosocial risk factors and establish the action plan for the respective control and intervention strategies. The Mexican Official Standard of the Secretariat of Labor and Social Welfare is still in the process of being drafted, authorized and published regarding the entire process of applying the RFSST.

Article 476 of the Federal Labor Law refers to the following: "In any case, work diseases shall be considered as determined by this Law and, if applicable, the updating by the Ministry of Labor and Social Security." This could involve the diagnosis of work-related illnesses associated with psychosocial risk factors and consequently affect the Social Security premium. Hence the importance of anticipating events and establishing the strategy for the prevention and control of psychosocial and ergonomic risks added to derivatives and associated with safety and hygiene in workplaces.

Strategies for Prevention of Psychosocial Risks

Identifying the negative psychosocial factors that impact the worker implies a deep assessment and analysis by the organization to generate a map of risks inherent to the company. The difficulty lies in the perception factor that prevails in the behavior of the worker. The attitude, knowledge, experiences, social and family environment that are part of the context in which the worker operates can affect his work performance and what for a worker is a normal situation without any particularity that worries him, for other people can Be an emotional trigger that impacts on their work and group work.

In order to ensure an effective diagnosis of the possible risks, it is necessary to evaluate the jobs involved in the organizational processes and that include the propensity to psychosocial risks so that methods must be used that really detect the problems that affect the company.

3. METHODOLOGY

There are a variety of psychosocial risk assessment instruments validated by researchers that have been applied in diverse work environments with highly successful results, the interesting thing is to be able to identify which is the most convenient according to the specific characteristics of the work organization to later evaluate The probability of risk and determine the strategies of intervention and control.

The ILO in 1984 provides a description of some of the most commonly used methods for measuring psychosocial factors, including measuring occupational satisfaction, Measuring psychological and psychosomatic symptoms, Measuring subjective well-being, Psychophysiological measures, and indicators. The report mentions the importance of the application of the questionnaires and interviews to detect risks involving the personnel to answer the questionnaires obtaining the direct information of the involved one.

The COPSOQ method is an international instrument for research, evaluation, and prevention of psychosocial risks originating in Denmark. The first version was made by a group of researchers from the.

One of the most commonly used methods is the Copenhagen Psychosocial Questionnaire (CoPsoQ) in its second version: ISTAS 21, is an international instrument for evaluation originated in Denmark, the first version was made by a group of researchers from the National Research Center for The Working Environment in the year 2000 (Kristensen et al, 2005, Pejtersen et al, 2010).

The questionnaire consists of four sections: Socio-demographic data and requirements of domestic and family work, Conditions of employment and work, Damage and effects on health and Psychosocial dimensions. Jiménez and Báez (2010) and measures the psychosocial risk factors can be applied in any type of work including 21 psychosocial dimensions which allow covering a wide field of action in the work (Moncada et al 2006)

It has been chosen a company of the automotive branch located in the state of Sonora, the company counts on more than 1000 direct employees in the area of production, has more than 25 years of antiquity in the locality and forms part of a corporate of great exigency in the results.

For the identification and evaluation of the psychosocial risks in the company, five stages were considered:

1. Planning and carrying out fieldwork.
2. Application of the Copenhagen Psychological Questionnaire adapted to Spanish and denominated CopSoQ-istas21 version 2.
3. Preparation of the report.
4. Analysis of results.
5. Mapping of psychosocial risks.

The following describes the methodology of work, the base for the first two phases of the DCOV, definition, and characterization of the problem.

1.- Planning and carrying out fieldwork. As mentioned previously, to evaluate the psychosocial risks, it was decided to use the instrument CopsoQ-istas 21

(http://www.istas.net), the questionnaire evaluates fifteen factors, listed below:
• Quantitative psychological requirements, which are derived from the amount of work, are considered high when more work is to be done than the scheduled work.
• Work rhythm, closely related to psychological demands, refers to the intensity of work, depending on the number of activities assigned and the time to perform them.
• Emotional psychological demands are the level of exigency to keep aside individual emotional situations of work derived from interpersonal relationships.
• Double presence, refers to the simultaneous synchronous presence of family matters and labor matters, are high when the demands of the work interfere with the family demands.
• Influence, it is the autonomy that the person has to carry out his work, specifically in relation to the work, quantity, order and method to be used.
• The possibility of development refers to the possibilities of putting into practice the knowledge, skills, and experience in the performance of work and the possibility of acquiring new ones.
• The sense of work, in general terms, refers to the content of the work and the vision of the worker about his contribution to the final product.
• The quality of leadership is the interaction of the work team with intermediate levels of command.
• Predictability means having adequate information, in quantity and time, to properly develop the work and be prepared for a possible change.
• Clarity of role is the concrete knowledge about the work to be done, instructions, time, activities to perform among others.
• Role conflict refers to the type of activities in which the worker may disagree and may represent an internal, personal conflict.
• Insecurity about employment is stability at work and the possibility of the help of the company to find another job if there is a dismissal.
• Uncertainty about the working conditions, it is presented when the changes will come to affect the current working conditions, for example, the salary or the amount of work to be performed.
• Vertical trust is the security that is in the actions of managers and workers in a competent and appropriate manner.
• Justice, it is the treatment of equity, the decision-making and the participation in these.

The questionnaire is based on the General Theory of Stress, is designed to evaluate any type of work, focuses on the relationship of work organization and working conditions, stresses the importance of the participation of various groups of workers and is of public and free use.

2. Application of the Copenhagen Psychological Questionnaire Istas21. For the application of the questionnaire to the members of the work group, an estimated time of 15 minutes was assigned to each of them. The employee does not require any kind of knowledge prior to the questionnaire as it does not contain specialized terms. For the application of the evaluation instrument it is necessary to download the application, available on the website, and accept the conditions of use; Preventive purpose, participation, anonymity, and confidentiality of personal data and non-

modification of the questionnaire. Prior to the application of the questionnaire, participants were informed of the scope of the instrument, the form of application and how to respond. This activity was performed with each of the work teams for each shift. In this part of the methodology, the questionnaire was applied in a work group composed of 10 employees in three shifts, which represents a total of 30 employees.

4. RESULTS

The information obtained from the questionnaires is summarized in Table 1. The data are ranked from the most unfavorable to the most favorable. The results show the percentage of workers who have responded to each factor. The results are significant when the percentage is higher than 60%, for Important; Work rhythm, role conflict, and job insecurity, although it does not reach the percentage should pay attention to the double presence factor. Thus, the most unfavorable factors are the pace of work, the role conflict, and security in the insecurity about employment. On the other hand, the most favorable factors include vertical confidence, recognition and group feeling.

Table 1.- Results of the istas 21 questionnaire

	Dimensión	Más Desfavorable	Situación Intermedia	Más favorable
MÁS PROBLEMÁTICAS	Ritmo de trabajo	90	10	0
	Conflicto de rol	60.7	25	14.3
	Inseguridad sobre el empleo	60.7	14.3	25
	Doble presencia	55.2	27.6	17.2
	Inseguridad sobre las condiciones de trabajo	44.8	24.1	31
	Influencia	36.7	23.3	40
	Exigencias emocionales	34.5	20.7	44.8
	Apoyo social de compañeros	33.3	40	26.7
	Exigencias cuantitativas	26.7	36.7	36.7
	Calidad de liderazgo	26.7	23.3	50
	Claridad de rol	24.1	34.5	41.4
	Posibilidades de desarrollo	17.2	20.7	62.1
	Exigencias de esconder emociones	16.7	20	63.3
	Apoyo social de superiores	13.3	30	56.7
	Sentido del trabajo	10	13.3	76.7
	Justicia	10	10	80
	Previsibilidad	6.7	40	53.3
MENOS PROBLEMÁTICAS O FAVORABLES	Sentimiento de grupo	3.3	26.7	70
	Reconocimiento	3.3	3.3	93.3
	Confianza vertical	0	3.4	96.6

Source: Elaboration of the format of the system istas21.

When analyzing the work rate factor, this factor is present equally in all three shifts appears in 90% of responses. On the other hand, in the role conflict factor was presented in 60.7% of the responses. In the third factor, job insecurity is perceived as unfavorable in 60.7% of the responses. The percentage coincides with the result obtained in the role conflict, however, it is perceived inversely in the intermediate condition and the favorable condition. The dual presence factor, although not fully attributable to the conditions in the company has an important result in the perception as unfavorable, it would be prudent to abound in its analysis.

The root cause is sought for each of the factors detected as unfavorable, with respect to the work rate factor it was found that the worker's perception has a directly proportional relation with the high levels in the percentages of use that are handled in the belonging stations To the working group. This percentage refers to the amount of time allocated for the development of activities with respect to the cycle time of each workstation, regularly the percentage is above 92% on average, sometimes the percentage is above 100%, making it necessary to compensate in the next cycle increasing the speed of work. In the analysis of reference times to assign the workload, the standard time is considered as the time allocated to each activity according to a generalization considered as normal, that is, any worker properly trained and working at a normal rate, Should meet working time without having to compensate by increasing the pace of work or by making additional efforts. The procedure to determine the time allotted to the workstation considers the standard time and does not allocate the additional time for personal factors, go to the bathroom for example, or for possible errors in the execution of the activity, nor is the factor of the Fatigue due to the demand of work pace and working postures.

Regarding the role conflict factor, the relationship between the years of seniority and the certifications that each employee must have is negative, which means that they do not have the certifications required for the time they are carrying out their work. For this reason, the employee's perception is related to the current situation.

Finally, in the factor of job insecurity, the results indicate that the first shift has the highest percentage of employees with an age of fewer than 3 years and a higher index of affectation in an electronic file, however, the percentages are low. That we can conclude that the employee's perception is subjective and does not correspond to the current situation.

The last stage of this methodology is where proposals are presented to mitigate the risk factors detected as unfavorable. In this case, to attack the psychosocial risk of work rhythm that is present in the three shifts, the following actions are proposed to correct this risk, which are:

It is necessary to identify the employees who have not been certified for the position in which they are being developed and given the appropriate induction and training in order to reduce the presence of the role conflict. A second action is the rotation of the staff, it is necessary to reinforce with the supervisor the attachment to the plan of versatility which marks that every 6 months the employee must be certified in a new station, without exposing the worker to another type of risk, psychosocial or ergonomic.

Regarding the psychosocial risk factor for job insecurity, which is present in the three shifts, it is proposed to recognize the worker's performance and recognition of teamwork, including the supervisor. This risk factor is considered subjective, it is the perception of the worker, therefore a strategy to analyze in the team is to hold regular meetings where they are informed about the results obtained by the company and make known the commitment of the company in Assist the worker in finding a new job when it should leave and its performance has been noticeable and positive.

5. CONCLUSIONS

The psychosocial risk factors have been little studied in Mexico in the AI, the expectation is the impulse to investigate the subject motivated by the changes to the labor regulation, undoubtedly the efforts by the companies in complying with the new Guidelines and academic work to abound in research on the subject, will translate into occupational health benefits and an improvement in business productivity.

The opinions of those involved in the project on the part of the company corroborate the factors of greater presence in the workers, industrial engineering personnel have been consulted regarding the standard times and have agreed on the use of normal time as the base time for The assignment of the workload to each station, the results concerning the conflict of roles with the supervisors and with the industrial engineers were consulted and there is a coincidence in the need to resume the certification or formalization of the worker's abilities to perform efficiently in a workstation and carry out all relevant activities, it is also emphasized the importance of strengthening the process of presenting instructions and working methods with the recognition and participation of the group of workers and industrial engineers. The third-factor present requires a relevant communication strategy to make the worker feel his importance for the company and the existence of a long-term successful vision if he works in a team and according to the standards recognized and agreed by the teams of work.

The double presence factor is in the threshold of 60% of population that would recognize it as unfavorable, this factor presents the disadvantage for the work center to combine particular aspects related to the personal and family situation of workers with the aspects related to work, The activities within the company are their responsibility and as a consequence of their control, however, combining personal and family aspects makes it difficult to identify and mitigate risk.

The inclusion of psychosocial risk factors in the regulation of work in Mexico will surely have a favorable medium- and long-term effect for all those involved in a workplace. In the case of study, the characteristic of the IA on the demands of the global markets to operate with greater flexibility in the production plants, the strategy to follow or the systems of production are most often based on the System Just in time and particularly the companies of great volumes of production, they maintain continuous rhythms of work where it is limited to the worker to establish his particular rhythm of work, generally takes care of the time of production until the minimum. These three factors have been identified by OSHA Europe as additional factors to psychosocial factors that have a pressure effect on organizations and are linked to some of the psychosocial risk factors.

The role of the federal authority will be fundamental to the success of regulatory changes, there must be clear rules for all involved, and the existence of an official standard to define scope and enforcement procedures will be basic. It will be important to have flexibility in the use of evaluation tools, fortunately there is a wide availability of methods, scientifically validated, to be used according to the needs of each company.

Changes in labor regulations should have an influence on the administrative procedures of companies, specifically on the condition of transparency of information on the psychosocial risks to which a worker is exposed, as the structure of the evaluation methods will be presented. Opportunity to raise awareness and train workers on the importance of health care in all aspects. And it will be important to follow-up the results of the evaluations, the workers mentioned in the regulation do not only refer to the production staff, it also includes the administrative and managerial staff.

6. REFERENCES

Cox Tom, Griffiths Amanda,Randall Raymond (2003) “A Risk Management Approach to the Prevention of Work Stress” En M.J. Schabracq y J.A.M. Winnubst, C.L. Cooper (Eds.), *The Handbook of Work and Health Psychology*. New York: John Wiley & Sons, Ltd.

Factores Psicosociales en el trabajo (1984): Naturaleza, incidencia y prevención. Informe del Comité Mixto OIT-OMS sobre Medicina del Trabajo, novena reunión Ginebra, 18-24 de septiembre, Oficina Internacional del Trabajo Ginebra

Fundación para la prevención de riesgos laborales (2009) “Los tiempos de la Organización del trabajo”: Incidencia de los riesgos psicosociales enLos sistemas de trabajo a turnos.Edit. Secretaría de Salud Laboral UGT CEC, http://www.estreslaboral.info/estres-laboral-en-mexico.html consultado en 30 de octubre de 2015

Kristensen TS, Hannerz H, Høgh A, Borg V. (2005) The Copenhagen Psychosocial Questionnaire—a tool for the assessment and improvement of the psychosocial work environment. Scand J Work Environ Health

Moncada y Llorens (2006), “NTP 703”, Ministerio del Trabajo y Asuntos sociales de España, Instituto Sindical de Trabajo, Ambiente Salud (ISTAS), www. istas.net/copsoq/

Moncada et al., (2001); El método COPSOQ (ISTAS21, PSQCAT21) de evaluación de riesgos psicosociales www. istas.net/copsoq/; NTP 703 ministerio de trabajo y asuntos sociales de España

Moreno Jiménez Bernardo, Báez León Carmen (2010), “Factores y riesgos psicosociales, formas, consecuencias, medidas y buenas prácticas” Ministerio del Trabajo y Asuntos Sociales, Madrid, Noviembre

Pejtersen J, Kristensen T, Borg V, Bjorner J. (2010) The second version of the Copenhagen Psychosocial Questionnaire. SJPH

Stavroula, Leka. Cox Tom, Griffiths Amanda, (2004) “La organización del trabajo y el estrés, “Estrategias sistemáticas de solución de problemas para empleadores, personal directivo y representación sindical” OMS, Francia

Schabracq, Marc J., Winnubst, Jacques A.M., Cary L. Cooper (2003) “The Handbook of Work and Health Psychology” 2d. edition, JOHN WILEY & SONS, LTD, England

Velázquez Fernández, Manuel (2010). “Riesgos Psicosociales y accidentes de Trabajo” Edit. Lettera

Secretaria del Trabajo y Previsión Social (STPS), “Reglamento federal de seguridad y salud en el trabajo” nov. 11, 2014 Diario Oficial de la Federación www.dof.gob.mx/nota_detalle.php?codigo=5368114&fecha=13/11/2014consultado el 30 de octubre de 2015

Secretaria del Trabajo y Previsión Social (STPS), Boletín de Prensa No 405/2015 www.**stps**.gob.mx/bp/secciones/sala_**prensa**/**boletines**/2015/abril/…consultado el 25 de octubre de 2015

CopsoQ-istas 21 http://www.istas.net/web/portada.asp

Eurofound and EU-OSHA (2014). Psychosocial risks in Europe: Prevalence and strategies for prevention, Publications Office of the European Union, Luxembourg.

European Risk Observatory.Milczarek Malgorzata, Brun Emmanuelle (2007). “Expert forecast on emerging psychosocial risks related to occupational safety and health”European Agency for Safety and Health at Work

Organización Internacional de Constructores de Automóviles (OICA), 2011

Woman, J., D. T. Jones, D. Ross (1992) “The Machine that Changed the World, Nueva York, Macmillan

Jeff Sabatini, http://blog.caranddriver.com/hecho-en-mexico-the-state-of-auto-manufacturing-south-of-the-border/ consultado el 15 de Octubre de 2015

http://www.amia.com.mx/AMIA Asociación Mexicana de la Industria Automotriz, 2015 consultado el 25 de Octubre de 2015

http://www.inegi.org.mx/prod_serv/contenidos/espanol/bvinegi/productos/integracion/sociodemografico/Automotriz/2013/702825051204.pdf. Consultado el 30 de junio de 2015.

AUDIOVISUAL DISPLAY FOR AVOID ACCIDENTS IN SLIPPERY AREAS

Luis Roberto Arce Lopez, Alberto Ramírez Leyva, Jesús Iván Ruiz Ibarra, Echavarria Quiñones Kenya Guadalupe, Valenzuela Melendres Yaritza Guadalupe

Instituto Tecnológico de Los Mochis
Industrial Engineer Department
Los Mochis, Sinalos, Mexico

Corresponding author's e-mail: kenya1210@outlook.com

Resumen: A lo largo del tiempo se ha buscado satisfacer las necesidades de todas las personas, comenzando por el análisis de los servicios, productos, señalamientos y su comportamiento durante su utilización. Así como un análisis exhaustivo de las capacidades y limitaciones de toda persona.

Por ello, se realizó un display preventivo, educativo e incluyente. El rediseño se elaboró en base al señalamiento de piso mojado, el cual lo encontramos por lo general en todas las instalaciones como supermercados, oficinas, tiendas, escuelas, hospitales, etc. Con el fin de promover y mantener el bienestar tanto físico como mental de toda persona que se rodea de este tipo de señalamientos.

Palabras clave: Preventivo, educativo, incluyente.

Abstract: Over time, we have sought to meet the needs of all people, starting with the analysis of services, products, indications and behavior during their use. As well as an exhaustive analysis of the capacities and limitations of every person.

For that reason, a preventive, educational and inclusive board was made. The redesign was developed based on the indication of wet floor, which is usually found in all installations such as supermarkets, offices, shops, schools, hospitals, etc. In order to promote and maintain the physical and mental well-being of all people who surround with this type of signals.

Keywords: Preventive, educative, inclusive.

1. INTRODUCTION

For ergonomics it is extremely important to improve the quality of people and increase their productivity, for this, it is necessary to make the displays are inclusive, educational and preventive since the design. When we talk about displays we have to keep in mind that we are dealing with the subject of communication. Mainly we know, that man has several forms of communication with each other, such as visual, written, spoken. Displays are the only way which the operator can interpret and receive information about his environment and be able to make a decision. This prototype was designed to fulfill the preventive, educational and inclusive. The redesign was developed and based of the indication of wet floor, which is usually found in all facilities such as plants, offices, shops, schools, hospitals, etc. In order to promote and maintain the quality of life (both the physical and mental well-being) to every person who surrounds of this type of signs.

2. OBJECTIVE

2.1 GENERAL OBJECTIVE:

Apply the ergonomic knowledge in the redesign of the display, making it inclusive, preventive from the design and educational, and thus avoid risks by optimizing its design to raise the quality of life of exposed people.

3. DELIMITATION

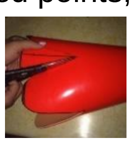
Applicable in areas of any organization, whether labor or social. From industries to home.

4. METHODOLOGY

1. Make a circular cut at the base of the cone

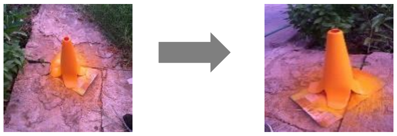
2. Mark 4 lines of 12 cm in the direction of the corners (using the base to guide).

3. With the ruler mark 3 cm to the left and 3 cm to the right, from the vertical line that we have already drawn in the previous step. Then draw two lines that join the vertical line with the marked points, and cut out the 4 triangles that were formed.



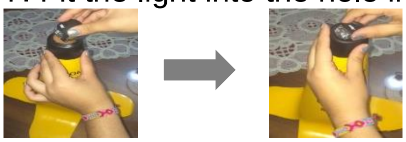
4. Shape banana peel to the four supports of our design that were formed when cutting the triangles.

5. Paint it yellow with spray paint and let it dry.

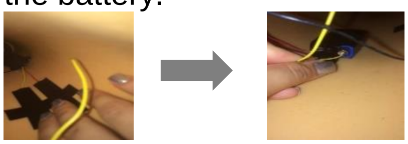


6. Make an inclusive label (Spanish-English) and stick the sticker to the cone. The paint the interior to give better design and appearance of banana.

7. Fit the light into the hole in the top of the banana design.



8. Glue the base of the alarm by the inside of the banana design. Attach the battery and put the yellow wire in the negative pole end the red wire in the positive pole of the battery.



5. RESULTS

Based on the redesign, the prototype was obtained with a height of 40 cm and a weight of 650 gr. (see figure 1). The banana structure is based on indicating the area is slippery, or there is some spillage of liquid, therefore indicates that the surface is wet. The redesign consisted in give a banana shape, using caution colors, sounds and light that made it preventive from the design. Adding a sign in two languages makes it even more inclusive. It is also thought of blind people, who can hear the sound of the alarm and identify the sign quickly. We met the goal of converting the idea of a visual board to one with creative form and inclusive features. In addition, there was a considerable improvement in the relationship between the individual and the environment, reducing accidents. Finally we achieve the objective of turn the idea of a visual display to one with creative form and inclusive features. In addition, there was a considerable improvement in the relation between the individual and the environment, reducing accidents.

Figure 1: Front view of prototype

6. DISCUSSION/CONCLUSIONS

The research presented above, leaves a lot of learning about the redesign of displays, the ergonomic guidelines that need to be followed are clear and useful to the operators and people who surround them. It was also sought that the display was inclusive at all times, from all points of view.

7. CONTRIBUTION TO ERGONOMICS

-Contribution to Occupational health.
-Included ergonomic design.

8. REFERENCES

Mondelo Pedro, Greogori Torada Enrique; (2001). En Ergonomía 3 Diseño de puestos de trabajo (P. 34). México: Alfaomega.

Oborrne, David J. (2003). Ergonomía en Acción “La adaptación del medio de trabajo al hombre”. México, D.F: editorial. Trillas.

Sanders, Mark S.; McCormick, Ernest J. (1993). Human Factors in Engineering and Design. New York: McGraw-Hill.

ERGONOMIC EVALUATION AND IMPLEMENTATION OF SMED METHODOLOGY (SINGLE MINUTE EXCHANGE OF DIES) WITHIN AUTOMOTIVE WINDSHIELD WIPERS MODULE PRODUCTION LINE.

Margarita Ortiz Solís[1], Aidé Aracely Maldonado-Macías[1], Jorge Luis García Alcaráz [1], Liliana Avelar Sosa[1] and Juan Luis Hernández Arellano [2].

[1]Industrial and Manufacturing Department.
Universidad Autónoma de Ciudad Juárez
Av. Del Charro 450 Norte
Ciudad Juárez, Chihuahua, 32310
al164612@alumnos.uacj.mx

[2]Department of Design
Universidad Autónoma de Ciudad Juárez
Av. Del Charro 450 Norte
Ciudad Juárez, Chihuahua 32310

Resumen: En este artículo se presenta un caso práctico sobre la implementación de la metodología SMED en conjunto con una Evaluación Ergonómica. Con tal implementación se redujo el tiempo de cambio de modelo en una línea específica de una planta de sistemas limpiaparabrisas y se evaluaron los riesgos ergonómicos que existían durante la ejecución de dicho cambio. El proyecto se enfocó en una línea de producción con tres tipos de cambio de modelo buscando la estandarización de los cambios. Existieron diversos puntos a corregir para las actividades de cambio de modelo y para las condiciones ergonómicas. Se obtuvo un ahorro del 76.98%, 31.32% y 25.75% para cada tipo de cambio. Se presentan recomendaciones para que próximas implementaciones sean ejecutadas con mayor éxito.

Palabras clave: Evaluacion ergonomica, SMED (Single Minute Exchange of Dies), Analisis del trabajo.

Abstract: This paper presents a case study of the implementation of the SMED methodology in conjunction with an Ergonomics Evaluation. With such implementation, the time for model change was reduced in a specific line of a system of windshield wiper systems and the ergonomic risks during the execution of that change were evaluated. The project focused on a production line with three types of model change seeking the standardization of changes. There were several points to correct for model change activities and ergonomic conditions. Savings was 76.98%, 31.32% and 25.75% for the three differents change of models. Recommendations are given for upcoming implementations to be implemented with greater success.

Keywords: Ergonomic Evaluation, SMED (Single Minute Exchange of Dies), Work Analysis.

Relevance to Ergonomics: After the combination of the SMED methodology and the ergonomic evaluation the model change time was significantly reduced providing personnel improvements and a savings to the company of $ 76,817 (dollars) per change of model. This amount is obtained from the saving average of the three changes, since the time saved is different according to the models that are in the activity.

It was expected to find ergonomic irrigation results at stations 10 and 20 but these only occurred at station 20. However, there were improvements related to ergonomics at station 10.

For the case of this hypothesis it can be considered that thanks to the appropriate analysis for the study of activities and the evaluation of ergonomic risks, there were some proposals to be applied in the stations and that once carried out they influenced in the reduction of time of change of model and performance of the activities by the operator.

1. INTRODUCTION

In Ciudad Juárez, one of the main employment sources is the manufacturing industry also named Maquiladora industry. Primarily, those foreign companies have one or more facilities for the manufacturing of their products. One of the most common is the automotive industry, where this project took place. This company produces windshield wipers systems for cars, including the module, arms and blades, as well as its subassembly. In this investigation, we will observe the improvement during change model, and ergonomics risk detection and reduction.

For the application of this project a combination of the SMED methodology was carried out with an Ergonomic Evaluation method.

The SMED methodology was established by Dr. Shigeo Shingo in 1950. Shingo observed the process and identified two types of activities that are carried out in a set up or model change, these are Internal Activities and External Activities. The internal activities that are like the assembly and disassembly of dice that the machine requires is stopped. The external activities that are like the transport of the dice that are going to be installed in the machine and this one can continue to produce (Dillon & Shingo, 1985).

The ergonomic evaluation method that was used in this case was RULA (Rapid Upper Limb Assessment) created by Dr. Lynn McAtamney and Professor E. Nigel Corlett. This method was published in 1993 in Applied Ergonomics. The authors suggest that RULA is a rapid method for assessing the posture of one or more workers at the same time as well as their muscular function and handling of loads. RULA is based on observing the position acquired by the back, neck, arms and legs during the execution of the task (Mcatamney & Corlett, 1993).

2. OBJECTIVES

To determine and apply SMED methodology and ergonomic evaluation to identify improvement areas in addition to reduce change model times in between A-LOW, B-HIGH y C-K models.

To determine ergonomic risks that exists at original change of model.
To apply the possible improvements that emerges while the workshop.
Propose a procedure of change of model, as like the company indicates.
To validate the improvement through the savings of time.

3. METHODOLOGY

SMED methodology was implemented through six (6) stages:

3.1 Gembtsu Gemba

With the term Gembutsu Gemba the reference made is to go to the production area for to observe tangible or physical things. For this stage, the objective is to obtain all the necessary evidence of how the operator makes the change of model. ,At this stage, video recording during the task of model change was taken for each of the operators working on the line identifying the model change task from the production of the last piece of the previous model to the production of the first good piece of the following model.

3.2 Analysis of Internal and External Activities

This stage is about the activity analysis using the video recording of the task.

3.3 Ergonomic Evaluation

The objective of this stage is to identify all the ergonomic risks that can exist in the change of model original procedure realized by the operator. To obtain the video recordings in the correct way should be followed the steps shown in the flow diagram for a job recording and it was consulted from Occupational Ergonomics (Karwowski & Marras, 2003). We will obtain a certain number of video frames from each station that we will be analyzed together with the RULA method to evaluate the ergonomic risks by lifting the load and propose an improvement to the job and / or model change procedure. The software that will be used to obtain the frames is GOM PLAYER 2.3.7.5261© (GOMLab, 2016). There are different methods of postural evaluation, but RULA offers advantages because it considers the evaluation of the posture adopted, its duration and frequency and the forces exerted when this posture is maintained. It will be evaluated through the RULA software using the analysis of work with the frames (Diego-Mas, 2015).

3.4 Conversion of internal activities into external ones.

In this stage, the task was analyzed to perform several actions among the are: the conversion of internal activities to external ones, the elimination of unnecessary activities, the elimination of ergonomic risks, the reduction of the time involved in certain activities and improvements to increase the reliability of the equipment or provide a benefit with respect to 5 S. In addition, an activity observation sheet was used to register the improvement that is to be done. After this, the corresponding action plan must be formulated.

3.5 Implementation of the improvement and effectiveness validation

An action plan will be made with the improvements / activities that have arisen in Stage 4. When the improvements have been implemented and task has been modified, the procedure will continue with the evaluation of the effectiveness of the project. This evaluation implies the uptading of the procedure in Gembutsu Gemba, andtraining the operative personnel according to the new procedure. After this, it is necessary to take the new model change time, which it is carried out with the same indications followed in in Sage 1. It is important that all The personnel of all the shifts that work in the M line must be trained in the new procedure. The new model change time will be monitored for two weeks by means of a check list After the estimated time for monitoring, the data will be analyzed to see if the improvement worked correctly. Finally, we will evaluate the improvement by evaluating the time saved in the model change by converting it into produced parts its correspondent dollar amount.

3.6 Standardization of procedure.

With the implemented improvements, the new model change time per station will be indicated. This procedure in this stage as in the previous one must be done according company's guidelines.

4. RESULTS

3.1 Gembtsu Gemba

Eight products were obtained for evidence as a result of step 1.

3.2 Analysis of Internal and External Activities

With the evidence from the stage 1 it was realized the analysis for to observe the type of activities carried out. In this way it was decided which should be changed or eliminated.

3.3 Ergonomic Evaluation

As a result of this stage, 200 frames of each video were obtained. With these, an analysis was performed, classifying the activities by their repetitiveness and indicating their frequency percentage. For station 10 there is table 1. This table shows only the most repetitive activities within the model change. Then in the table 2 it will be able to observe the activities with more frequency of station 20.

Table 1. Frame analysis at station 10.

Frame (activity)	Frame (image)	Frequency	% of frequency	Frequency acumulated
Breakdown of central fixing screws.		20	20%	20%
Breakdown of die’s big screws.		7	7%	27%
Die’s transportation.		6	6%	33%
Breakdown and adjustment of screws.		5	5%	38%
Setting of screws in dies.		4	4%	42%
Total		42	42%	42%

Table 2. Frame analysis at station 20.

Frame (activity)	Frame (image)	Frequency	% of frequency	Frequency acumulated
To leave die.		64	64%	64%
To connect hartings, to select model's change in control panel view, to move screw's tool and to move dies's cars.		15, 7, 4 y 10, respectively.	15%	79%
Total		100	100%	100%

With respect to table 1 it is observed that the existing activities do not affect the posture of the operator because they are performed in the short periods and there is no need for mayor effort than that of the hands. However, improvements such as fast pins and screws have been made to avoid applied stress and repetitions.

For table 2, the activity with the highest frequency being 64% shows us an incorrect operator posture while carrying a heavy load. The conditions of this activity were submitted to the RULA method. The results of the analysis are shown below. Figure 1 shows the ergonomic risk in the right arm. Figure 2 shows the ergonomic risk in the left arm.

Based on the figures 1 and 2 evaluation, it can conclude that it is necessary to change the design of the task. Since the cost of the tools is very high and requires a long time, the operating instructions will be modified so that the task is carried out by two people.

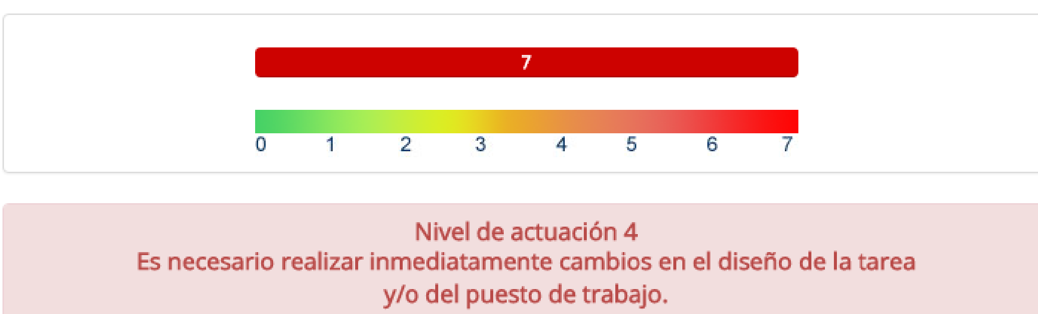


Figure 1. Ergonomic evaluation result for the right arm.

Figure 2. Ergonomic evaluation result for the left arm.

3.4 Conversion of internal activities into external ones.

For the conversion of the internal activities into external ones, elimination of waste, reduction of ergonomic risks and improvements applicable to the change of model, there were activities to improve such as: misadjusting fast bolt of the left tooling with pressure clamps, that the operator does not count on Mechanical tweezers, misfit angle measuring tool from previous model and place angle measuring tool to produce, among others. An action plan was drawn up and assigned responsibility.

3.5 Implementation of the improvement and effectiveness validation.

At this stage the activities that emerged from stage 4 were carried out and the effectiveness of the implementation was evaluated. The major impact occurred at the station 30 of the change between the A-LOW and B-HIGH models, this is because the original time was very high because of the affectation caused by the stations 10 and 20. As the most relevant problems in these stations were solved, the wait at station 30 was avoided and only the time involved in the change of tooling was reflected. The second major impact occurred at station 40 during the same model change. The table 3 shows the original and improved time per station. At change from model A-LOW to B-HIGH the saving was 76.98%, from model C-K to A-LOW was 31.32% and from C-K to B-HIGH was 25.75%. The quantity of minutes appears at table 4. According to the results of the monitoring checklist, it was established that the new model change time will be 15 minutes with 20 seconds since a single procedure is the one used to perform the three types of model change and establish only one time exchange. However, the savings were calculated on the real time of model change and table 4 is shown to show the time saved by type of change of model against the previous one and the one that had been stipulated on the initial take of the new change of model.

Table 3. Original and improved time per station.

Change of model type	Station	Original time	Improved time	Saving
A-LOW ⬄ B-HIGH	10	29:41	13:22	16:19
A-LOW ⬄ B-HIGH	20	25:19	2:30	22:49
A-LOW ⬄ B-HIGH	30	58:17	4:32	53:45
A-LOW ⬄ B-HIGH	40	41:05	9:57	31:08
A-LOW ⬄ B-HIGH	All stations	58:17	13:22	44:55
C-K ⬄ A-LOW	10	19:07	15:45	3:22
C-K ⬄ A-LOW	20	14:11	4:49	9:22
C-K ⬄ A-LOW	30	20:39	7:56	12:43
C-K ⬄ A-LOW	40	6:14	4:36	1:38
C-K ⬄ A-LOW	All stations	20:39	15:45	4:54

Table4. Original, improved and established time per change model type.

Change of model type	Original time (minutes)	Improved time (minutes)	Stablished time (minutes)	Savings (minutes)
A-LOW ⬄ B-HIGH	58:17	13:22	13:15	44:52
C-K ⬄ A-LOW	20:39	15:45	14:11	6:28
C-K ⬄ B-HIGH	20:39	15:45	15:20	5:19

After a correct implementation of the SMED methodology and the results obtained, the standardized instruction was shown to the department of windshield wiper systems to be taken as an example as well as the action plan that was used.

5. CONCLUSIONS

A new methodology was determined that mixes the steps of the SMED methodology with an ergonomic analysis to obtain improvements and reduce the model change in more than 40% that was raised in the justification.

Ergonomic risks were identified at Station 20 but not at Station 10 due to the repeatability of the activity, yet the tool to be used was redesigned to make it easier for the operator to perform the operation.

The company's procedure was followed to establish a new operating instruction that was followed by the line workers and to respect their quality guidelines.

Thanks to the implementation of the methodology established a significant saving in time and money that will provide a flexible line character to the line M. In this way, it will be possible to have the certainty that to make a change of unforeseen model will not cause more 15 minutes dead time.

6. REFERENCES

Diego-Mas, J. A. (2015). Evaluación postural mediante el método RULA. Retrieved November 28, 2016, from http://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

Dillon, A. P., & Shingo, S. (1985). *A revolution in manufacturing: the SMED system.* CRC Press.

GOMLab, W. gomlab. co. (2016). GOM Player 2.3.7.5261. www.gomplayer.com.

Hernández, J. C., & Vizán, A. (2013). *Lean manufacturing: Conceptos, técnicas e implantación.* Madrid: Fundación EOI.

Implementar SMED-SINGLE MINUTE EXCHANGE OF DIES. (2016). Retrieved September 8, 2016, from http://www.manufacturainteligente.com/implementar-smed-lean-single-minute-exchange-of-dies/

Karwowski, W., & Marras, W. S. (2003). *Occupational ergonomics: engineering and administrative controls.* (W. Karwowski & W. S. Marras, Eds.). United States of America: CRC Press.

Mcatamney, L., & Corlett, E. N. (1993). RULA : a survey method for the . irwestigation of world-related upper limb disorders, *24*(2), 91–99.

Minaya V., R. (2015). Estandarización como elemento clave del LEAN Manufacturing. Retrieved November 22, 2015, from http://senseilean.blogspot.mx/2015/11/22/estandarizacion-como-elemento-clave-del.html

Smith, D. (2004). *Quick Die Change.*(2nd. Edition). Dearborn, Michigan: Society of Manufacturing Engineers.

EVALUATION AND ERGONOMIC ANALISYS OF THE FURNITURE AT "NUEVA CREACIÓN" ELEMENTARY SCHOOL IN MOCTEZUMA, SONORA.

Penélope G. Álvarez Vega, Cristian Vinicio López Del Castillo, Dinora Monroy Meléndez, María Jesús Moreno Peralta, Javier Francisco Almazán Romero

Departamento de Ingeniería Industrial
Universidad de la sierra
Carretera Moctezuma-Cumpas, Km. 2.5
Moctezuma, Sonora.
palvarez@unisierra.edu.mx, div.ingenieria@unisierra.edu.mx, dmonroy@unisierra.edu.mx

Resumen: La realización de un análisis y evaluación ergonómica nos brinda una idea de cómo los estudiantes se sienten respecto a su salón de clases y cómo las condiciones de éste afectan significativamente su proceso de aprendizaje, contar con el mesabanco adecuado es vital para corregir la postura, sobre todo si se mantiene la posición sedente durante largos periodos de tiempo; además, con el mobiliario adecuado se evitan lesiones y problemas de salud, especialmente en la espalda y piernas. **Objetivo:** Mediante la aplicación de técnicas y procedimientos ergonómicos y antropométricos, se pretende determinar el grado de adecuación del mobiliario de la institución a las necesidades y fisionomía de los alumnos. Además, se desea conocer la relación entre el nivel del confort de los niños y su desempeño académico. **Delimitación:** Las medidas antropométricas fueron tomadas a los niños que cursan de cuarto a sexto grado de Escuela Primaria "Nueva Creación" ubicada en el municipio de Moctezuma, Son. Donde la edad oscila entre los 9 a 12 años. **Metodología:** Se tomaron medidas para realizar las cartas antropométricas a los niños de 9 a 12 años de edad de la primaria, se evaluaron las posturas que los niños adoptan al escribir usando el Método RULA para conocer el grado de riesgo ergonómico al que están expuestos y se diseñó prototipo de mesabanco ergonómico. **Resultados:** Estos mesabancos cuentan con una altura apropiada para el estudiante, otra ventaja es que la inclinación de la mesa son regulables para adaptarse a las necesidades de los usuarios (niños de entre 9 y 12 años), incluso es posible cambiar la orientación del plano de escritura y ayuda a los niños a adoptar una postura no prejudicial, durante su jornada académica, evitando a la larga una fatiga que puede llegar a ocasionar un trastorno en el sistema musculoesqueletico.

Palabras claves: Antropometría, diseño, postura.

Abstract: Introduction: The ergonomic analysis and assessment gives an idea of how students feel with respect to their classroom and how its conditions can significantly affect their learning process; having the proper desk is vital to correct the proper posture, especially if the same posture is kept for long periods of time; along with the adequate furniture health problems and injuries can be avoided, especially for the back and legs. **Objective:** To determine the adequacy degree of the Institution furniture according to the students' physiognomy and necessities, through the application of ergonomic and anthropometric techniques and procedures. Besides this, it is a desire to know the relationship between the children comfort and their academic performance. **Delimitation:** Anthropometric measurements were taken from the children in fourth to sixth grade from "Nueva Creación" elementary school at the municipality of Moctezuma, Son. Where the ages range between 9 to 12 years old. **Methodology:** Measurements were taken to make the anthropometric cards for children from 9 to 12 years old, of elementary school age, assessing the children´s posture when they write; using RULA method to know the degree of ergonomic risk that the children are exposed, and a prototype of an ergonomic desk was design. **Results:** These desks have an appropriate posture for the student, another advantage is that the table inclination is adjustable so that it can be adapted to the necessity of the user (children between ages of 9 to 12 years old), it is even possible to change the writing plane and it also helps the children to not adopt a harmful posture, during their academic journey, avoiding a long term fatigue that can cause a disorder in the musculoskeletal system.

Key words: anthropometry, design, posture.

1. INTRODUCTION

In order to have an adequate teaching learning process it is necessary to be surrounded with the appropriate environment so that one is able to work and get the most out of it. Therefore, all that concerns to the work environment must be taking into account such us study, the room or place, desk, light, etc.

This work is focused on one of these variables, the school desk. When the user of the desk are seated, it gives them constant health discomfort on their backs, acting as distractors that compete against their main job activity: to study; and their school performance is negatively influenced.

It is an actual problem having the absence of an adaptation of the current furniture, in addition to the time the students spend in the classroom, and cannot continue to ignore the importance of design and ergonomics on these spaces.

The objectives pursued by this study are to carry out a detailed evaluation of the desks from this Institution by following ergonomic and anthropometric principles, to evaluate the body posture of the students when writing using the RULA method, to give ergonomic recommendations to improve the mentioned furniture in favor of an ergonomic posture for writing like designing and creating a desk prototype that meets the ergonomic criteria and that is in accordance to the children needs.

1. OBJECTIVE

To determine the degree of adequacy of the Institution´s furniture to the needs and physiognomy of the students, through the application of ergonomic and anthropometric techniques and procedures. In addition, to know the relationship between the comfort level of children and their academic performance.

2. METHODOLOGY

This project took four stages: in the first, a survey directed to the teachers of the elementary schools “Benito Juárez” and “Nueva Creación” to collect their opinion on the problem and to get the following information about the student population:

- Know if the students are comfortable with their desks.
- What percentage of desk per classroom are not fit for use.
- Identify the main ergonomic problems faced by students.
- Know if the use of this furniture has caused discomfort or health problems in children.

In the second stage, anthropometric measures were taken in a seated position of the 4th, 5th and 6th grade students from the “Nueva Creación” Elementary School. The anthropometric charts of the children were made using the data obtained in the measurements.

In the third stage, the evaluation of the postures of the children seating in their desks was done using the RULA method. This evaluation was to establish the student´s exposure to risk factors that can lead to disorders in the upper limbs of the body.

The last stage of the study consisted in the proposal of a design of an ergonomic prototype that adapted to the requirements of the student population, taking into account the anthropometric charts and the results of the evaluation with the RULA method. In addition, a series of recommendations were given to the institution to improve this situation.

3. RESULTS

Anthropometric Measurements

The mean, standard deviation and the 95th and 5th percentiles of the anthropometric measures taken for a sample of 53 children in grades 4 to 6 at "Nueva Creación" Elementary School are shown in Table 1.

Table 1. 95th and 5th percentiles

ERECT POSITION	MEAN	STANDARD DEVIATION	95th PERCENTIL	5th PERCENTIL
920	36.8720	9.0849	51.8167	21.9273
805	136.9280	21.3911	172.1164	101.7396
328	131.3480	5.5932	140.5489	122.1471
23	115.8960	5.8367	125.4974	106.2946
309	87.8160	4.3369	94.9502	80.6818
949	83.1480	4.3794	90.3521	75.9439

398	66.6480	4.1013	73.3947	59.9013
973	67.3240	4.4126	74.5827	60.0653
265	51.3720	2.6711	55.7659	46.9781
797	135.3280	26.1998	178.4267	92.2293
798	72.5120	4.2895	79.5682	65.4558
80	68.4720	3.5430	74.3003	62.6437
752	62.2440	3.8175	68.5238	55.9642
122	34.5440	3.0434	39.5505	29.5375
223	24.0400	2.8324	28.6993	19.3807
457	28.5360	8.6507	42.7664	14.3056
32	63.9880	3.1171	69.1156	58.8604
639	28.8400	2.4779	32.9161	24.7639
230	72.3480	8.2506	85.9202	58.7758
931	65.2200	8.4546	79.1279	51.3121
178	77.5400	8.3727	91.3131	63.7669
430	53.7680	1.7114	56.5833	50.9527
144	35.0600	1.1665	36.9790	33.1410
165	10.9440	0.5440	11.8388	10.0492
427	14.8204	0.6515	15.8921	13.7487

SEDENTARY POSITION	MEAN	STANDARD DEVIATION	95th PERCENTIL	5th PERCENTIL
595	18.9680	0.8601	20.3829	17.5531
441	18.0760	0.6043	19.0701	17.0819
420	14.6680	2.1283	18.1691	11.1669
656	8.2680	0.5398	9.1560	7.3800
411	6.3640	1.8741	9.4470	3.2810
402	35.9360	7.3645	48.0506	23.8214
859	26.2040	2.7155	30.6709	21.7371
758	72.4600	4.1064	79.2150	65.7050
330	62.9600	5.4086	71.8572	54.0628
25	48.4800	3.0598	53.5134	43.4466
312	20.3160	2.6973	24.7531	15.8789
856	10.1920	1.7168	13.0162	7.3678
914	106.3280	5.5044	115.3827	97.2733
912	100.2560	5.1139	108.6683	91.8437
200	37.6600	2.9917	42.5813	32.7387
194	48.1840	3.2035	53.4537	42.9143
2FGM	106.8920	11.0968	125.1462	88.6378

4FGM	37.0840	1.7245	39.9208	34.2472
529	45.2800	2.0704	48.6859	41.8741
678	36.4360	3.3862	42.0064	30.8656
381	37.9440	2.2006	41.5640	34.3240
507	31.1760	3.4220	36.8052	25.5468
459	29.1200	3.1349	34.2769	23.9631
775	21.3120	1.2781	23.4145	19.2095
776	6.4520	0.5917	7.4253	5.4787
777	8.0625	1.2222	10.0730	6.0520

RULA Method

The following table shows the results with the Rula Method were there are thirteen specific cases studied.

Tabla 2. RULA Method Evaluation

Child	Body zone		Posture	Muscular use	Force	Punc C and D	Total Punc	Level
Boy #1	**Group A**	**Right**	4	1	0	5	7	4
		Left	2	1	0	3	5	3
	Group B	**B**	5	1	0	6		
Girl #2	**Group A**	**Right**	2	1	0	3	4	2
		Left	2	1	0	3	4	2
	Group B	**B**	3	1	0	4		
Boy #3	**Group A**	**Right**	3	1	0	4	6	3
		Left	4	1	0	5	7	4
	Group B	**B**	7	1	0	8		
Boy #4	**Group A**	**Right**	2	1	0	3	6	3
		Left	3	1	0	4	6	3
	Group B	**B**	6	1	0	7		
Boy #5	**Group A**	**Right**	4	1	0	5	7	4
		Left	4	1	0	5	7	4
	Group B	**B**	6	1	0	7		
Girl #6	**Group A**	**Right**	3	1	0	4	6	3
		Left	2	1	0	3	6	3
	Group B	**B**	7	1	0	8		
Girl #7	**Group A**	**Right**	3	1	0	4	6	3
		Left	1	1	0	2	5	3
	Group B	**B**	5	1	0	6		
Boy #8	**Group A**	**Right**	3	1	0	4	6	3
		Left	4	1	0	5	7	4
	Group B	**B**	5	1	0	6		
Girl #9	**Group A**	**Right**	3	1	0	4	6	3
		Left	4	1	0	5	7	4
	Group B	**B**	7	1	0	8		

Boy #10	**Group A**	**Right**	4	1	0	5	7	4
		Left	4	1	0	5	7	4
	Group B	**B**	8	1	0	9		
Girl #11	**Group A**	**Right**	2	1	0	3	6	3
		Left	3	1	0	4	6	3
	Group B	**B**	7	1	0	8		
Boy #12	**Group A**	**Right**	4	1	0	5	7	4
		Left	4	1	0	5	7	4
	Group B	**B**	7	1	0	8		
Boy #13	**Group A**	**Right**	2	1	0	3	6	3
		Left	3	1	0	4	6	3
	Group B	**B**	7	1	0	8		

LEVEL OF ACTION	
AVERAGES	
L. Right =	3.2
L. Left =	3.4
TOTAL =	3.3

Current desk

Figure 1 Actual Desk from top view

Figure 2 Actual Desk from side view

Ergonomic proposal design

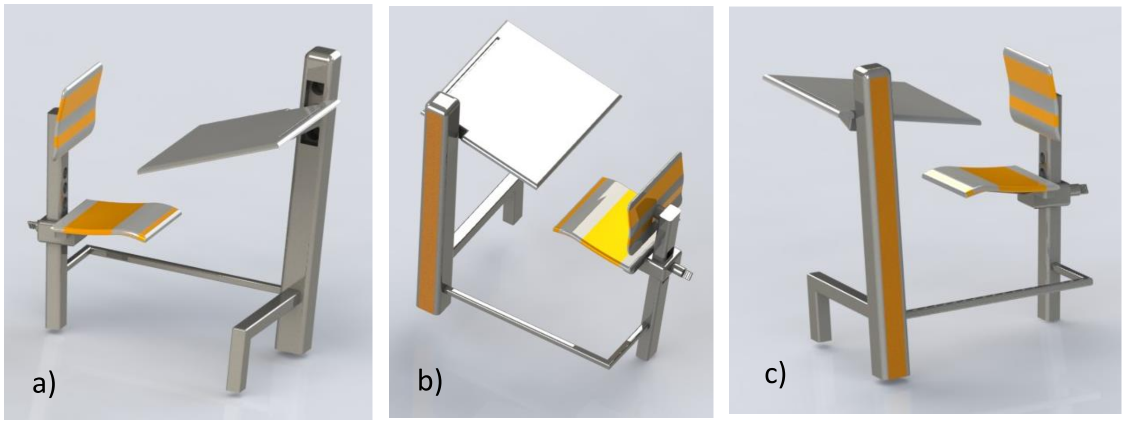


Figure 3 Proposed desk, a) right side view; b) left and top side view; and c) left side view

This proposed design for children desks will have an appropriate posture for the students. Having and adjustable table inclination may also be an advantage so that it can be adapted to the children between ages of 9 to 12 years old, it is even possible to change the writing plane. Besides, it also helps the children to not adopt a harmful posture, during their academic journey, avoiding fatigue from a long term that can cause a disorder in the musculoskeletal system.

4. CONCLUSIONS

The evaluation with the RULA method yielded a level of performance of 3, indicating the need for rapid changes in the design of the task and / or job position. This qualification indicates that the replacement of school furniture should be carried out in the short term.

It is necessary the design of an adjustable desk that allows its adaptation to the different activities and users. The height of the seat and the inclination of the table should be adjustable. It is essential to base the design of school furniture on the anthropometric characteristics of users as the one proposed by this research, in this case, elementary school children.

It is advisable to carry out a training process for teachers, students and parents in order to instill a habit of maintaining a good posture in children, in conjunction with the replacement of the furniture.

5. REFERENCES

Prevención de Riesgos Ergonómicos. Consulted on november 18th, 2015. Available at: http://www.croem.es/prevergo/formativo/1.pdf

RULA (Rapid Upper Limb Assessment). Consulted on november 18th, 2015. Available at: http://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

Laboratorio de Condiciones de Trabajo. Consulted on november 18th, 2015. Available at. Disponible en: http://www.escuelaing.edu.co/uploads/laboratorios/2956_antropometria.pdf

Estudiantes de diseño industrial conciben los pupitres que revolucionan el mobiliario escolar. (june 20th de 2013). Consulted on november 18th, 2015. Available at: http://noticias.infurma.es/diseno-2/estudiantes-de-diseno-industrial-conciben-los-pupitres-que-revolucionan-el-mobiliario-escolar/13751

Niebel B, Freivalds A. (2004). INGENIERÍA INDUSTRIAL Métodos, estándares y diseño del trabajo. 11ª edition. ALFAOMEGA GRUPO EDITOR. México. 745 pages.

Mondelo P. R., Gregory T. E., Blasco B. J.; Barrau B. P. (2001). Ergonomía 3. Diseño de puestos de trabajo. 2nd edition. ALFAOMEGA GRUPO EDITOR. México. 270 pages.

ERGONOMICS OF ELDERLY TEACHERS: A LITERATURE REVIEW

Jesus A. Dávalos Martínez, Jorge A. Gálvez Choy, Armando de Jesús Hernández Zúñiga and Arturo Tovar Reyes

Department of Industrial Engineering
Instituto Tecnológico de Ciudad Madero
Av. 1 de mayo s/n
Col. Los Mangos
Ciudad Madero, Tamaulipas C.P. 89440
Corresponding author's e-mail: jadmpie92@hotmail.com

Resúmen: En este artículo se presenta una revisión de la literatura realizada para la evaluación ergonómica de docentes de la tercera edad; en la búsqueda de información se consultaron bases de datos de los cuales se escogieron 50 fuentes científicas que cumplían con los requisitos de las variables que se tomaron a consideración y de esta información se encontró que evidentemente si existe una problemática entre actividades físicas y fisiológicas para con los maestros de edad avanzada en el ambiente laboral. Tambien se identificaron las principales variables relacionadas con este tema.

Palabras clave: veteranos, Métodos ergonómicos, Salud, Maestros, Condiciones de trabajo.

Abstract: This paper shows a literature review regarding the ergonomic assessment of elderly teachers; we consulted databases over which were chosen 50 scientific sources that achieved with the requirement of the variables that were taken into consideration. As a result of this information we found that actually there is a problematic among physical and physiological activities related to elderly teachers in their work environment. Also, we identified the main issues related to this subject.

Keywords: Elderly, Ergonomic Methods, Health, Teachers, Work conditions.

Relevance to Ergonomics: present a document that has an updated analysis of the literature applicable to present studies on anthropometry and ergonomics of elderly people to support future research.

1. INTRODUCTION

As people get old, their cultural, physical, physiological and psychosocial conditions decrease; this causes lack of strength, flexibility, balance, vision and hearing problems. (Perry, 2010).

Age is often defined in relation to changes associated with the aging process depending on their activities, work performance and way of life (Heymsfield, Núñez y Gallagher, 2000; Fox, Broamus y Maynard, 2015).

Older adults who have to walk long distances are prone to falls, and there is a study that shows that older women are more likely to suffer more falls than men, as well as having high fatigue symptoms after 10 minutes of walking (Jenkins, Cecins, Camarri, Williams, Thompson y Eastwood, 2009).

Focused on the educational field, the average number of elderly teachers is increasing globally (Kaur, Sharma y Rastogi, 2010) so classrooms and laboratories must have certain characteristics to be ergonomically ideal for both teachers and students. It is recommended that they have windows to the outside that allow the circulation of air and natural lighting (Cumbá, Aguilar, Pérez, Acosta, Mezquía y López, 2013). The ideal temperature for classrooms should be between 17 and 20 degrees Celsius (Ocaña, Rodríguez, Platas y Zarur, 2015).

According to Velazco, Díaz, Lopez and De la Vega, (2008) senior teachers with a high workload are prone to work stress which can cause harm to their health and it is recommended that they do not teach more than 5 classes and that the number of students do not be more than 25 (International Organization for Standardization, 2011). Teachers are exposed to prolonged desktop work and the repetitive overhead of writing on whiteboards, so senior teachers are more likely to suffer from musculoskeletal disorders of the back, neck and shoulders resulting in early retirement (Yue, Liu y Li, 2012; Shuai, Yue, Li, Liu y Wang, 2014; Cheng, Woug, Yu y Ju, 2016).

Considering the importance of these facts, we decided to carry out a documental investigation of the scientific literature related to the main variables and subvariables of this subject.

2. OBJECTIVES

General objective:

- To identify main issues related to the ergonomic conditions of elderly teachers.

Specific objectives:

- To know standards and trends regarding the working conditions of older adults.
- To analyze adequate architecture for classrooms and school labs adapted for elderly teachers.
- To discover health risks for elderly teachers in poor ergonomic working conditions.

3. METHODOLOGY

The search for papers led us to the use of the following electronic databases: Routledge, BMC public health and Elsevier; the keywords that were used: biomechanics elderly, biomechanics teacher health, Job Strain Index elderly, RULA teacher health, RULA, ERIN elderly, working conditions ergonomic, ergonomic conditions elderly, evaluation methodology elderly, evaluation college elderly, classroom environment elderly, elderly teachers ergonomics, teachers classroom, older adults, older teachers and elderly ergonomics. The search period comprised from February 21 to March 6, 2016 and covered articles published between 1998 and January 19, 2016.

The review of the literature led to the identification of articles related to the physical and physiological work areas of the teachers of the third age.

The places where the papers originated were the United States, Mexico, Cuba, Spain, Taiwan, Portugal, London, India, Iran, Germany and China; the selected papers were written in English and Spanish.

The articles were selected by variable according to the following criteria: senior citizens and their ergonomics, physical-environmental conditions, working conditions, evaluation and health methodologies.

Using individual key terms, the strategic search initially yielded 221 articles. Of these, based on the criteria previously indicated, 50 articles were selected, which will be represented in the results.

4. RESULTS

Table 1. Results about variables

VARIABLE 1	**THIRD AGE AND ERGONOMÍCS**
AUTHORS	Abbott (2006); National Center for Chronic Disease Prevention and Health Promotion (2012); Roper y Yeh (2007); Crawford, Graveling, Cowie y Dixon (2010); Cañas, (2011); Perry (2010); Schwerha (2010); International Labour Ofice (2010); Fox, Broamus y Maynard (2015); Heymsfield, Núñez y Gallagher (2000).
INFORMATION	They make reference to the ergonomics applied in elderly people, especially to the last decades of life where it approaches the maximum age in which human beings can live, focusing on the conditions of adaptation in a habitable environment.
RESULTS	Age is often defined in relation to other changes associated with the aging process; it depends on activities, work performance and way of life. Older adults who have to walk long distances are prone to falls, and there is a study that shows that older women are more likely to suffer more falls than men, in addition to having symptoms of fatigue after 10 minutes of walking. The average number of elderly teachers is increasing globally so classrooms and computer labs must have features that are ergonomically ideal for both teachers and students. It is recommended that there be

	windows to the outside that allow air circulation and natural lighting. The ideal temperature for classrooms should be between 17 and 20 degrees Celsius.

VARIABLE 2	**METHODOLOGIES**
AUTHORS	Pereira, Carnide, Machado, André y Veloso (2012); Leveau (2010); Rai, Gandhi y Sharma (2012); Gray y MacMillan (2003); Kaliniene, Ustinaviciene, Skemiene y Januskevicius (2013); Arenas y Cantú (2013); Choobineh, Tabatabaei, Tozihian y Ghadami (2007); Rodríguez y Guevara (2011); Rowshani, Mortazavi, Khavanin, Mirzaei y Mohseni (2012); Laurig y Vedder (1998).
INFORMATION	Data collection where research plans were applied to elderly people with the objective of improving their work environment ergonomically, documents related to the ERIN and RULA methods were investigated.
RESULTS	With the RULA method, results shows that researchers measure muscular tension exerted on the body parts such as: neck, lower and upper back, trapezius, shoulders and neck; this is to identify musculoskeletal disorders or MSDs that are the most common problems in work environments. Examples of ergonomic hazards are neck pain, back pain from working for more than 2 hours without taking a break. 30% of cases can lead to a risk of incapacity for work. Individual Risk Assessment, also known as ERIN, is a simple method for performing job evaluations evaluating the posture of the four body regions that are trunk, arm, wrist and neck relating them to the frequency and rhythm of movement when performing a task.

VARIABLE 3	**LABOR CONDITIONS AND PHYSICAL ENVIRONMENTAL**
AUTHORS	Chen y Wang (2012); Choi, Kang, Shin y Tack (2014); Kaur, Sharma y Rastogi, (2010); Cumbá, Aguilar, Pérez, Acosta, Mezquía y López (2013); Ocaña, Rodríguez, Platas, López y Zarur (2015); Education Publishing Worldwide (2016); Etman, Kamphuis, Prins, Burdof, Pierik y Lenthe (2014); Velazco, Diaz, López y De la Vega (2008); International Organization for Standardization (2011); Yue, Liu y Li (2012); Cheng, Wong, Yu y Ju (2016); Radas, Mackey, Leaver, Bouvier, Chau, Shirley y Bauman (2013); Bidassie, McGlothlin, Goh, Feyen y Barany (2010); Debroux (2015); Martínez, Frick, Kim y Fried (2010).
INFORMATION	Documents were collected based on the conditions in which an older adult works ergonomically, mentioning the risks and the different studies that have been done. Also the consequences of having a bad working environment.
RESULTS	Working conditions are affected by lighting, distance and periods of time. Large distances between campus classrooms and facilities are a great impediment for elderly teachers because it is common that their walking balance and speed decreases.

	Taking into account the high proportion of older teachers, the relationship between young students and teachers can become negative and be harmful to the health of elderly teachers. In office work is recommended to have adjustable seats and protectors on computer screens.

VARIABLE 4	**HEALTH THIRD AGE**
AUTHORS	Pinto, Zlotnicki y Sant (1997); Rodríguez y Pérez (2014); Richman y Stampfer (2010); Schönrock, Schablon, Nienhaus y Peters (2015); Gardner (2013); Shuai, Li, Liu y Wang (2014); Bardin y Dourado (2012); Gaffney, Insogna y Rodriguez (2009); Thinius y Jakob (2014); Cheung, Tang y Yan (2003); Boominathan, Mahalingam, Samuel, Dinesh y Nallamuthu (2012); Di Favio, Kurszewski, Jorgenson y Kunz, (2004); Jenkins, Cecins, Camarri, Williams, Thompson y Eastwood (2009); Piñón y Licón (2012); Schnelle, Buchowski, Ikizler, Durkin, Beuscher y Simmons (2012).
INFORMATION	The variable covers the relationship of health in the elderly and how this affects their physical characteristics, including physical performance, possible risks of diseases and accidents that old age may cause.
RESULTS	As people get older, their cultural, attitudinal, physical, physiological and psychosocial capacities decrease; this is worrying for some body functions such as strength, flexibility, balance, vision and hearing. A study was conducted in a group of older adults who indicated that mortality is more likely when the older adult starts to lose weight progressively as this can lead to chronic illness. Teachers are exposed to prolonged desktop work and the repetitive overhead of writing on whiteboards, so senior teachers are more likely to suffer from musculoskeletal disorders of the back, neck and shoulders resulting in early retirement.

5. DISCUSSION

This literature aims to examine the impact of the risks related to older teachers and the relationship with the environment and working conditions; the basis for research on this topic is to increase knowledge about the facts related to the activity of older teachers and the risks that exist based on the variables already stated; also, to verify and recognize if there is a problem between these factors.

The results shown by the research mention that there is a high relation of the aging process with the loss of the motor and sensorial capacities. We also found that there is a relationship between the health of elderly people and their working life. There is few research on the impact of older teachers and if the lack of ergonomic facilities has a correlation in the increase in the cost of workers, disabilities, forced retirement and due pensions.

Further research is needed to clearly explore the direct relationship between the costs that can be generated by work-related accidents and their consequences, such as compensation costs and the demand for trained teachers to care for the students. With the studies carried out, it is necessary to implement an ergonomic program that supports the elderly teachers to perform their daily tasks, reducing the risks generated in the environment and being able to provide a safe environment for them.

6. CONCLUSIONS

Ergonomic assessment will be a tool that will provide valuable recommendations to improve conditions and provide better support for older adults. This review study investigated and summarized the association of degeneration of physiological and emotional capacities; research indicates that there are minor risks such as loss of balance, fatigue, etc.; and older as musculoskeletal disorders and traumas. It is also concluded that it is of the utmost importance to take into account that an elderly teacher does not work in the same way as a young teacher, so that the facilities must be ergonomically adapted, be it classrooms, laboratories and even space between buildings in a way that covers all the needs that these workers may need.

7. REFERENCES

Abbott, D. (2006). Can ergonomic intervention benefit the ageing worker? Safety & Health, 1, 1-1.

Arenas, L; Cantú, O. (2013). Factores de riesgo de trastornos músculo-esqueléticos crónicos laborales. Med Int Mex, 29, 370-379.

Bardin, M, Dourado, V. (2012). Association between the occurrence of falls and the performance on the Incremental Shuttle Walk Test in elderly women. *Revista Brasileira de Fisioterapia*, 16(4), 275-80.

Bidassie, B; McGlothlin, J; Goh, A; Feyen, R; Barany, J. (2010). Limited economic evaluation to assess the effectiveness of a university-wide office ergonomics program. *Applied Ergonomics*, 41, 417-427.

Boominathan, P; Mahalingam, S; Samuel, J; Dinesh, M; Nallamuthu, A. (2012) Voice characteristics of elderly college teachers: A pilot study. *Journal of Laryngology and Voice*, 2(1), 21-25.

Cañas, J. (2011). Ergonomía en los sistemas de trabajo. España: Secretaría de salud laboral de la Ugt.

Chen, H; Wang, Y. (2012). Age Stereotypes of Older Primary Teachers in Taiwan. *Educational Gerontology*, 38, 362-371.

Cheng, H; Wong, M; Yu, Y; Ju, Y. (2016). Work-related musculoskeletal disorders and ergonomic risk factors in special education teachers and teacher's aides. *BMC Public Health*, 137, 1-10.

Cheung, F; Tang, C; Yan, E. (2003). Psychosocial factors influencing service duration among elderly Chinese voluntary workers in Hong Kong. *Australian Journal of Psychology*, 15(1), 119-119.

Choi, J; Kang, D; Shin, Y; Tack, G. (2014). Differences in gait pattern between the elderly and the young during level walking under low illumination. *Acta of Bioengineering and Biomechanics*, 16(1), 380-701.

Choobineh, A; Tabatabaei, S; Tozihian, M; Ghadami, F. (2007). Musculoskeletal problems among workers of an Iranian communication company. *Indian Journal of Occupational and Environmental Medicine*, 11(1), 32-36.

Crawford, J; Graveling, R; Cowie, H; Dixon, K. (2010). The health safety and health promotion needs of older workers. *Occupational Medicine*, 60, 184–192.

Cumbá, C; Aguilar, J; Pérez, D; Acosta, L; Mezquía, A; López, J. (2013). Recomendaciones ergonómicas para las aulas y laboratorios de computación de las instituciones educacionales. *Revista Cubana de Higiene y Epidemiología*, 51(3), 338-347.

Debroux, P; Hachioji, T. (2016). Elderly workers in Japan: The need for a new deal. *Management review*, 27(1-2), 82-96.

Di Fabio, R; Kurszewski, W; Jorgenson, E; Kunz, R. (2004). Footlift Asymmetry During Obstacle Avoidance in High-Risk Elderly. *The American Geriatrics Society*, 52(12), 2088-2093.

Education Publishing Worldwide. (2016). Older teachers are leaving the classroom. *Education Journal*, 225(1), 7-7.

Etman, A; Kamphuis, C; Prins, R; Burdorf, A; Pierik, F; Lenthe, F. (2014).Characteristics of residential areas and transportational walking among frail and non-frail Dutch elderly: does the size of the area matter?. *International Journal of Health Geographics*, 13(7), 186-201.

Fox, P; Broamus, E; Maynard, W. (2015). Aging workers and ergonomics: a fresh perspective. *Professional Safety*, 60(1), 33-41.

Gaffney, E; Insogna, K; Rodriguez, N. (2009). Increasing Dietary Protein Requirements in Elderly People for Optimal Muscle and Bone Health. *The American Geriatrics Society*, 57(6), 1073–1079.

Gardner, S. (2013). Positive Behavior Supports in Classrooms and Schools: Effective and Practical Strategies for Teachers and other Service. *Providers Research & Practice for Persons with Severe Disabilities*, 38(3), 206–207.

Gray, H; MacMillan, F. (2003). ergonomic microscopes: can they reduce the risks of work-related musculo-skeletal disorders?. *Cytopathology*, 14(1), 14-19.

Heymsfield, S; Nuñez, C; Gallagher, D. (2000). Anthropometry and methods of body composition measurement for research and field application in the elderly. *European Journal of Clinical Nutrition*, 54(3), 26-32.

International Labour Office. (2010). Ergonomic checkpoints: practical and easy-to-implement solutions for improving safety, health and working conditions (2a ed.).Geneva: International Labour Office.

International Organization for Standardization. (2011). ISO 26800:2011 Ergonomics, general approach, principles and concepts.

Jenkins, S; Cecins, N; Camarri, B; Williams, C; Thompson, P; Eastwood, P. (2009). Regression equations to predict 6-minute walk distance in middle-aged and elderly adults. *Physiotherapy Theory and Practice*, 25(7), 516-522.

Kaliniene, G; Ustinaviciene, R; Skemiene, L; Januskevicius, V. (2013). associations between neck musculoskeletal complaints and work related factors among public service computer workers in Kaunas. *International Journal of Occupational Medicine and Environmental Health*, 26(5), 670-681.

Kaur, N; Sharma, P; Rastogi, S. (2010). Mismatch between anthropometric measurements and dimensions of toilet chair: a cause of accidents. *Agricultural Research Communication Centre*, 29(1), 52-55.

Laurig, W; Vedder, J. (1998). Ergonomía. Enciclopedia de la OIT (3ª ed., vol1, pp. 29.1-29.106) España: Instituto Nacional de Higiene en el Trabajo.

LeVeau, B. (2010). Biomechanics of Human Motion: Basics and Beyond for the Health Professions. *Journal of Sports Science and Medicine*, 676(9), 1- 189.

Martinez, I; Frick, K; Kim, K; Fried, L. (2010). Older adults and retired teachers address teacher retention in urban schools. *Educational Gerontology*, 36, 263–280.

National Center for Chronic Disease Prevention and Health Promotion. (2012). Older Employees in the Workplace. *National Center for Chronic Disease Prevention and Health Promotion*. 1, 1-16.

Ocaña, R; Rodríguez, A; Platas, F; Zarur, J. (2015). Ergonomics in the design of a classroom. *Ergonomía Ocupacional*, 8, 14-17.

Pereira, V; Carnide, F; Machado, M; André, H; Veloso, A. (2012). Falls in Portuguese older people: procedures and preliminary results of the study Biomechanics of Locomotion in the Elderly. *Acta Reumatol Port*, 37, 324-332.

Perry, L. (2010). The aging workforce: using ergonomics to improve workplace design. *Professional Safety,* 55(4), 22-28.

Pinto, M; Zlotnicki, A; Sant, C. (1997). Reduced visual acuity in elderly people: the role of ergonomics and gerontechnology. *Age and Ageing*, 26, 339-344.

Piñón, F; Licón, R. (2012). Analysis of jobs for people with disabilities. *Ergonomía Ocupacional*, 5, 245-252.

Radas, A; Mackey, M; Leaver, A; Bouvier, A; Chau, J; Shirley, D; Bauman, A. (2013). Evaluation of ergonomic and education interventions to reduce occupational sitting in office-based university workers: study protocol for a randomized controlled trial. *Trials*, 13(10), 330-456.

Rai, A; Gandhi, S; Sharma, D. (2012). Ergonomic evaluation of conventional and improved methods of Aonla pricking with women workers. *Work*, 41(12), 1239-1245.

Richman, E; Stampfer, J. (2010). Weight loss andmortality in the elderly: separating cause and Effect. *Journal of Internal Medicine*, 268, 103–105.

Rodríguez, C; Pérez, E. (2014). Procedimiento ergonómico para la prevención de enfermedades en el contexto ocupacional. *Revista Cubana de Salud Pública*, 40(2), 279-285.

Rodríguez, Y; Guevara, R. (2011). Empleo de los métodos erin y rula en la evaluación ergonómica de estaciones de trabajo. *Ingeniería Industrial* ISSN, 32(1), 19-27.

Roper, K; Yeh, D. (2007). Ergonomic solutions for an aging workforce. Journal of Facilities Management, 5(3),172-178.

Rowshani, Z; Mortazavi, S; Khavanin, A; Mirzaei, R; Mohseni, M. (2012). Comparing RULA and Strain index methods for the assessment of the potential causes of musculoskeletal disorders in the upper extremity in an electronic company in Tehran. *Journal of Kashan University of Medical Sciences*, 17(1), 61-70.

Schnelle, J; Buchowski, M; Ikizler, T; Durkin, D; Beuscher, L; Simmons, S. (2012). Evaluation of Two Fatigability Severity Measures in Elderly Adults. *The American Geriatrics Society*, 60(8), 1527–1533.

Schönrock, S; Schablon, A; Nienhaus, A; Peters, C. (2015). What do healthcare workers in elderly care know about occupational health and safety? An explorative survey. *Journal of Occupational Medicine and Toxicology*, 36(10), 1-11.

Schwerha, D. (2010). Ergonomics for the experienced. *Industrial Engineer*, 42(11), 35-39.

Shuai, J; Yue, P; Li, L; Liu, F; Wang, F. (2014). Assessing the effects of an educational program for the prevention of work-related musculoskeletal disorders among school teachers. *BMC Public Health*, 14, 1-19.

Thinius, M; Jakob, M. (2014). Ergonomic workplace evaluation and epidemiology of musculoskeletal discomfort on German dairy farms. *Work*, 49(4), 25–32.

Velazco, T; Díaz, M; López, F; De la Vega, E. (2008). Identificación de los posibles factores estresantes en el ámbito de la docencia, en el nivel medio superior. *Ergonomía Ocupacional*, 1, 189-205.

Yue, P; Liu, F; Li, L. (2012). Neck/shoulder pain and low back pain among school teachers in China, prevalence and risk factors. *BMC Public Health*, 789(12), 1-8.

DECREMENT IN GRIP AND PINCH STRENGTH IN MEXICAN POPULATION OVER 70 YEARS OLD

Laura Patricia Mata Jurado

Departamento de Diseño de Imagen de Productos
Universidad Autónoma de Aguascalientes
Av Universidad 940
Aguascalientes, Ags
lpmata@correo.uaa.mx / lmj_ags@hotmail.com

Resumen: El envejecimiento tiene un efecto degenerativo en la prensión manual, uno de los indicadores de este decremento es la pérdida de fuerza en el asimiento. El objetivo de este estudio es determinar la fuerza máxima y mínima de agarre y pinza en hombres y mujeres mexicanos de entre 70 y 90 años, estimando el decremento porcentual entre estas edades así como las diferencias entre género. El método utilizado para el levantamiento de datos se llevó a cabo con una muestra representativa de 50 adultos mayores (33 mujeres y 17 hombres) que se encuentran en inicio de dependencia funcional y asisten a una estancia de día en la ciudad de Aguascalientes. Se utilizaron dinamómetros hidráulicos de pinza y agarre para evaluar la fuerza de mano dominante en dos registros con un lapso de recuperación muscular intermedio. El resultado de este estudio muestra que el decremento promedio en el asimiento de agarre en mujeres entre los 70 y los 90 años presenta una reducción cercana al 42%, mientras que en los hombres se aproxima al 45%. Las mujeres mostraron una pérdida de fuerza cercana al 34% de fuerza de pinza, mientras que en los hombres fue del 38% de pérdida. El análisis de los datos mostró una correlación negativa e incremental entre la edad y la fuerza, estas relaciones entre decremento de fuerza, género y edad se describen en los resultados.

Palabras clave: Envejecimieto, fuerza de pinza, fuerza de agarre.

Abstract: Aging has a degenerative effect on manual grip, one of the indicators of this decrease is the loss in pinch and grip strength. The objective of this study is to determine the maximum and minimum grip and pinch strength in Mexican men and women between 70 and 90 years old, estimating the percentage decrease between this ages as well as differences between gender. The method used for the data collection was carried out with a representative sample of 50 elderly adults (33 women and 17 men) who are at the beginning of functional dependency and attend a day stay in the city of Aguascalientes. Hydraulic clamp and grip dynamometers were used to evalute strenghts in dominante hand through two records with an interval of intermediate muscle recovery. The result of the study shows that the average decrease in grip streghts in women between the ages of 70 and 90 is about 44% while in men it approaches 41%. Women showed a loss of about 34% in pinch strenght while in men it was 38% loss. Data analysis showed a negative and incremental correlation between age and strength, these relationships between strength decrease, gender and age are described in the results section.

Keywords: Aging, Grip strenght, Pinch strenght.

Relevance to ergonomics: Even when the focus of ergonomic studies is on the productive population, it is important to predict the demographic conditions that our country will have in the following decades, the statistical data revealed by this research propose a limit of pinch and grip strength for older adults that can be applied to design geriatric products, consumable products and hand tools focused on the characteristics and capabilities of older adults with the aim of promoting autonomous and safe life.

1. INTRODUCTION

The grip strength of elderly maintains a pattern of incremental and proportional decrease that could be determined by age and gender, this research estimates the percentage of decrease during aging by age cohort and differences by gender in Mexican population.

In the progressive loss of adaptation to the environment during the aging; the ability to manually hold has an important role as it enables the basic functions of daily work: feeding, grooming and personal care, medication and communication.

Geriatric studies recognize that gross motor skills are usually preserved until age 75; however, the decrease in fine motor skills is evident before age 65 (Jaxtrzembski & Charness, 2007). During the aging process, manual grip is diminished by factors such as loss of sensitivity, decreased grip strength and reduced joint mobility (Staal & De Vries, 2011). This study analyzes the decrease of grip and pinch strength of adults over 70 years old in México in a representative population sample.

2. OBJECTIVE

To determine the maximum and minimum pinch and grip strength in Mexican elderly adults from 70 years to 92 years estimating the percentage decrease between this ages as well as differences between gender

3. METHODOLOGY

Decreasing force investigations in older adults are presented in two different study methods: cross-sectional studies and longitudinal studies.

The work of Forrest, Zmuda & Cauley (2007), used a cross-sectional study with women aged 65 to 91 years and a longitudinal study during 7 years with a single case study. Their longitudinal study provided an average deviation of 2.8% of manual force decrease per year and the analysis by age group showed that the variation was 2% under 60 years old and the 3.4% per year in those over 75 years old. The percentage change by age predicts that loss of strength is proportional to the increase in age.

3.1 Subjects

The study method in this research is cross sectional case, with a representative sample of 50 older adults between 70 and 92 years, of whom 33 are women and 17 men attending a day stay in the city of Aguascalientes: "La Casa del Abuelo". The main limitations of join movement in the participants who were interviewed and observed are on the shoulder and knees due to accidents or musculoskeletal injuries as well as after effects of arthritis.

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

3.2 Instruments

The equipment used to evaluate pinch and grip strength respectively were: hydraulic pinch Gauge baseline 50 pounds/22.5 kilograms to assess the strength of clamp and hydraulic hand dynamometer baseline 200 pounds/90 kilograms to assess grip strength. The opening of the palmar dynamometer adjusted to the Herztberg proposal (1985), on the separation distance of two inches. This separation generalizes the adaptability to the 50 percentile and allows a good manual contact area.

3.3 Procedure

The procedure for obtaining data was performed following the protocol by Jin Seo & Armstrong (2006). In this practice the participants are placed in a sedentary position and perform two records of maximum effort with the dominant hand at intervals of two minutes between each to promote muscular physiological recovery, posture considers the elbow flexed at 90° and forearm pronation aligned with the arm as shown in Figure 1. In the case of the pinch dynamometer, the hydraulic sensor is placed between the thumb and the index finger as shown in Figure 2. Both results were averaged for greater consistency of the data.

Figure 1. Image of grip strength evaluation

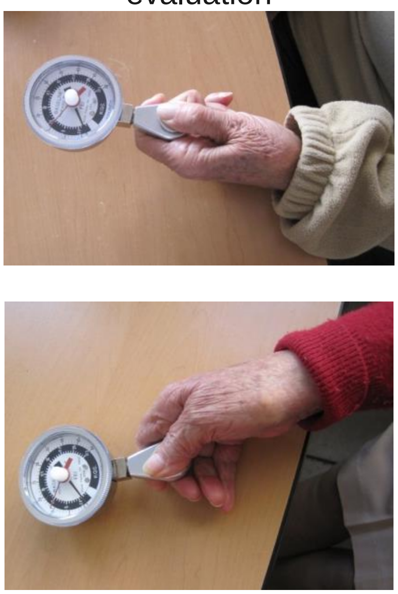


Figure 2. Image of pinch strength evaluation

Data forms were designed for the recording of pinch and grip strength (Table 1)

Table 1. Collecting data form

GRIP STRENGHT			Date	Attempts		Average
Name	Gender	Age	Dominant hand	1º	2º	
Observations						

For the analysis a database was prepared in Microsoft Excel software, the information collected in de data forms were treated with descriptive statistics and organized by age groups in which maximum, average and minimum pinch and grip strength was estimated. The categorization by age was carried out as the National Institute of Statistics Geography and Informatics orders the demographic and socioeconomic studies of older adults in Mexico, this by order of 5 years from the 60 years old.

4. RESULTS

The data collected in the forms were ordered by age groups, the minimum and maximum strengths of each age group are presented in table 2 and table 3. The purpose of this record is to show the negative correlations between age and strength. In table 2, the data of the pinch strength for women and men are ordering by age group and gender, the number of cases in each group are mentioned, in some age groups there were only two records, as is the case of men aged 70 to 75 years and those over 90 years.

Table 2. Descriptive statistics: Maximum and minimum pinch strength (pounds)

Age Groups	**MEN**			**WOMEN**		
	CASES	Maximum	Minimum	**CASES**	Maximum	Minimum
70 to 75 years old	2	14	5.5	4	9	4
76 to 80 years old	4	13	5	8	8.5	4
81 to 85 years old	6	12.5	5	9	8	3.5
86 to 90 years old	3	11	4	8	7	3
+ 90 years old	2	9	3	4	6	2.5

Table 3 shows the data of the maximum and minimum grip strength in men and women ordered by age groups.

Table 3. Descriptive Statistics: Maximum and minimum grip strength (pounds)

Age Groups	**MEN**			**WOMEN**		
	CASES	Maximum	Minimum	**CASES**	Maximum	Minimum
70 to 75 years old	2	64	30	4	38	21
76 to 80 years old	4	55	28	8	32	19
81 to 85 years old	6	50	24	9	27	18.5
86 to 90 years old	3	40	22	8	24	15
+ 90 years old	2	35	20	4	19	14

The differences in pinch and grip strength exposed by age group and gender were compared using the average (Table 4).

Table 4. Comparison of the average in grip and pinch strength (pounds) by age group and gender

Age Groups	GRIP STRENGTH		PINCH STRENGTH	
	Men average	Women average	Men average	Women average
70 to 75 years old	47	29.5	9.75	6.5
76 to 80 years old	41.5	25.5	9	6.25
81 to 85 years old	37	22.5	8.75	5.75
86 to 90 years old	31	19.5	7.5	5
+ 90 years old	27.7	16.5	6	4.25

In order to estimate the decrease in pinch and grip strength of the Mexican elderly between the ages of 70 and 92, the variation in the average by age group was calculated, the results are shown in figure 3 and 4.

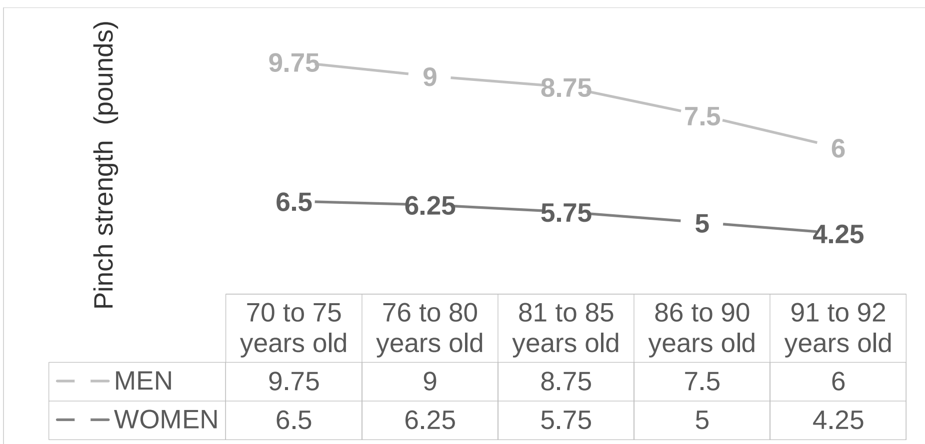


Figure 3. Decrease of average pinch strength by age group and gender

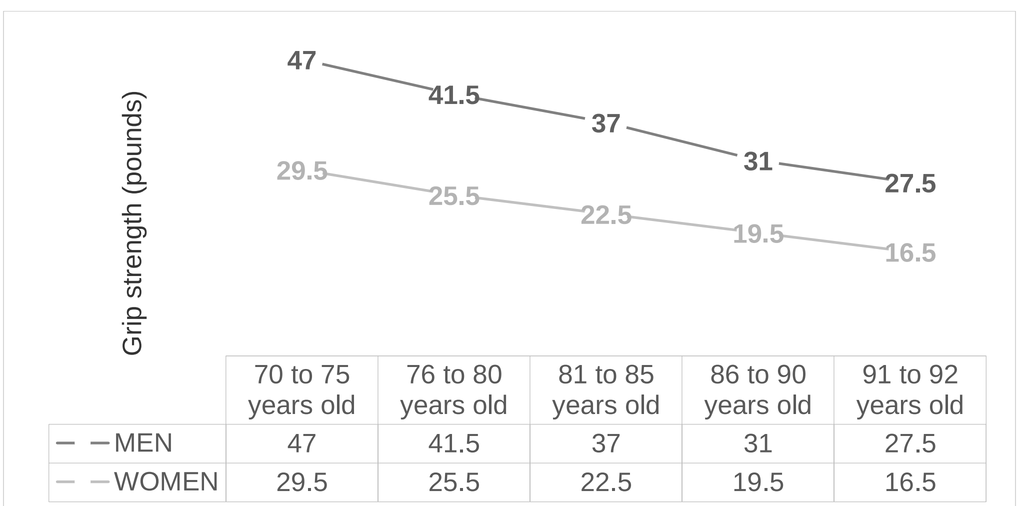


Figure 4. Decrease of average grip strength by age group and gender

5. CONCLUSIONS

The results indicate that there is a significant difference in the maximum pinch strenght between men and women older than 70 years, the women have a minor force close to 35%, which is maintained regularly during aging. In the case of maximum grip strength the difference between men and women is greater than 40% in all age groups studied.

There is no well-defined pattern of decrement however it is identified that men have a greater decrease of pinch strength during aging than women; In the average pinch strength the percentage decrease of the men of the 70 to the 92 years was of 38.4% whereas for the women it was of 34.6% and the average decrease in grip streghts in women is about 44% while in men it approaches 41%.

8. BIBLIOGRAPHY

Forrest, K., Zmuda, J., & Cauley, J. (2007). *Patterns and correlates of muscle strength loss in older women and man.* Pennsylvania: Slippery Rock University.

Hertzberg. (1985). Some Contributions of applied Physical Anthropology to Human Engineering. *Annals of the New York Academy of Scienes*, 616-627.

Jaxtrzembski, T. & Charness, N. (2007). The model human processor and the older adult. *Experimental Psychology Applied*, 13, 224-248.

Jin S.N. & Armstrong, T. J.(2008). Grip force, contact area, and hand size. *Human Factors,* 50 (5), 734-744. Retrived from:http://hfs.sagepub.com/content/50/5/734.full.pdf

Staal, J. & De Vries, N. (2011). Outcome instruments to measure frailty: A systematic review. *Ageing Research Reviews*, 104-114.

ERGONOMIC ASSESSMENT OF WORK STATIONS: AN ALTERNATIVE FOR PROCESS IMPROVEMENT AND THE COMBAT OF CUMULATIVE TRAUMATIC DISORDERS

Ernesto Ramírez Cárdenas, Adriana Ramírez Mexia, Claudia Álvarez Bernal, Francisco Javier Soto, Diana Verónica Torres Gastelum

Department of Industrial Engineering
Instituto Tecnológico de Sonora
Highway to Airport km 3
Guaymas, Sonora

ernesto.ramirez@itson.edu.mx; adriana.ramirez@itson.edu.mx;
calvarez@itson.edu.mx; fsoto@itson.edu.mx;

Resumen: La ergonomía es la ciencia que encuentra la óptima relación entre las características físicas de las máquinas y herramientas con sus usuarios y el ambiente en el cual se desempeñan, siendo las evaluaciones ergonómicas de puestos de trabajo vitales para toda organización al buscar el bienestar de sus trabajadores. El objetivo de este trabajo es realizar una evaluación ergonómica en el área de producción de cierta compañía automotriz para reducir los factores de riesgo en el sistema musculo esquelético. Para ello se siguieron los pasos sugeridos por Ávila, describir el puesto de trabajo, identificar los factores de riesgo de trabajo mediante la aplicación del método BRIEF, evaluar mediante herramientas de evaluación ergonómicas tales como RULA y Checklist Ocra y finalmente establecer alternativas de solución, mismas que servirán para el cumplimiento del objetivo planteado. Permitiendo de esta manera el aumento del nivel de satisfacción personal y al mismo tiempo la mejora en el sistema productivo.

Palabras clave: Ergonomía, Estaciones de trabajo, factores, riesgo, Desordenes de trauma acumulado.

Abstract: Ergonomics is the science that finds the optimum relation between the physical characteristics of the machines and tools with their users and the environment in which they perform, being the ergonomic evaluations of jobs vital for any organization when seeking the welfare of its workers. The objective of this work is to perform an ergonomic evaluation in the production area of a certain automotive company to reduce the risk factors in the skeletal muscle system. To do this, the steps suggested by Ávila were followed, to describe the workplace, to identify the risk factors of work by applying the BRIEF method, to evaluate with ergonomic evaluation tools such as RULA and Ocra Checklist and finally to establish alternative solutions which will serve the purpose of meeting the objective. This allows the increase of the level of personal satisfaction and at the same time the improvement in the productive system.
Keywords: Ergonomics, work stations, factors, risk and cumulative trauma disorders.

Relevance to Ergonomics: Contribute to an ergonomic culture in companies.

1. INTRODUCTION

The automotive sector in the world has been characterized by a constant process of restructuring, especially during the last decades, making it one of the most dynamic industries and generating important effects in the different economies, in terms of productivity, technological development and competitiveness. The companies in the sector have always been looking for innovations that allow them to strengthen and make their production and organizational processes more competitive, in order to have the first places in production and sales in the world markets (Carbajal, 2013). Currently, Mexico has the eighth place in the world as a producer of cars (Forbes México, 2015), this industry generates a PIB of 4% and represents a source of stable employment, because of the low operating costs (Andrade, 2014). With increased production, there is also an increased risk of injury to workers, according to Ley Federal de Trabajo Article 994 the owner is obliged to pay an equivalent fine of 15 to 155 times of the general minimum wage. In the same way a fine will apply, according to Article 488, when the worker is not given medical and surgical assistance in case of a work risk. According to statistics from the Instituto Mexicano del Seguro Social (IMSS), diseases of work in Sonora was 43 in 2004 and 335 in 2013; the work disabilities presented a change of 366 in 2004 to 1168 in 2013, observing in both indicators, a clear and unfavorable increase. Guaymas- Empalme is home of a group of medical, aerospace and automotive industries, being this last one belonging to the company under study. This company, focus their production in the manufacture of splices for cars, in recent years has shown a greater interest in problems or injuries that are associated with repetitive movements. To know the origin of cumulative traumatic disorders an instrument was applied from which the following information was obtained (figures 1 y 2).

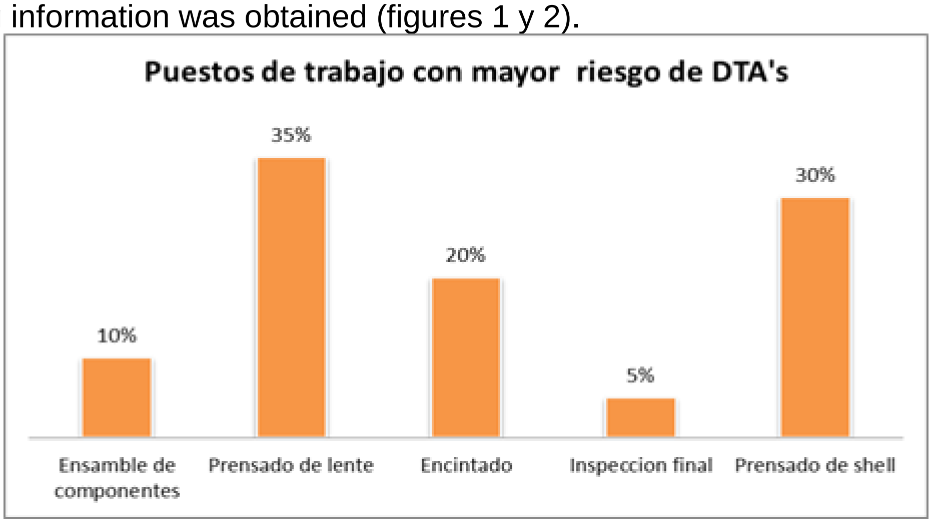


Figure 1. Work stations at increased risk for cumulative trauma disorders

Figure 1 shows that operations with higher risk being prensado 1 and 2 and encintado, which have the characteristic of being carried out while standing the worker and with a considerable frequency. To know the extremities of major annoyance the following information is presented.

Figure 2. Extremities with most annoyance in operators

The most frequently injured parts of the body are the shoulders, wrists, hands and arms with 19%, fingers with 13% and back with 8%. Recent studies show that back injury is the main source of wasted time and compensation payments, in this sense, Klein says that back injuries are responsible for 25% of all workers' compensation, which makes them the most expensive (Ayoub, 1992; cited by Prado, 2003). When observing the work stations there are incorrect positions that the operator adopts as part of his work and that may be the cause of 71% of production efficiency, this leads to the following research question: What will be the actions that the company will have to undertake in order to reduce the ergonomic risk factors, to avoid the presentation of cumulative trauma disorders and to contribute with the increase of the efficiency of the process?

2. OBJECTIVE

Develop an ergonomic evaluation in order to reduce the risk factors for musculoskeletal disorders present in the production area of the company.

3. METHODOLOGY

For project development methodology by Ávila (2014) was applied, which it is composed of: a) Describe the job, here the work stations will be recorded with a take of 10 cycles of the activity or at least 30 minutes of it. This activity should be described generally; b) Identify work risk factors, to perform an evaluation of each worker's movement (this includes counting each small movement and counting its duration in the 10 work cycles), and use identification methods like a BRIEF; c) Evaluate using ergonomic evaluation techniques or tools: This evaluation will be chosen depending on the ergonomic risks previously found. The tools used for job evaluation on this time correspond to the RULA and OCRA checklist methods; d) Solution alternatives, a proposal or alternative solution will be developed, which objective is to eliminate ergonomic risk, a work cell will be redesigned, a change in environmental factors, or a change in work instruction. This proposal should reduce the ergonomic risks or eliminate them completely, so when applying the proposal should be reapplied ergonomic assessment to see if it really made a significant change in the operator.

4. RESULTS

To analyze the current situation, it was identified that the area has two work centers, where, through the use of video, the types of activities were observed. This was complemented by the application of the Kuorinka Nordic questionnaire resulting in a higher percentage of ergonomic risks related to work design, tool management, duration and frequency; the extremities most affected ergonomically were shoulders, elbows, neck and upper back. When applying the checklist, it was found that there are repetitions in the lower lever of the presses which translates into waste of movements. Also there is disagreement on the part of the operator in the handling of the equipment since it is difficult to handle because of the pressure that needs to be done with his wrist, arm and shoulder. As a next step, the application of the BRIEF / BEST method was used to obtain the identification of risk factors for work in two operators, the results of which are shown in figure 3.

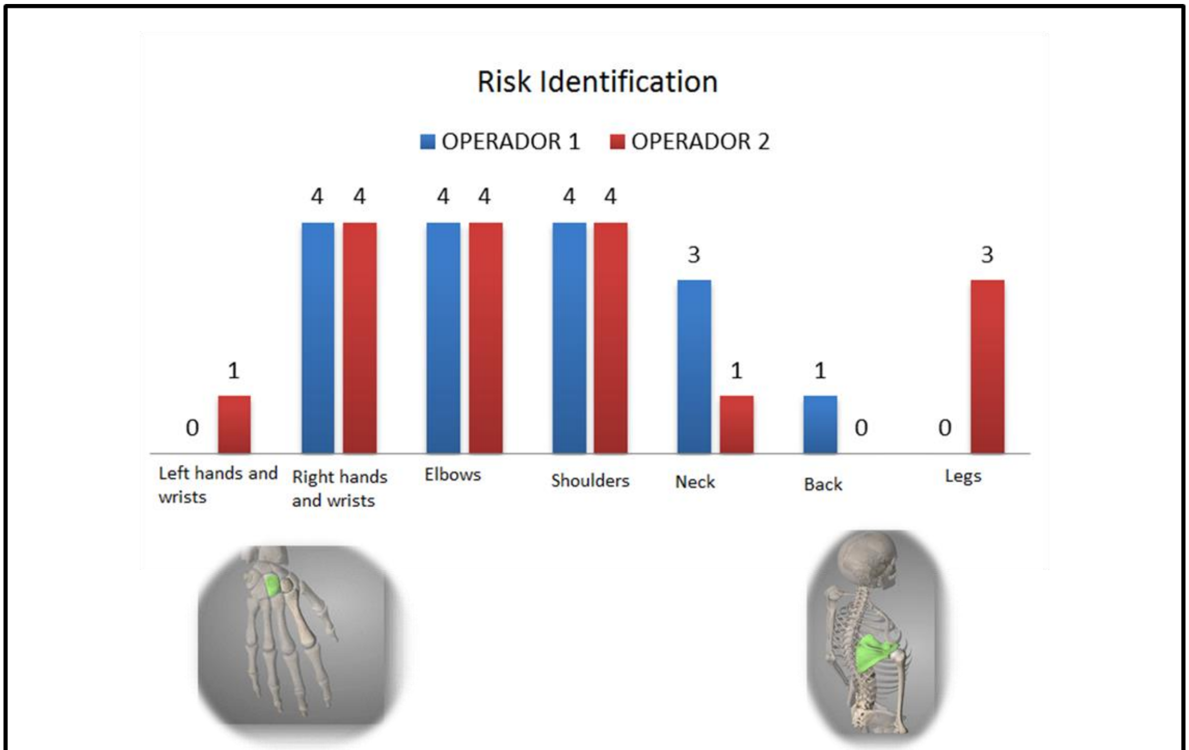


Figure 3. Identification of extremities with risks according to BRIEF / BEST

When applying the BRIEF / BEST method it was obtained that the hands, elbows and shoulders have a scale of 4, high level of risk, however it should be mentioned that operator 1 also has a High level of risk with a score of 3 in the neck and the operator 2 has a score of 3 due to the position he has during the working day. When analyzing facts and data is premised that the design of the stations is not suitable for the operator. The most affected parts of the body of the operators are the scapula, the head of the humerus and the metacarpals and semilunar. In these regions of the body certain musculoskeletal diseases such as cervical tension syndrome, carpal tunnel syndrome, tenosynovitis and contractures are generated. As part of the ergonomic evaluation tools, the OCRA Checklist method was applied to both jobs, the results of which was of more than 22.5 points, a high risk level was obtained in both positions evaluated, reason why as action it is proposed the improvement of the position, greater medical supervision and immediate training, to avoid the risk of presenting musculoskeletal disorders. As a second method, the RULA method was selected, for which photographs were taken of the postures performed by the operators and what, in their opinion, caused a greater degree of nonconformity. The results, after making use of the mobile application, are described in figure 4.

Figure 5. Results of the application of the RULA method

In the previous figure we can see the final scores of the application of the RULA method being for operator 1 a value of 7 which means that urgent changes must be made and 5 for operator 2 which makes it necessary to carry out research activities. After obtaining the results of the ergonomic evaluations and concluding that a change is needed immediately for the presses, some improvement proposals were developed like changing the manual presses to pneumatic presses, these presses were quoted with a high cost, nevertheless it is known that the cost-benefit is of great importance, for which it was implemented, being necessary to make changes in the work instructions, where it was established how the operation should be performed for the correct management of the same. The flexible adaptation of the workstations was implemented, so that they are easily adapted to the worker depending on their height, for it was made a prototype of workstation, which will be easily adapted to the operator; As part of continuous improvement, greater involvement of staff and work teams should be promoted in any situation that may arise. Finally, a document was drawn up in which the comparative of the efficiency indicator and the ergonomic risk factors were elaborated once the evaluation methods and the implementation of improvements were applied (see Table 1).

Table 1. Comparison of results before and after implementation of improvements

Operational indicator	Before	After	Improvement
Efficiency	71%	83%	12% +
	130 p/h	152 p/h	22 pieces
Ergonomic Factors	**Before**	**After**	**Improvement**
OCRA	84.3	14.3	Si
	36	13.5	Si
RULA	7	4	Si
	5	2	Si

As shown in the table, the efficiency indicator shows an increase of 12 percentage points, a marked improvement in the second evaluation of the OCRA Checklist and the RULA method, which represents a decrease in ergonomic risk factors. It is important to note that the indicators can improve over time, however, only the method implementation period was considered.

5. DISCUSSION/ CONCLUSIONS

When the results were obtained, it was possible to conclude that the objective was satisfactorily fulfilled, since different ergonomic evaluations were applied, and the skeletal risk factors were significantly reduced, providing ergonomic evaluation improvements in the workstations and a better comfort for the operators, eliminating future risks, the inconvenience of them and the increase of efficiency. Ergonomic evaluation is highly relevant to strengthen the economic development of companies since it encompasses both the protection of lives and the reduction of costs caused by musculoskeletal risk factors. The implementation of an ergonomic culture in the companies would be ideal for the development of the same ones as they would be carried out continuous ergonomic evaluations, taking preventive measures for the elimination of ergonomic risks and personal awareness.

6. REFERENCES

Andrade, A. 2014. Determinantes del mercado importador y ensamblador de vehículos ecuatorianos, período 2002- 2012.

Avila C. Rosalio. 2014. Metodos y Tecnicas para el Analisis Ergonomico del Puesto de Trabajo. México. Universidad de Guadalajara.

Carbajal, Y. y Jesús, L. de. 2013. El sector automotriz en México, un análisis regional, en Pablo Mejía Reyes (coord.), Fluctuaciones cíclicas y crecimiento económico en México, Plaza y Valdés Editores, México.

Forbes México. 2015. México ocupa el octavo lugar en producción automotriz. Recuperado de: https://www.forbes.com.mx/mexico-ocupa-el-octavo-lugar-en-produccion-automotriz/#gs.0K2RhAY

Instituto Mexicano del Seguro Social. 2013. Memoria estadística 2013. Recuperado el 28 de Enero del 2015 de http://www.imss.gob.mx/conoce-al-imss/memoria-estadistica-2013

Prado, L. Lilia R. 2003. Factores ergonómicos en las lumbalgias ocupacionales: Un estudio de casos y controles. México. Editorial Universidad de Guadalajara.

ERGONOMIC EVALUATION OF THE SANDING TASK AT A CAR BODY SHOP

Andrea Ávalos, Arturo Realyvásquez, Alejandra Arana

Department of Industrial Engineering
Technological Institute of Tijuana
Calzada Tecnológico S/N
Tijuana, Baja California 22414
Corresponding author's e-mail: aavalos668@gmail.com

Resumen: Diferentes factores de riesgo laboral (posturas incómodas, movimientos repetitivos, manejo manual de cargas, condiciones ambientales, contaminantes, etc.) están presentes en diferentes tareas de trabajo. Esto puede provocar desórdenes músculo-esqueléticos (DMEs) en los trabajadores. Una de las tareas que cuentan con la presencia de dichos factores de riesgo es la tarea de lijado de automóviles. Es por ello que esta investigación está enfocada en determinar el nivel de riesgo ocasionado por las posturas, los movimientos repetitivos, y las condiciones ambientales presentes en dicha tarea. Para ello se aplicaron los métodos REBA y JSI. Los resultados indicaron una puntuación REBA de 8, 9 y 10 en tres diferentes posturas evaluadas, mientras que la puntuación JSI fue de 81. Todo esto indica que la tarea representa un alto riesgo para los trabajadores, favoreciendo la aparición de DMEs a largo plazo. Por lo anterior, se recomienda implementar mejoras lo antes posible para disminuir el nivel de riesgo en dicha tarea.

Palabras clave: Evaluación ergonómica, REBA, JSI, posturas, movimientos repetitivos

Abstract: There are different labor risk factors (uncomfortable postures, repetitive movements, manual material handling, environmental conditions, pollutants, etc.) in different work tasks. These may cause musculoskeletal disorders (MSDs) in employees. One ask where these risk factors are present is the task of sanding a car. For this reason, this research is aimed to define the risk level provided by postures, repetitive movements, and environmental conditions in such task. To achieve this, the REBA and JSI methods were applied. Results showed REBA scores of 8, 9 and 10 for three different postures analyzed, and a JSI of 81 for repetitive movements. All this means that the task represents a high risk for employees, and facilitates the appearance of MSDs at long term. Then, some improvements are recommended to implement and decrease the risk level provided by this specific task.

Keywords: Ergonomic assessment, REBA, JSI, postures, repetitive movements

Relevance to Ergonomics: This research is relevant to Ergonomics since it explores, analyzes and displays evidence that risk factors exist not only in large manufacturing companies, but also in small and medium-sized enterprises (SMEs), such as car body shops, which are very forgotten by ergonomists. In addition, this research may be the beginning to implement ergonomic improvements that help decrease the risk factors in SMEs. Then, publication of this article is important, since it can help ergonomist and SMEs perform researches to decrease risk factors and provide comfort, health and safety to employees.

1. INTRODUCTION

Ergonomics is defined as the science of fitting the job to the worker or the art of matching job demands with worker capabilities (Stave, 2016). Most ergonomics researches are conducted in large manufacturing companies, as workers in them are exposed to different risk factors, such as uncomfortable postures of the body segments (Deros, Daruis, Ismail, & Rahim, 2010; Maldonado-Macías, Realyvásquez, Hernández, & García-Alcaraz, 2015), repetitive movements (Ardila & Mauricio, 2013; Deros, Daruis, Ismail, Sawal, & Ghani, 2010; Ruvalcaba-Torres et al., 2016), manual material handling (Caicedo, Manzano, Gómez-Vélez, & Gómez, 2015), psychosocial factors (Vandergrift, Gold, Hanlon, & Punnett, 2012), and the interaction with a variety of machinery (Maldonado, García, Alvarado, & Balderrama, 2012) and manual tools (Kee & Lee, 2012).

All these risk factors favor the appearance of musculoskeletal disorders (MSDs), which are one of the most common causes of occupational injuries that appear in back, neck and upper and lower limb mainly (Zamanian, Salimian, Daneshmandi, & AliMohammadi, 2014). However, workers in small enterprises are not exempt from work risks (Arias-Gallegos & Jiménez-Barrios, 2013; Diaz-Lima, 2000), so they can also suffer MSDs because of uncomfortable postures, repetitive movements or other factors. Such is the case of workers in a car body shop, specifically those workers who perform the task of sanding, who are forced to perform repetitive movements and to adopt uncomfortable positions to perform such task. In addition, they are also exposed to unfavorable environmental conditions and to different chemical contaminants. All these factors can favor the appearance and development of injuries and diseases in workers.

2. OBJECTIVES

Based on the backgrounds stated above, this article focuses on analyzing the task of sanding a car in a car body shop located in the city of Tijuana, Mexico. This task is evaluated to determine the risk level caused by the postures that the worker adopts, as well as by the repetitive movements that he / she performs.

3. LITERATURE REVIEW

3.1 REBA method

The Rapid Entire Body Assessment (REBA) method is a postural analysis tool sensitive to musculoskeletal risks that can be applied in a variety of tasks (Ansari & Sheikh, 2014). It is used to assess the risk exposure associated with MSD's based on the posture of the operator at work. REBA considers the body postures adopted by the employees during physical work, distinguishing the following body segments: trunk, neck, legs, upper arms, lower arms and wrists. Also, REBA includes load/force required, hand-object coupling used and an activity score (static postures held repetition, large rapid changes in postures, or unstable base) (Lasota, 2014). According to the posture of each body segments, the REBA method assigns them a score associated with the risk level generated by the posture. The higher the score, the higher the risk level of the posture of the body segment. It is showed that a REBA assessment provides a quick and systematic result of the complete body postural risk for a worker. It is labeled as a better tool for the whole body, for static, dynamic, and rapidly changing postures (Suman, Orchi, & Debamalya, 2015). Then, REBA aggregates all the scores to obtain a final score. This final score represents the general risk level of the task analyzed. Then, the REBA method provides action levels to decrease the risk level. Table 1 shows the different REBA scores, and their associated risk levels and action levels (Ergonautas.upv.es, 2017; Singh & Singh, 2014).

Table 1. REBA scores and their associated risk and action levels

REBA score	Risk level	Action level
1	Negligible	No action required
2-3	Low	Action can be required
4-7	Medium	Action is required
8-10	High	Action is required as soon as possible
11-15	Very High	Action is required immediately

3.2 JSI method

According to (Chiasson, Imbeau, Aubry, & Delisle, 2012),the Job Strain Index (JSI) method is a technique that quantifies exposure to MSD risk factors for the hands and wrists. It provides an index that takes into account the level of perceived exertion, duration of effort as a percentage of cycle time, number of efforts, hand and wrist posture, work speed and shift length. Also, (Diego-Mas, 2015) states that the method is based on the measurement of six variables, which once evaluated, give rise to six factors multipliers of an equation that provides the Strain Index. This value indicates the risk of occurrence of disorders in the upper limbs, the greater the risk the higher the index. This author points out that variables to be measured by the evaluator are:

1) the intensity of the effort, 2) the duration of the effort per work cycle, 3) the number of efforts performed in a minute of work, 3) the deviation of the wrist from the neutral position,4) the speed with which the task is performed and the duration of the task per working day. JSI values <= 3 indicate that the task is probably safe, whereas JSI values >= 5 indicate that the task is related to MSDs in upper limbs.

4. METHODOLOGY

Methodology presented in this research is transversal and non-experimental. Following sections describe the materials used in this research, as well as the different stages in which methodology is divided.

4.1 Materials

For this study, the following materials were used:

- Video/photo camera.
- Software online (Ergonautas.upv.es)
- Acer Aspire laptop computer

4.2 Method

4.2.1 Subjects

In this research, only one volunteer employee was included. The employee was a 44-year-old man who had 26 years of experience in sanding. The work shift lasted 9 hours, from which 2 hours were dedicated to the task of sanding every day.

4.2.2 Procedure

Methodology applied in this research is divided into seven stages. Figure 1 shows the different methodology stages. These stages are described below.

Stage 1. Task Capture. At this stage photos and videos of the sanding task were taken. This was made to capture the different postures and movements that perform workers, as well as the duration of such movements.

Stage 2. Selection of postures to be evaluated. At this stage, and based on the information obtained in Stage 1, authors selected the more critical postures adopted by the worker, as well as repetitive movements. This selection was done by visual analysis.

Stage 3. Evaluation of postures and repetitive movements. Once more critical postures and repetitive movements were selected, they were evaluated using the ergonomic methods. The REBA method was used to evaluate the postures.

Authors decided to use this method since it has the following advantages (Hignett & McAtamney, 2000; Maldonado-Macías et al., 2015):

1) It provides a scoring system for muscular activity due to static, dynamic, rapidly changing and unstable postures.

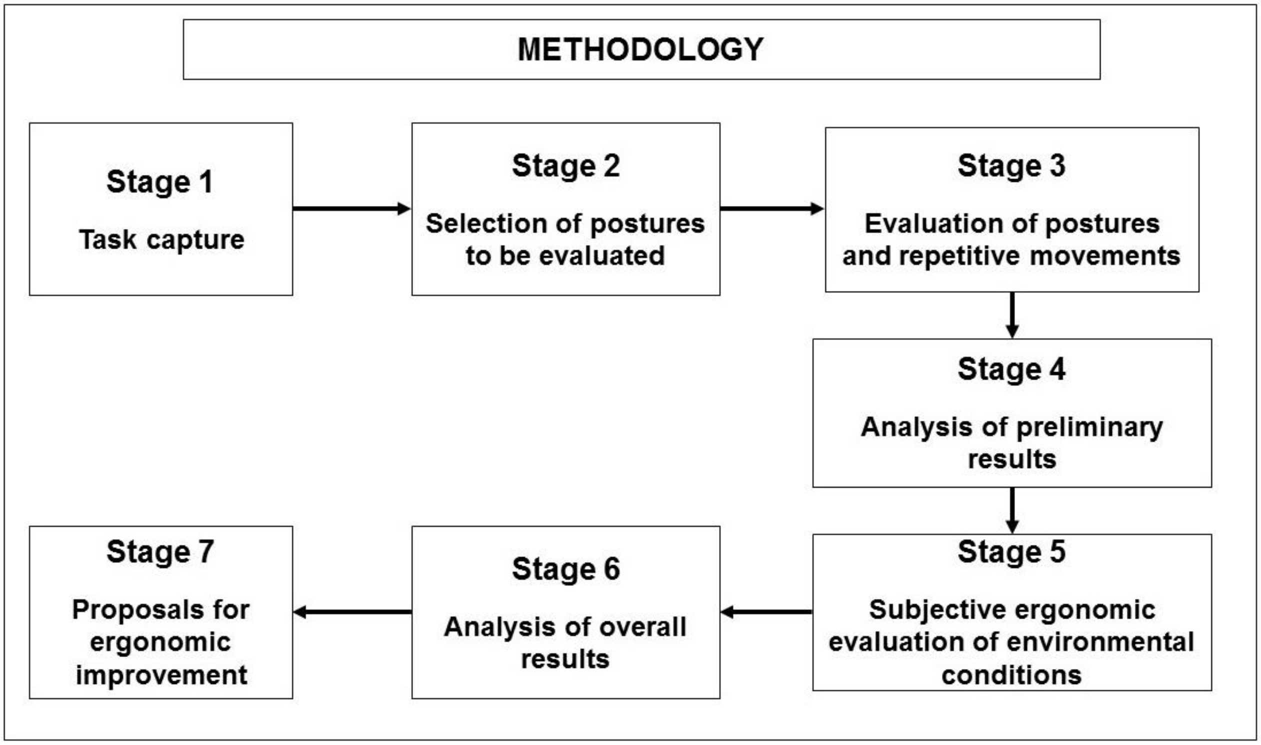


Figure 1. Methodology and its different stages

2) it also provides an action level with and urgency indication that helps find what kind of ergonomic interventions must be implemented.

3) it is not time and resources consuming.

Angles of postures were determined using the tool of RULER, and then the risk level of the task was determined by means of the REBA method. Both tool, RULER and REBA, were applied on the platform of Ergonautas.upv.es.

In the case of repetitive movements, these were evaluated by means of the JSI method. Authors applied this method due to it is one of the most widely used to evaluate the risk level derived from repetitive movements of hands and wrists. As the other methods, the JSI was applied using the platform of Ergonautas.upv.es.

Stage 4. Analysis of preliminary results. At this stage the results obtained by applying the above-mentioned methods (REBA, and JSI) are analyzed, and the level of risk derived from postures and repetitive movements is determined. In addition, action levels are defined to implements improvements that help decrease the risk level associated with the task of sanding.

Stage 5. Subjective ergonomic evaluation of environmental conditions. At this stage, the environmental conditions of the car body shop are evaluated. To do this, a survey will be carried out to obtain information on how workers perceive the physical conditions and pollutants to which they are exposed inside the car body shop.

Stage 6. Analysis of overall results. This stage analyzes the results obtained on the risk level caused by the worker's postures and the repetitiveness of his movements, as well as the results on the environmental conditions and the contaminants with which the worker interacts, thus determining the global risk level to which the workers of the task of sanding are exposed.

Stage 7. Proposals for ergonomic improvement. Based on the results analysis developed in the previous stage, improvements are proposed, both in the design of the task and in the environmental conditions. It is hope that these proposals, if they are implemented, help improve the worker's health and safety, as well as his work performance.

5. RESULTS

This section presents the results obtained from the ergonomic analysis of the task of sanding, both for postures and repetitive movements.

5.1 Results from postural analysis

Figure 2 shows some of the most uncomfortable postures that the employee adopted when he performed the task of sanding. For posture A, result indicated a REBA score of 8, which means that the risk level is high. Then, according to Table 1, it is required an action level of 3: action is required as soon as possible.

For posture B, a REBA score of 9 was obtained. Therefore, the risk level associated to this posture is high, and the action level is 3: action is required as soon as possible. Finally, for posture C, the REBA score was 10, which belongs to the same category as the previous scores.

5.2 Results from repetitive movements analysis

Respect the analysis of repetitive movements, the JSI was 81, which means that the task of sanding has a high-risk level for the employee’s health.

Figure 2. Posture adopted by the employee during the task of sanding

Respect the environmental conditions and pollutants, the employee mentioned that due to the nature of the task, they are always exposed to humidity, even in cold weather, since they need water to work. Respect the noise, the employee said that the most annoying noise comes from cars that circulate along the road.
In addition, employees are exposed to different chemical pollutants, such as H315, H319, H350, H3600, which can cause various health damages such as skin irritation, eye irritation, genetic defects, cancer, organ damage, among others (Guardino, 2010). Moreover, the surveyed employee said that they do not use mask and lens when perform the task.

In addition to these risk factors, we detect that employee did not wear safety footwear, which can favor the risk factors.

6. CONCLUSIONS AND RECOMMENDATIONS

After the results obtained, we conclude that the task of sanding is a high-risk level task. Risk factors are multiple: body segments' postures, repetitive movements, and environmental conditions. All of these risk factors may cause MSDs and other diseases that may be fatal for the employee. Then company must implement ergonomic improvements to redesign the task and decrease the risk level associated with it as soon as possible.

Following recommendations are given to decrease the risk level of the analyzed task:

1. Perform the task using an electric sander.
2. Always use lens, nose and mouth masks, gloves and safety foot wear.
3. For performing the tasks at high and low altitudes, we recommend to use car lifts and benches, respectively

Table 2 shows the before and after improvements are implemented, however, it is decision of the company to implement these recommendations.

Table 2. The before and after the implementation of the proposed improvements

Improvement	Before	After
1	Repetitive movements are frequent	Repetitive movements will be rare
2	Employees are exposed to pollutants, humidity and safety accidents	Employees will be protected against pollutants, humidity and accidents
3	Employees are forced to adopt uncomfortable postures	Employees will adopt more comfortable postures

7. REFERENCES

Ansari, N., & Sheikh, M. (2014). Evaluation of work Posture by RULA and REBA: A Case Study. *IOSR Journal of Mechanical and Civil Engineering*, *11*(4), 18–23. Retrieved from www.iosrjournals.org

Ardila, C., & Mauricio, R. (2013). Riesgo ergonómico en empresas artesanales del sector de la manufactura, Santander. Colombia. *Med. Segur. Trab*, *59*(230), 102–111.

Arias-Gallegos, W., & Jiménez-Barrios, N. (2013). Relaciones humanas en mypes de Arequipa. *Contabilidad Y Negocios*, *16*(8), 48–60.

Caicedo, A., Manzano, J., Gómez-Vélez, D., & Gómez, L. (2015). Factores de Riesgo, Evaluación, Control y Prevención en el Levantamiento y Transporte Manual de Cargas. *Revista Colombiana de Salud Ocupacional*, *5*(1), 5–9.

Chiasson, M.-È., Imbeau, D., Aubry, K., & Delisle, A. (2012). Comparing the results of eight methods used to evaluate risk factors associated with musculoskeletal disorders. *International Journal of Industrial Ergonomics*, *42*(5), 478–488. http://doi.org/10.1016/j.ergon.2012.07.003

Deros, B., Daruis, D., Ismail, A., & Rahim, A. (2010). Work Posture and Back Pain Evaluation in a Malaysian Food Manufacturing Company. *American Journal of Applied Sciences*, *7*(4), 473–479.

Deros, B., Daruis, D., Ismail, A., Sawal, N., & Ghani, J. (2010). Work-Related Musculoskeletal Disorders among Workers' Performing Manual Material Handling Work in an Automotive Manufacturing Company. *American Journal of Applied Sciences*, *7*(8), 1087–1092. http://doi.org/10.3844/ajassp.2010.1087.1092

Diaz-Lima, C. (2000). Condiciones de Trabajo e Impacto Ambiental en la Pequeña y Microempresa. *Revista de La Facultad de Ciencias Económicas*, *4*, 19–30.

Diego-Mas, J. (2015). Evaluación de la repetitividad de movimientos mediante el método JSI. Retrieved April 1, 2017, from http://www.ergonautas.upv.es/metodos/jsi/jsi-ayuda.php

Ergonautas.upv.es. (2017). Método REBA Rapid Entire Body Assessment. Retrieved January 4, 2017, from http://www.ergonautas.upv.es/metodos/reba/reba-ayuda.php

Guardino, X. (2010). Regulación UE sobre productos químicos (II). Reglamento CLP: aspectos básicos. *Instituto Nacional de Seguridad E Higiene En El Trabajo*, pp. 1–8.

Hignett, S., & McAtamney, L. (2000). Rapid Entire Body Assessment (REBA). *Applied Ergonomics*, *31*(2), 201–205. http://doi.org/10.1016/S0003-6870(99)00039-3

Kee, D., & Lee, I. (2012). Relationships between subjective and objective measures in assessing postural stresses. *Applied Ergonomics*, *43*, 277–282. http://doi.org/10.1016/j.apergo.2011.06.002

Lasota, A. (2014). A REBA-Based Analysis of Packers Workload: A Case Study. *Scientific Journal of Logistics*, *10*(1), 87–95. Retrieved from http://www.logforum.net/vol10/issue1/no9

Maldonado-Macías, A., Realyvásquez, A., Hernández, J., & García-Alcaraz, J. (2015). Ergonomic assessment for the task of repairing computers in a manufacturing company: A case study. *Work*, *52*(2), 393–405. http://doi.org/10.3233/WOR-152118

Maldonado, A., García, J. L., Alvarado, A., & Balderrama, C. O. (2012). A hierarchical fuzzy axiomatic design methodology for ergonomic compatibility evaluation of advanced manufacturing technology. *The International Journal of Advanced Manufacturing Technology*, *66*(1–4), 171–186. http://doi.org/10.1007/s00170-012-4316-8

Ruvalcaba-Torres, J., Gómez-Bull, K., Méndez-González, L., Ibarra-Mejía, G., Realyvásquez, A., & Hernández-Ramos, M. (2016). Evaluación de nivel de riesgo ergonómico en la estación de cepillado de molde. *CULCyT*, *59*(13), 236–243.

Singh, T., & Singh, J. (2014). Ergonomic Evaluation of Industrial Tasks in Indian Electronics Industries. *International Journal of Science and Research*, *3*(7), 1056–1059. Retrieved from www.ijsr.net

Stave, G. (2016). *Physical and biological hazards of the workplace*. (G. Stave & P. Wald, Eds.) (3rd ed.). New Jersey: John Wiley & Sons.

Suman, N., Orchi, B., & Debamalya, B. (2015). Analysis of Posture of Rickshaw Pullers Using REBA and Suggestion for Change in Design. *Ergonomics for Rural Development*, 406–412. Retrieved from http://inet.vidyasagar.ac.in:8080/jspui/bitstream/123456789/197/1/49.Analysis of Posture of Rickshaw Pullers Using_enc.pdf

Vandergrift, J., Gold, J., Hanlon, A., & Punnett, L. (2012). Physical and psychosocial ergonomic risk factors for low back pain in automobile manufacturing workers. *Occup Environ Med*, *69*, 29–34. http://doi.org/10.1136/oem.2010.061770

Zamanian, Z., Salimian, Z., Daneshmandi, H., & AliMohammadi, Y. (2014). The REBA technique Ergonomic Assessment of Musculoskeletal Disorders Risk Level among Midwives of Shiraz State Hospitals. *The Journal of Urmia Nursing and Midwifery Faculty*, *12*(1), 24–18. Retrieved from http://unmf.umsu.ac.ir/browse.php?a_code=A-10-749-2&slc_lang=en&sid=1

ERGONOMIC RESEARCH WITH OWAS, RULAS AND ERGOTEC METHODS IN CARPENTERS OF THE CITY OF LOS MOCHIS, SINALOA

Luis Armando Valdez, Alberto Ramírez Leyva, Raúl Armando López Verdugo, Ramón Alberto Barrón Romero, Jordan Josue Arroyo Carrillo

Industrial Engineering department
M.S. Engineer and Professor
Institute Technologic of Los Mochis
Los Mochis, Sinaloa
lvaldez_888@yahoo.com.mx

Resumen: el presente trabajo muestra los resultados de una investigación ergonómica realizada a carpinteros de la ciudad de Los Mochis, Sinaloa durante el periodo de diciembre y enero de 2017 con una duración de tres semanas, apoyado en tres métodos de evaluación subjetivos que son OWAS, RULA Y ERGOTEC que miden los puestos de trabajo, para saber si están provocando daños en la persona y poder proponer alternativas y mejoras para reducir las fuentes de daños o si es posible eliminarlos. Para medir las posturas en el lugar de trabajo se utilizó los métodos OWAS Y RULA que miden el nivel de esfuerzo por el cambio de posturas y levantamiento de objetos durante el trabajo. Por otro lado se utilizó ERGOTEC para medir el nivel de desgaste metabólico, presencia de DTA, nivel de dificultad de manejo de materiales y nivel de complejidad de la ejecución de las tareas. Los resultados obtenidos en esta investigación fueron analizados estadísticamente, los cuales mostraron que existe suficiente evidencia de que si se presenta daño laboral de tipo físico en los carpinteros de la ciudad de Los Mochis, Sinaloa.

Palabras clave: Carpinteros, OWAS, RULA, ERGOTEC

Abstract: The present work shows the results of an ergonomic investigation realized to the carpenters from the city of Los Mochis Sinaloa during the period of December and January of 2017 with a duration of three weeks, supporting in three evaluation methods that are OWAS, RULA and ERGOTEC subjective Which measures jobs, to know if they are causing damages in the person, to be able to propose alternatives and improvements to reduce the sources of damages or even if it is possible to eliminate them. In order to measure the postures in the workplace, the OWAS AND RULA methods were used to measure the level of effort by changing postures and lifting objects during work. By other way, ERGOTEC was used to measure the level of metabolic attrition, presence of DTA, level of difficulty of material handling and level of complexity of task execution. The results obtained in this investigation were statistically analyzed, which showed that there is enough statistical evidence collected during the three weeks to say that if there is physical damage to the carpenters in the city of Los Mochis Sinaloa.

Key words: Carpenters, OWAS, RULA, ERGOTEC.

Ergonomic importance: This research will facilitate largely to the analysis of the work in the area of carpentry, which makes it possible to evaluate and consider proposals for the resolution of problems. It is intended to detect possible signs of injuries and problems that may cause in the medium and long term. In this way, create a basis to lessen these problems by improving job positions.

1. INTRODUCTION

For a few years, carpentry has been considered a heavy and exhausting job, this is because the activities are performed without be measured, bad postures, repetitive movements and intensive efforts, however, there has not been an appropriate analysis that allows to measure the exact damages, then to perform an improved work. For the reason, the present investigation provides a real evaluation of the conditions in which they work in Los Mochis, Sinaloa, they carry out their daily activities, also, they establish a margin that allow to make a redesign of the work.

2. OBJECTIVES

2.1 General objective

Evaluate and register a date basis that shows the ergonomic risk that have the carpenters from the city of Los Mochis, Sinaloa, by the methods: OWAS, RULA and ERGOTEC.

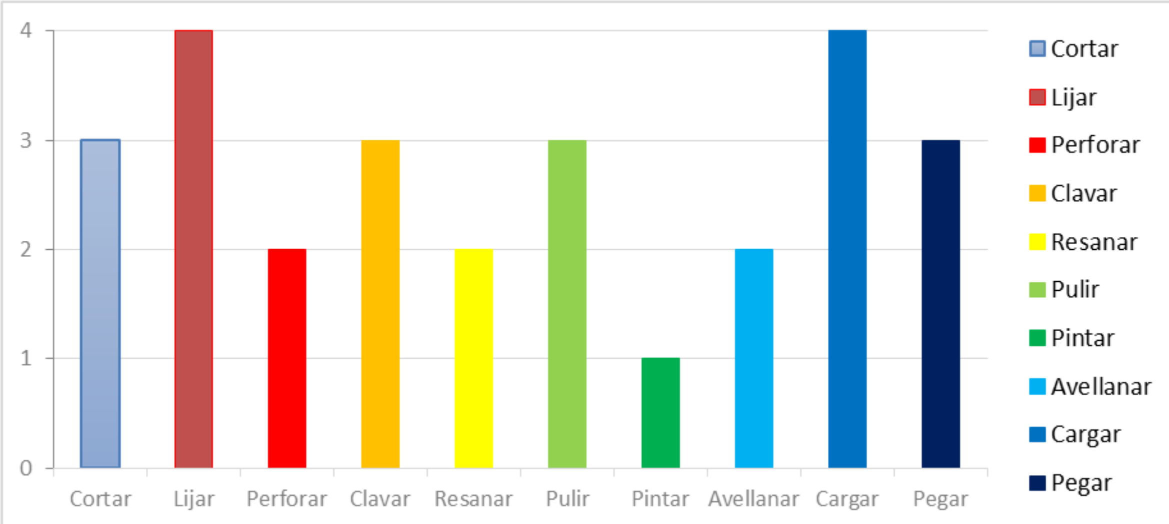
2.2 Specific objectives

1. Identify carpenters's main activities.
2. Perform evaluation OWAS, RULA and ERGOTEC.
3. Register and analisy results registered in *Microsoft Excel©*.
4. Identify high-risk activities to redesign the work area.

3. METHODOLOGY

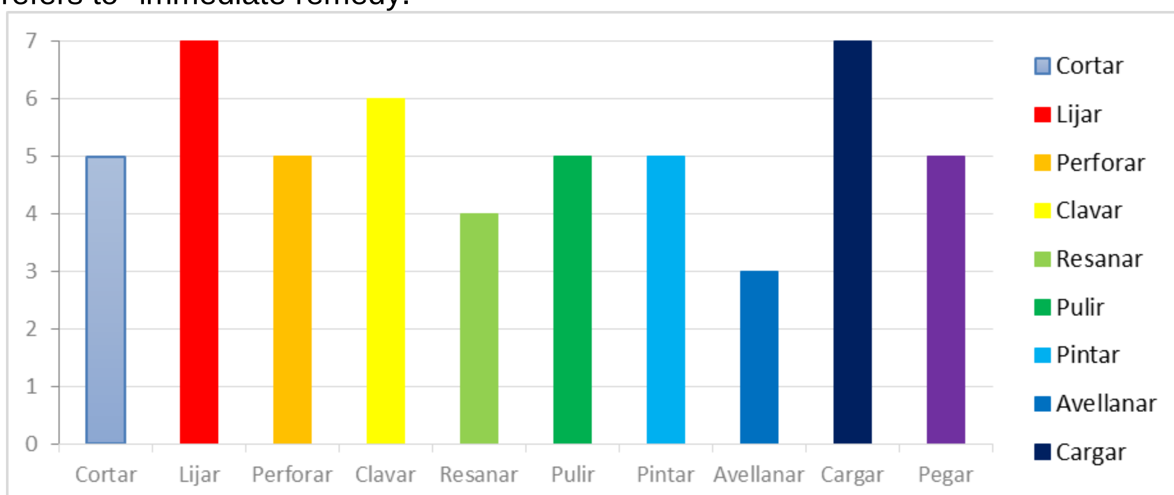
The ergonomics evaluations OWAS, RULAS and ERGOTEC were carried out to determine the main damages of carpenters of Los Mochis, Sinaloa. For such evaluations a field investigation was carried out which consists mainly of the observation of each activity, as well as make notes, oral questions, and photographs. This is due to the fact that the results of the research tools are considered reliable, in this way, subsequently, each result obtained was recorded and analyzed.

4. RESULTS



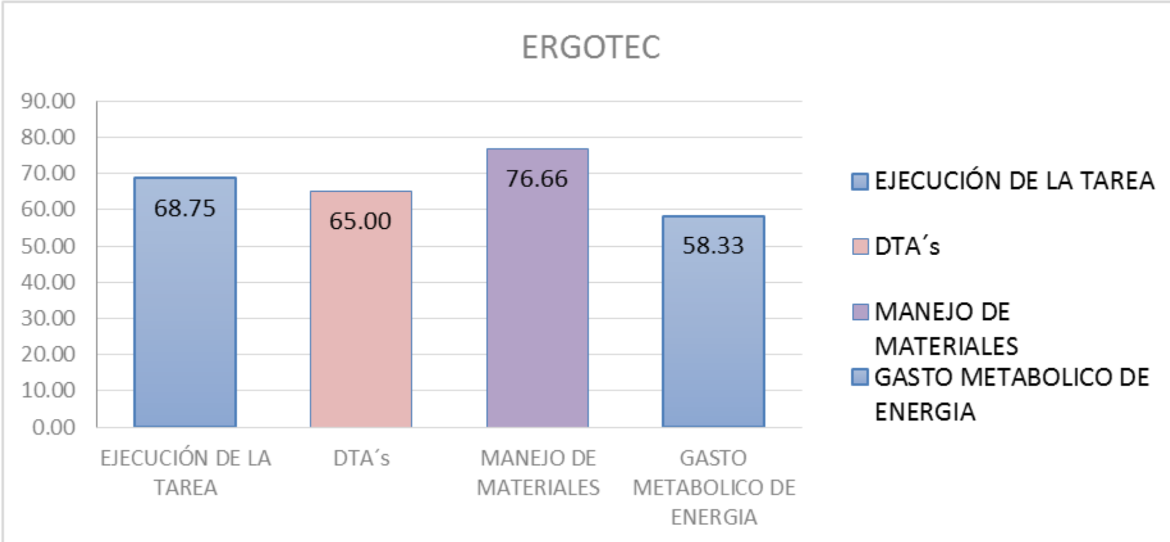
Graphic 1. OWAS METHOD

When the activities were evaluated using this method, it was found that the most harmful to the worker are sandpaper and carry, obtaining in these a 4 as a diagnostic, which refers to "immediate remedy."



Graphic 2. RULA METHOD

The application of this method was done to the activities most commonly realized by carpenters, from which it was obtained that the activities with worse positions by the worker were: nailing (final score 6), sandpaper (final score 7), and carry (final score 7); For which further research and immediate change is needed.



Graphic 3. ERGOTEC METHOD

After analizy the carpenters work with respect to their most common activities, the following conclusions is:

- At the moment of the work execution there is a 68.75% average total tabulation; Which means that the operator, surface, work area, furniture and handling, and equipment incite attrition on the worker.
- With relation to the risks of injury by DTAs the method shows a 65% average tabulation, which means that there is a prominent risk.
- There is a 76.66% of total tabulation in injuries by manual handling of materials, shows that the activities maked for a carpenter that require a movement of materials with excessive force, in a precise and complicated way.
- Finally, with relation to metabolic energy expenditure, 58.33% of the average tabulation was obtained; That shows that the worker has the capacity to maked the work but that he will experience premature fatigue.

5. CONCLUSIONS

With respect to the results obtained in the ergonomic risk evaluation in the carpenters of the city of Los Mochis Sinaloa, where they were evaluated with OWAS, RULA and ERGOTEC methods, it can be concluded that most of the activities that develop perform with inadequate postures; It is a work unsuitable task, which is not changed, and put in risk the physical health of the worker in developing their activities.

6. REFERENCES

José María Aizcorbe Sáez. Instituto Navarro de Salud Laboral. (2008). SEGURIDAD EN LA EDIFICACIÓN. 14 de marzo de 2016, de Instituto Navarro de Salud Laboral Sitio web: http://www.navarra.es/NR/rdonyres/775A941BAFBA4A&EAA9B8E84507C12C4/160204/11CarpinterosEdiCAST.pdf

Memorias IMSS 2004-2013. (2015). Información sobre Accidentes y Enfermedades de Trabajo Sinaloa 2004-2013. 10/febrero/2016, de IMSS Sitio web: http://www.stps.gob.mx/bp/secciones/dgsst/estadisticas/Sinaloa%202004-2013.pdf

Secretaría General Técnica. (2000). MOVIMIENTOS REPETIDOS DE MIEMBRO SUPERIOR. 14 de marzo de 2016, de COMISIÓN DE SALUD PÚBLICA, CONSEJO INTERTERRITORIAL DEL SISTEMA NACIONAL DE SALUD Sitio web: http://www.msssi.gob.es/ciudadanos/saludAmbLaboral/docs/movimientos.pdf.

EVALUATION OF ERGONOMIC RISK IN VULCANIZERS FROM LOS MOCHIS, SINALOA.

Alberto Ramírez Leyva, Luis Armando Valdez, Karina Luna Soto, Blanca Daniela Inzunza Reyes, Juan de Dios Lugo Montoya

Department of Industrial Engineering
Technological Institute of Los Mochis
Los Mochis, Sinaloa Boulevard Juan de Dios Batiz
Los Mochis, Sinaloa, Mexico

Alberto_ramirez_leyva@yahoo.com, lvaldez_888@yahoo.com.mx, karinaluna1@yahoo.com, daniela_inzunza_r@hotmail.com, juandd_343@hotmail.com

RESUMEN: En la presente investigación se buscará medir los niveles de riesgo ergonómico en los vulcanizadores de Los Mochis, Sinaloa. Dicha evaluación se realizará mediante la aplicación de los métodos Rula, Owas y Ergotec. Estos métodos demostraron la existencia de riesgos en los vulcanizadores, y esto es debido a las actividades que realizan en sus rutinas diarias de trabajo, las cuales incluyen movimientos repetitivos que requieren de mucho esfuerzo además de posiciones inadecuados de trabajo. Como resultado se demuestra la existencia de riesgos ergonómicos para esta actividad laboral.

PALABRAS CLAVE: Vulcanizadores, Rula, Owas y Ergotec.

RELEVANCIA PARA LA ERGONOMÍA:

- Aporta un punto de referencia para futuras investigaciones
- Busca dar mayor facilitación de información
- Proporciona datos reales de una evaluación ergonómica

ABSTRACT: In the present investigation it is tried to measure the levels of ergonomic risk in vulcanizers of Los Mochis, Sinaloa. This evaluation is done by applying the Rula, Owas and Ergotec methods. These methods demonstrate the existence of risks in the vulcanizers, and it is due to the activities they perform in their daily work routines, victims of repetitive movements that require a lot of effort in addition to inappropriate work positions. As a result of the demonstration of the existence of ergonomic risks for this work activity.

KEYWORDS: Vulcanizer, Rula, Owas and Ergotec

RELEVANCE FOR ERGONOMICS:

- Provides a benchmark for future research
- Seeks to provide more information
- Provides real data of an ergonomic evaluation

1. INTRODUCTION

At present, conducting studies that allow the evaluation of the worker's activities provides the security that he needs to carry out his work, as well as the knowledge to do it in the right way. The vulcanizer, when carrying out a heavy, repetitive and inappropriate work, is exposed to repercussions on the body and therefore not able to lead a full life. This research that followsis the reason to evaluate the conditions under which the worker performs and establish the references to have a margin that allows the redesign of the work.

2. JUSTIFICATION

Given the importance of the use of cars, trucks and tractors today, the breakdown of a tire can cause problems for users. Hence the importance of the work performed by vulcanizers to give them response and attention. However, this activity is not very safe since it has different ergonomic risks present.

3. GENERALOBJECTIVE

To evaluate the ergonomic risk to which vulcanizers are exposed using the Owas, Rula and Ergotec method.

4. SPECIFIC OBJECTIVE

- Determine positions that cause an ergonomic risk.
- Establish a database for future use.
- Determine the need to carry out a redesign of activities.
- Evaluate work activities and determine the highest risk.

5. DELIMITATION

Application of evaluation of ergonomic risks in vulcanizers of the city of Los Mochis, Sinaloa.

6. REFERENCE FRAMEWORK

The accumulation of fatigue in vulcanizadores is due to a series of activities that they carry out in their work activities; these include the manipulation of objects of unconventional dimensions and relatively heavy for the amount of movements that realize.

The methods of work plus the handling of heavy objects can cause injuries and fatigue in vulcanizadores, as mentioned by Guzmán(2013)"Verification of the relationship ercentile-maximum lifting load, tabulated in liberty mutual tables, for man and woman young” And Ramírez(2016) in the article" Determination of possible CTD'S in vulcanizing Los Mochis, Sinaloa "both papers show That there is existence of risks, so that there arises the need to analyze the working methods in vulcanizadores of Los Mochis, Sinaloa.

7. METHODOLOGY

In this research project the evaluation of the working method used by vulcanizers in the task of repairing tires was carried out, it was analyzed by the RULA, OWAS and ERGOTEC methods because they allow to obtain reliable information on the different positions, activities and movements.

There are conditions in the tire repair process in which the worker is subjected to inappropriate positions, incorrect environmental conditions, excessive loads and therefore, health risks. Vulcanizers are developed under the following conditions:

Environmental conditions:

- The work to be carried out is developed in an uncontrolled environment, where the temperature, light, surface and other conditions do not comply with the necessary measures.
- The workload is sporadic, with a low repetition rate.
- The work surfaces are not conditioned to the worker neither to standardized measures.
- The work area does not have the basic conditions, such as visual or safety aids.
- The tools are poorly distributed and located beyond the worker's reach.

Image 1: Working surface

Positions:

Image 2: Disassembler posture

Imagen 3: Disassembly posture

- There are different parts in the process of tire repair where the worker operates in non-neutral positions

- When performing tasks the vulcanizer arms exceed 45 degrees
- The wrists are positioned over 15 degrees repeatedly
- Neck exceeds 20 degrees
- The back is located between 20 and 60 degrees during the entire process of changing, unpacking and relocating the tire

Loads:

Image 4: Disassembler loads

- The handling of heavy materials is done manually and without any protection, the load kilograms can be between 25 and 35.
- The loads are carried over considerable distances
- No tools are used to help with the load

Within the investigation were found critical characteristics in the process, documented and evaluated in the respective methods as shown in the results.

8. RESULTS

After analyzing the aforementioned positions and conditions, the following results were obtained:

RULA:

Table 1: Results of the RULA method

A. Arm and wrist analysis		B. Neck, trunk and leg analysis	
Locate upper arm position	+3	**Locate neck position**	+3
Locate lower arm position	+3	**Locate trunk position**	+3
Locate wrist position	+3	**Legs**	+2
Wrist twist	2	**Look-up posture score in table B**	5
Look-up posture score in table A	4	**Add muscle use score**	0
Add muscle use score	0	**Add force/load score**	+2

Acid force/load score	+2	**Find column in table C**	7
Find row in table C	7		
Final score: 7			
Investigate and change immediately			

When obtaining a final score of 7 points, the RULA method specifies that the operation to be carried out needs an investigation and immediate change to the form of work and positions in which it is incurred when performing it.

OWAS:

Table 2: Results of the OWAS method

N°	**ACTIVITY**	**BACK**	**UPPER LIMB**	**LOWER LIMB**	**LOAD**	**ACTION CAT.**
1	Fix the car	2	1	5	2	**3**
2	Select hydraulic jack location	2	1	5	2	**3**
3	Attach the hydraulic jack	2	1	5	2	**3**
4	Use hydraulic jack	4	2	5	+2	**4**
5	Remove car tire	2	1	5	+2	**3**
6	Check tire	2	2	3	+2	**3**
7	Dismantle tire from the wheel	4	2	4	+2	**4**
8	Tire repair	1	1	1	+1	**1**
9	Ride tire	4	2	3	+2	**3**
10	Put tire on car	2	2	5	+2	**4**
11	Remove hydraulic jack	1	1	5	+1	**2**
12	Save hydraulic jack	1	1	6	+1	**1**

6 activities were identified that need corrective action as soon as possible and 4 activities that need immediate corrective measures either because of the position in which they occur or the amount of weight being mobilized.

ERGOTEC:

Table 3: Results of the OWAS method

Type of task		Result
Execution of the task	Percentage	35.71%
	Tabulation	Median
Ctd´s	Percentage	34.81%
	Tabulation	Median
Material handling	Percentage	61.11%
	Tabulation	High
Energy metabolic expenditure	Percentage	51.85%
	Tabulation	Median

Finally the ERGOTEC method shows us that the sector with the greatest damage to the vulcanizer is the material handling followed by the metabolic expenditure that it suffers during the working day.

9. CONCLUSIONS

With the analysis of results obtained from the ergonomic evaluation methods RULA, OWAS and ERGOTEC in the vulcanizers of the city of Los Mochis, Sinaloa, it was demonstrated the existence of inappropriate positions and activities followed by high repetitions at the end of the working day.

RULA: According to the results obtained in this method (final score 7), an investigation and an immediate change is necessary, due to the bad positions on the part of the worker when carrying out his daily activities.

OWAS: This method was more specific in its results, highlighting stages of the process, which are the most harmful to the worker. A 4 was obtained as a diagnosis, which refers to "immediate corrective measure" mainly in the positions to use the hydraulic jack, dismantle the tire of the wheel and place the tire in the car.

ERGOTEC: once the process of repair of tires of the vulcanizer was analyzed the following results were obtained

- In the execution of the work there is a 35.71% average total tabulation, which means that the operator, surface area, work area, furniture and material handling and equipment present a wear and tear on the worker.
- With regard to the risk of injury by DTAs, the method shows a 34.81% average tabulation, which means that there is an imminent risk.
- There is a 61.11% of total tabulation in the injuries by manual handling of materials which means that the development of the work has activities of movement of objects with excessive force, precisely, difficult to grasp and heavy, this section having the highest percentage should be considered as a priority.
- Finally, in the metabolic energy expenditure, a 51.85% average tabulation was obtained, which shows that the worker can perform his tasks but that he experiences early fatigue.

It can be concluded that, taking as a reference the results of the ergonomic irrigation evaluation in the vulcanizers of the city of Los Mochis, Sinaloa subjected to the RULA, OWAS and ERGOTEC methods, there is a considerable amount of inadequate positions, as well as areas That it is necessary to consider applying a change and that there is a considerable risk to the worker in performing this task.

10. REFERENCES

Guzmán J., Vásquez J., De La Vega E., López O. (2013). Verification of the relationship: percentile-maximum lifting load, tabulated in liberty mutual tables, for man and woman young. En ERGONOMÍA OCUPACIONAL

INVESTIGACIONES Y APLICACIONES (133-137). Hermosillo, Sonora, México: Sociedad de Ergonomistas de México A.C. (SEMAC)

Ramírez A., Ruiz I., Inzunza B. y Lugo J. (2016). “Determination of possible ctd's in vulcanizing Los Mochis, Sinaloa”. En ERGONOMÍA OCUPACIONAL INVESTIGACIONES Y APLICACIONES volumen 9(299-302). Tijuana, Baja California: Sociedad de Ergonomistas de México A.C. (SEMAC).

ERGONOMIC MECHANISM FOR THE BRAIDING OF CHEESE TYPE OAXACA.

Osmar Aranda Juarez[1], Salazar P[2]., Saldaña M[1]., Rivera J[1]., Melendez N[1].

[1]Unidad Profesional Interdisciplinaria de Ingeniería Campus Guanajuato - Av. Mineral de Valenciana 200, Col. Fraccionamiento Industrial Puerto Interior, 36275 Silao de la Victoria, Gto.
[2]Escuela Superior de Ingeniería Textil-Avenida Instituto Politécnico Nacional 2047, Gustavo A. Madero, Lindavista, 07300 Ciudad de México, CDMX.

Resumen: El presente artículo propone la introducción de un mecanismo ergonómico para mejorar las condiciones la tarea de trenzado de queso tipo Oaxaca, con el fin de aumentar la productividad, disminuir el desperdicio. Los movimientos del actual método se estudiaron por medio de un diagrama bimanual, una estimación en tablas tiempo normal y el análisis por el método de postura, brindándonos un panorama amplio de la tarea en cuestión.

Seguido con esto, se propuso el mecanismo que disminuye las tareas repetitivas. El trenzado del queso únicamente con las manos y los dedos de herramientas; el mecanismo en cuestión requiere que el operador esté sentado, esté accionará el mecanismo con un pedal situado debajo de la banda transportadora; se eliminará la tarea de pesado pues el mismo mecanismo controlará el peso por medio de las revoluciones dadas, las tareas y movimientos en cuestión serán: Fijar el pabilo de queso al mecanismo, accionar el mecanismo, retirar la bola de queso. Las medidas de nuestro mecanismo están justificadas por un estudio antropométrico elaborado con la población de estudiantes de nuestra institución.

Palabra clave: Mecanismo ergonómico, Trenzado de queso, Ergonomía, Antropometría, Postura.

Abstract: This article proposes the introduction of an ergonomic mechanism to improve the conditions of the Oaxaca cheese braided, with the aim to increase the productivity and decrease the waste. The movements were studied by means of a bimanual diagram, estimate with normal time and the analysis with posture method, giving us a broad picture of this task.

Continuing with this, we propose this mechanism who decrease the repetitive tasks. To braid the Oaxaca cheese, the employees use their fingers as a tool. This mechanism requires the operator to be seated to actuate the mechanism with a pedal located under the conveyor belt; with this mechanism we can remove the heavy work since the mechanism will control the weight by the turns, the tasks and the moves will be: Fix the cheese wick to the mechanism, operate the mechanism, remove the cheese ball. The measures of our mechanism are justified by an anthropometric study elaborated with the student population of our institution.

Keyword: Ergonomic Mechanism, Cheese Braid, Ergonomics, Anthropometry, Posture

1. INTRODUCTION.

The present way to braiding the oaxaca cheese is by a manual form, the employers use their fingers as a tool to braid the cheese, but this tires the employers because is too repetitive, then the cheese ball is weighed on a scale and the excess must be removed since the cheese must have a specific weight.
We propose a new mechanism to improve the ergonomic conditions and decrease in the waste of twisting task of Oaxaca cheese at a workstation in SIGMA food. The mechanism that we show is an adaptation of Winding system, used in the textile sector.

The Winding process is the rotation of a mast at a 45 ° angle from which the beginning of the cheese wick is held, the turning of this generates a twist type coil, respecting the traditional form of this cheese; The turning of the mast is generated thanks to the connection of two horizontal gears and one vertical, which is directly related to a pedal; The movement of the mechanism generates a pedal powered by the person who is performing the task at that time.

The mechanism will have a spin count sensor, reaching the calculated number of turns it will send an auditory signal, indicating to the operator the exact moment of cutting, reducing the waste of the operation.

1.1 Importance of the ergonomy

This abstract propose to solve an ergonomic need in a work station, attacking the problems like fatigue in repetitive movements, the body posture and the productivity in the tasks, we use the ergonomic tools like OCRA and EPR, also to justify our ergonomic mechanism we have elavorated an anthropometric studio.

2. METHODOLOGY.

2.1 Analysis to the braiding.

We used differents ergonomic tools and also our knowledges of Industrial Engineering to characterize the task, identify the chances and propose improvements.

2.2 Bimanual analysis

The bimanual analysis disaggregated the operations, transitions, waits and retentions that has the right hand and the left hand when performing the task, as can be seen in Table 1.1. The two hands in total have the same number of operations, both use as their main tool their fingers, this task is repetitive generating fatigue considering that it is a continuous production line.

Table 1, Abstract bimanual diagram.

Method.	No. Operation of each hand.	
Operations.	Izq.	Der.
Transportation.	9	12
Wait.	1	0
Sostenerse.	3	2
Total.	14	14

2.3 Study of times, Zero return method.
To identify the opportunity areas that we have, we made a study of times, also we propose a percent of slack by the ILO method as can be seen in Table 2.

Table 2 Abstract of the ILO method.

Kind.	Estimated percentage.	Characteristics.
Necessity.	5.00	Applies: Go to bathroom
Básic fatigue.	4.00	Applies: To be stand.
Variable fatigue..	3.00	Applies: Repetitive works..
Especial.	0.00	
% os total slack..	12.00	

With the help of the Westinghouse qualification system and the proposed slacks we were able to consolidate a normal time for the task. In the study of times, we divided the task into two essential elements: Taking more wrapped cheesecloth and cutting and positioning.

2.4 Postural evaluation
We have made a postural evaluation of the operator on his workstation, we got a static charge of 9 and a one action level of 4, guiding us by the indicators; is necessary introduce improvements to the post, the employee can suffer strong fatigues and inconvenience, on table 3 we can appreciate better the indicator.

Table 3 Static charge indicators.

Level.	Static charge.	Risk.
1	0,1,2	Satisfactory situation.
2	3,4,5	Weak discomfort.
3	6,7	Medium discomfort.
4	8,9	Strong discomfort.Fatigue..
5	10 or more	Noxiousness.

2.5 Conclusions of the analysis tasks.

The task of cheese braiding Oaxaca in the long run will cause damage to the operator, both on his fingers and wrists as in his back because of the posture he has during long working days. Thought the bimanual diagram we can detect the operation performed by both hands, 14 methods per hand. The evaluation of the position in the provided data of the static load, through the means of the indicators shown in table 1.4 we conclude the need to adapt the workstation.

The normal time of the task is in which a qualified worker performs a job, unnecessary movements and tasks are identified. The objective of the study of times is to reduce normal time, standardize and efficient the task, it was concluded that rolling the cheese with the hands and fingers is inefficient, since it involves unnecessary movements and tired for the operator, can not be standardized nor to carry out an efficient control of the turns of wick to reach the final product; On the other hand the decline is uncontrollable.

3. PROPOSAL.

3.1 Description.

Mechanism based on "yarn roller manual" used in the textile industry for the winding of reels of thread. Our mechanism, driven by a 100A variable speed motor, will move a 15cm diameter pulley connected to a bearing, which in turn will have a food grade stainless steel structure, this will serve as a guide for braiding Of the cheese wick, will rotate and by means of sensors will count the revolutions per second and the duration time of these, this information will be sent to a controller in charge of calculating the linear quantity of twisted cheese - cheese loaves with a uniform mass - And therefore the amount in twisted grams, reaching the desired amount the circuit will stop the engine in automatic. The operator will activate the mechanism by means of an actuator pedal which will force him to be in his seat.

3.2 Mechanism parts.

1. Pulley 1. This will have a diameter of 8 cm, piece manufactured by 3D printing.

2. “Valero” This will have a diameter of 4 cm, with a speed ratio of 4: 1 in relation to the pulley 1, Part manufactured by 3D printing.
3. Guide. Connected directly to the Valero, thus having the same speed ratio
4. 4: 1 with respect to pulley 1. It will have two parts:
to. L. L-shaped piece with an angle of 130 °, with dimensions of 8 cm x 8 cm, piece of stainless steel.
B. S. Cylindrical piece with a 10 cm lard and with a diameter of 2 cm, counting with a crack to hold the top of the cheese strip on top.
5.Hook. Stainless steel bra with adjustable length, it has the function of guiding the cheese wick to the guide.
The diagram of the mechanical parts can be seen in Figure 1.1.

3.3 Ergonomics of the mechanism.
The position of the operator was defined to manipulate, to operate and to supervise the mechanism in the task of the braiding of the cheese wick. The position of the operator to operate the mechanism pedal has be seated, as shown in Figure 1.2. On the other hand, operations will decrease considerably as the only necessary operations will be the positioning of the cheese wick in the mechanism and the withdrawal of the cheese ball of the mechanism as shown in Figure 1.3.

3.4 Anthropometric studio.
An anthropometric study was carried out in the student community to obtain the most representative statistical data of the measurements of the human body involved in our mechanism, the study was carried out to 50 students, table 2.5 presents a summary of the study; In this the average, standard deviation, percentile 05 and 95 is shown.
For our mechanism to be flexible to the measures we opted for the introduction of an adaptable chair in height and sides, with this we ensure that our mechanism is suitable for most people, this analysis can be shown in figure 2.5. Is intended to cover 95.5% of measures ranging from -2 Sigma to 2 Sigma.

Table 4 Summary anthropometric study.

Element.	Mean.	standard deviation.	P95	P05
Seated height.	126.1	11.42	139.3	105.3
Leg.	44.7	8.80	52	38.4
Radial-Estiloidea.	31.9	5.53	41.9	23.2
Radial-Style.	24.9	2.24	28	23

Foot.	25.7	2.45	28.7	22.0
Acromial Radial.	32.2	2.99	36.8	28.2

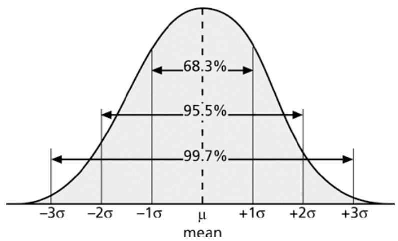


Figura 2.5 Normal curve

4. CONCLUSIONS.

The introduction of this ergonomic mechanism will improve working conditions, and 95.5% of the population will be able to use it. Ergonomics is fundamental to improve the productivity of the company, and of each operator. With this proposal it is based its importance also to show the impact that it has in all the productive elements.

5 REFERENCES

Azucena del Carmen Carrasco Martínez. (2010). Estudio ergonómico en la estación de trabajo PT0780 de la empresa S-Mex, S.A de C.V. León. México.(Consultado 28/03/2014)

Bernal, C. (n.d.). Origen y evolución de la ergonomía. Scribd. (Consultado el 24/02/2014)

Lupton Tom, Efficiency and the Quality of work life Organizational dynamics, Autum 1975.

M.E. Mundel, Estudio de Tiempos y Movimientos, Ed. Continental, 1984.

Niebel, Benjamin, Ingeniería Industrial. Estudio de Tiempos y Movimientos. Ed. AlfaOmega, 1996.

NIEBEL, Benjamín y FREIVALDS, Andris, Métodos, Estándares y Diseño del Trabajo, 10ª Edic., Ed. Alfaomega. 2001.

Prokopenko, Joseph, La gestión de la productividad, Manual práctico, Ed. Limusa, Grupo Noriega Editores, 1987.

Seisdedos Nicolás, “El clima laboral y su medida”, Revista “Psicología del Trabajo y de las Organizaciones” (Núm. 2), 1996.

vilés. (16/11/2013). Congreo aborda nuevas tecnologías en la Ergonomía. España. (Consultado el 24/02/2014)http://www.elcomercio.es/v/20131116/aviles/congreso-aborda-nuevas-tecnologias-20131116.html

PROTOTYPE HELMET FOR WELDER WITH ERGONOMIC APPROACH.

Luis Roberto Arce López, Alberto Ramírez Leyva, Jesús Iván Ruíz Ibarra, Kevin Antonio Cadena López, Ana Valeria Delgadillo Mora.

Departamento de Ingenieria Industrial
Instituto Tecnológico de Los Mochis,
Juan de Dios Batiz y 20 de noviembre s/n código postal 81259.
Los Mochis, Sinaloa, Mexico
luisarceitlm@hotmail.com, alberto_ramirez_leyva@yahoo.com,
jesus_ruiz@hotmail.com, kevinlpz.21@hotmail.com, ana_delga97@hotmail.com.

Resumen: La ergonomía es indispensable para complementar el diseño propuesto que se centra al usurario final. El mal uso de las herramientas de protección de soldadura como el casco y la careta, al paso del tiempo originan lesiones, en rostro, columna, cuello, nuca y vías respiratorias, es por eso que el prototipo de casco para soldador con enfoque ergonómico se diseñó en base a esos problemas, y lograr reducir esas lesiones causadas por el uso de cascos y caretas convencionales. Se realizaron investigaciones de los cascos y caretas que hay en la actualidad, para observar las bases existentes de estos. Como resultado obtenemos este prototipo de casco para soldador con enfoque ergonómico para promover la salud, satisfacción laboral, y calidad de vida de los usuarios.

Palabras claves: Herramienta de protección, rediseño ergonómico, salud ocupacional.

Abstract: Ergonomics is indispensable to complement the proposed design that focuses on the end user. The misuse of welding protection tools such as helmet and care, the passage of time in the ears, face, spine, neck, neck and respiratory tract, is why the prototype helmets for the welder with the ergonomic approach was designed on the basis of these problems, and reduce those injuries caused by the use of helmets and conventional masks. Investigations were carried out on the helmets and masks found today, in order to observe the existing bases of these. As a result, we get this prototype welder helmet with an ergonomic approach to promote health, job satisfaction, and most importantly the quality of life of users.

Keywords: Protection tool, ergonomic redesign, occupational health.

Relevance to ergonomics: With the results of the percentiles, obtained from Latin American people of the feminine and masculine gender, a safety tool is designed adaptable to the anthropometric measurements of the users, as well as demonstrating to the workers the importance of using ergonomic tools and Promoting constant innovation to the use of security tools.

1. INTRODUCTION.

The present prototype protective tool was developed to resolve possible ocular, cutaneous, respiratory, auditory and cranial injuries due to the risk of hot sparks, high noise generated in the work area, blows to the head, falls or slips, landslides of structures, and exposure to noxious gases.

These disorders usually appear when working in unsafe areas, improper use of the work equipment, and environmental conditions unsuitable for operation. This prototype features ergonomic redesign focused on occupational health in charge of promoting and protecting the health of workers.

1.1 GENERAL OBJECTIVE.

Design a prototype of a multifunctional tool that solves the problems of the welder caused by the use of conventional welding masks.

1.2 ERGONOMICS.

The scientific discipline is interested in the understanding of the interaction between the human beings and the elements of a system; and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance. (Ruiz, Ochoa, De la Vega, Villarreal 2009).

1.3 ANTHROPOMETRY.

Measurement science of the human body generally uses a large number of devices similar to the calipers to measure the structural dimensions, e.g. height and forearm length. (Niebel, 2004).

1.4 SAFETY HELMET.

In welding masks there are different designs, also combined with a safety helmet to carry out jobs in the workplace and with adaptations to protect the eyes when needing to clean scoria. Hand-held displays have applications in welding; its use is not convenient in high altitudes or where the operator requires his two hands to work. (Oviedo, 2013).

Figure 1: Mask with attachment to the safety helmet. (Source: Oviedo, 2013).

2. METHODOLOGY.

The elaboration of this prototype arose through the considerations that were reflected in a welder when observing how it elaborated a protection of window inside a small workshop of cut and weld, supporting themselves on their security equipment conformed by a mask with dark lenses and a pair of gloves. It was observed that the person presented irritation in the skin around the neck, and signs of intoxication due to smoke inhalation, showing as a symptom a series of constant cough, eye irritation, excessive sweating in the area of the face, complication when breathing, and discomfort in the ears due to the external noise produced by cutting pieces in the place.

The reason for these problems are related to the ability to use their tools, which do not meet the necessary function required by the welder to perform their work efficiently and safely because of the negative factors that affect the person.

2.1 HULL DESIGN.

Recent research on welder helmets are based on the safety they provide, the weight of the design, the lighter it is can facilitate the work of the welder reducing injuries. Most helmets use an adjustable design, this design will help to be manipulated by people with different skull anthropometric measures, allowing a comfortable and secure fit to the head. Below are just some of the helmets with masks that served as reference for the formulation of what is called the State of the art.

Figure 2: Scott Safety filtered air respirator mask system. (Source: Oviedo, 2013).

The Scott Safety mask is an example of an alternative welder case design.

Figure 3: Infield helmet mask. (Source: Oviedo, 2013).

A clear example of safety in the helmet mask Infield is in the upper part of the skull, representing the helmet as a source of safety against a fall or blow by some object suspended in the air.

2.2 FORMULATION OF THE HELMET PROTOTYPE.

As a prerequisite for the prototype design, anthropometric percentiles were necessary, initially a 50th percentile was chosen for the design, finally the decision was made to use a range from the 5th percentile to the 95th percentile in order to make it more inclusive regarding adjustment and comfort for the user, so that it can be adapted to the design, taking as reference industrial workers of masculine and feminine gender with age from 18 to 65 years.

The following tables were collected from the article: Anthropometric dimensions of Latin American population. Second edition 2007. Published by the University Center of Art, Architecture and Design. (Avila, Prado, Gonzalez, 2007)

Table 1: Results of measures in session of positions in men aged 18-65 years.

Dimensions	Percentiles		
	5%	50%	95%
Diameter a-p head	182	194	205

Table 2: Results of measures in session of positions in women aged 18-65 years.

Dimensions	Percentiles		
	5%	50%	95%
Head perimeter	525	552	580

2.3 LENGTH OF THE SKULL.

The length of the skull is delimited by head width and face height.

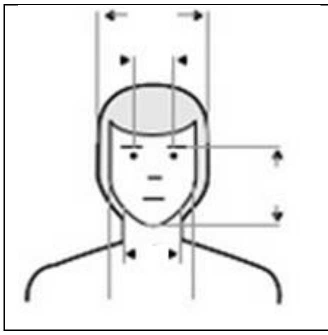
	Head width Neck width Face height Face width Interpupillary diameter

Figure 4: Representation of human head measurements.

The following chart shows some of the percentiles of head measurements.

Table 3: Results of the study in men aged 18-65 years.

Dimensions	Percentiles		
	5%	50%	95%
Head width	134	151	165
Neck width	97	109	122
Face height	114	128	138
Face width	106	124	139
Interpupillary diameter	49	57	65

Table 4: Results of the study of women aged 18-65 years.

Dimensions	Percentiles		
	5%	50%	95%
Head width	134	150	164
Neck width	97	109	123
Face height	114	128	138
Face width	106	123	138
Interpupillary diameter	49	56	65

2.4 DESIGN OF THE FACE MASK.

The mask is a protection tool that is used on the top of the head, usually plastic and aluminum. The importance of providing safety and comfort required by welders has become an indispensable element in any trade that handles welding.

2.5 STATE OF THE ART OF GRIMACE.

The first mask that was known was a hand mask in the 30's, but it was not the most efficient because it did not have the appropriate dimensions and it being manual was ineffective, although it fulfilled its function of protecting your face and eyes, it was not the most optimum design as it did not consider certain points.

Figure 5: Handkerchief. (Source: Oviedo, 2013).

With the appearance and use of plastic in the 60s, the thermoformed and injected were produced, and by the 80s their formal characteristics were left aside as they went to simple geometries, acquiring greater complexity in their features. At the same time they became more enveloped, covering a larger area of the head.

Figure 6: Bollé head mask. (Source: Oviedo, 2013).

The symbolic aspect grew, not only in relation to the inherent scope, but also to others, which are not related to the labor field. As an example shows a face mask with ergonomic design with full face and neck protection, a fastening system for perfect fit, only that does not consider the weight of the mask due to the material with which it is manufactured.

Figure 7: Libus Mask. (Source: Oviedo, 2013).

3. RESULTS.

After an investigation focused on the health problems that are most commonly experienced in welding, we identify certain factors that generate them. The decision was taken to cover and resolve all these aspects that affect the worker's productivity and health in some way, through the following components embodied in the design (figure 8,9,10): Adjustable, neck-length, full protection; Helmet with internal reinforced structure in case of fall, conformed by ABS plastic and metal; Harness with polyester straps adjustable to the contour of the head and chin; Earplugs and / or adjustable caps for excess noise, yellow reflective paper on the helmet for dark; Side air vents in helmet and face mask; Extra plastic insert injected into the back of the helmet that fulfills the function of covering the neck.

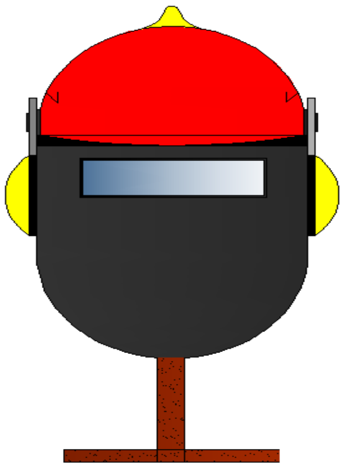


Figure 8: Bottom view of the helmet prototype with integrated mask.

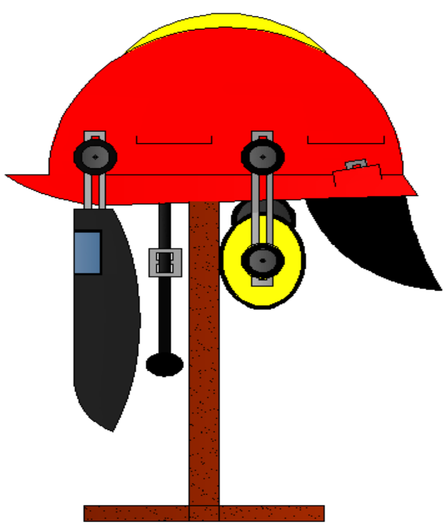


Figure 9: Right side view.

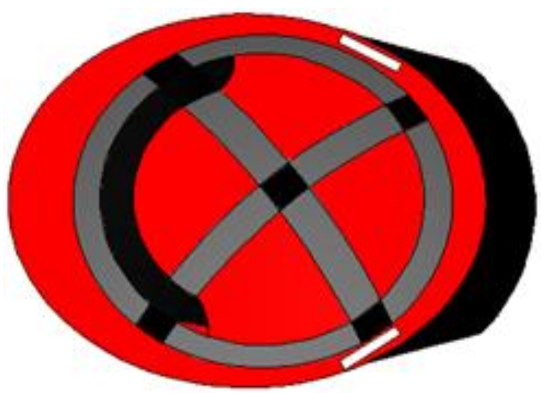


Figure 10: Elevation view.

4. CONCLUSIONS.

It is very important to know what the most common work accidents are that are generated in these types of activities, so that you identify the area in which you can provide solutions to workers in order to offer them a better quality of life. For this we consider that the innovation of the ergonomic face-piece is fundamental, because in this way we avoid very common problems that are usually cumulative, such as deafness due to the continuous and excessive tone of the noise, lesions on face, neck, and chin by the type of material with which it is being welded, besides that we avoid eye wear thanks to the visualization window with which it counts, as well as many other things.

5. REFERENCES.

Germán Alonso Ruiz-Domínguez, Arnulfo Ochoa Indart, Enrique Javier de la Vega Bustillos, Carmen Leonor Villarreal Lizárraga. (2009). 24 de Marzo del 2015, de Sociedad de Ergonomistas de México, A.C. Sitio web: http://www.semac.org.mx/archivos/congreso11/ANTRO4.pdf

Benjamín W. Niebel.(2004). Ingeniería Industrial: Métodos, estándares y diseño del trabajo. Impreso en México: Mc Graw Hill.

Adrián Oviedo. (2013). Diseño de productos en la historia, máscara de soldador. Universidad Nacional de la Plata.
http://www.inti.gob.ar/prodiseno/pdf/historia_prod/docto_mascara_219.pdf

Rosario Ávila Chaurand, Lilia Roselia Prado León, Elvia Luz González Muñoz. (2007). Dimensiones antropométricas de población latinoamericana. Guadalajara, Jalisco, México: Universidad De Guadalajara.

Alberto Ramírez Leyva, Carlos Enrique Flores Apodaca, Karina Luna Soto, Jesús Guadalupe Chávez Ahumada, Salvador Francisco Lugo Urías. (2015). Sociedad de Ergonomistas de México, A.C. Sitio web: http://www.semac.org.mx/images/stories/congreso_xvii/Libro%20SEMAC%202015.pdf

DETECTION OF OSTEOMUSCULAR INJURIES OF SUPERIOR MEMBERS IN MANUFACTURING AND ELECTRONICS MICRO-CIRCUIT PROOF COMPANY.

Graciela Torres-Luna[1], Luis Lima-Cortes[2], Claudia Gastelum-Romero[2], Rodolfo Castro-Miranda[3], Paola Esquer-Cervantes[1]

[1] *Skyworks Solutions de México, S. de R.L. de C.V.*
gracielatorres@skyworksinc.com
paolaalejandra.esquer@skyworksinc.com

[2] *ASCOTECH S.A. de C.V.*
Luis.Lima@emerson.com
Claudia.Gastelum@emerson.com

[3] *Ingeniería en control ambiental y riesgo industrial S. de R.L.*
Rodolfo.castrom@icar-ambiental.com

RESUMEN: El sistema musculo-esquelético está compuesto por la unión de huesos, articulaciones, tendones y ligamentos con el fin de constituir al sostén, la protección de los órganos circundantes, la estabilidad y el movimiento del cuerpo humano.

En el ámbito industrial la principal fuente de enfermedades profesionales corresponde a la exposición de segmentos osteomusculares de los trabajadores referidos a las actividades que requieren repetición, fuerza y posturas forzadas disfuncionales por periodos prolongados, siendo este un factor causal en el ambiente laboral, potencialmente lesivo para la salud.

En datos obtenidos a nivel nacional por la Secretaria de Trabajo y Previsión Social (IMSS, 2012). Se observa que en el informe de enfermedades de trabajo según la naturaleza de lesión y sexo, en Baja California un 75% de estas correctamente clasificadas corresponden a lesiones osteomusculares de miembros superiores y que un 57% pertenecen al género femenino.

En el transcurso del año 2016 en el área médica de la empresa, por medio de la consulta se detectaron cinco casos potenciales a calificar como enfermedades de trabajo del proceso especifico de inspección de rollo con bicicleta, lo cual motivo a ser retrospectivos en dichas actividades que fungían como factor causal, mediante la valoraciones ergonómicas de los puestos de trabajo, así como identificar a nuestra población vulnerable.

Palabras clave: Lesiones osteomusculares, factores de riesgo.

Aportación a la Ergonomía: La aplicación de Programas Ergonómicos-preventivos/correctivos contribuye a mejorar el bienestar biopsicosocial y la eficiencia laboral así como la automatización de los procesos en las áreas de trabajo ha sido un aspecto fundamental a considerar para la reducción de lesiones musculo esqueléticas y riesgos ergonómicos a los que se encuentran expuestos las personas que laboran en sus diferentes áreas de trabajo por lo que se puede sintetizar en una mejora a la salud integral y por ende a una eficacia en la productividad laboral.

ABSTRACT: The musculoskeletal system consist In the union of bones, joints tendons and ligaments in order to constitute support, protection of surrounding organs, stability and movement of the human body.

In the industrial field, the main source of occupational diseases corresponds to the exposure of workers in musculoskeletal segments to those activities that require repetition, strength and dysfunctional forced postures for prolonged periods, a causal factor in the environment, potentially harmful to the environment Health.

In data obtained at national level by the Secretary of Labor and Social Security (IMSS, 2012). It is observed that in the report of work diseases according to the nature of the injury and gender, in Baja California 75% of these correctly classified correspond to musculoskeletal lesions of upper limbs and that 57% belong to female gender.

During the year 2016 in the medical area of the company, through the consultation were identified five potential cases to qualify as work diseases of a specific área inspection of reel with bicycle, which is why they are retrospective in such work activities that function as a causal factor through ergonomic assessments of jobs, as well as identify our vulnerable population.

Key words: Musculoskeletal injuries, risk factors

Contributions to ergonomics: The application of Ergonomic-preventive Programs contributes to improve the biopsychosocial well-being and the work efficiency as well as the automation of the processes in the work areas has been a fundamental aspect to consider for the reduction of musculoskeletal injuries and ergonomic risks to which are exposed the people who work in their different areas of work so that it can be synthesized in an improvement to the biopsychosocial health and therefore to an efficiency in the labor productivity

General objective:

To detect musculoskeletal injuries of the upper limbs in the manufacturing company and test of the electronic microcircuit, in the inspection of reel with bicycle process.

Specific objectives:

- Identify the most common injuries by Works stations in inspection of reel with bicycle.

- Detection of more susceptible personnel to develop musculoskeletal illness in the inspection of reel with bicycle process.

- Ergonomically evaluations of Works stations in inspection of reel with bicycle process.

- Implement a specific action plan to reduce or eliminate the incidence of musculoskeletal trauma cases by repetitive cumulative trauma and forced posture in inspection of reel with bicycle process.

METHODOLOGY:

The methodology was carried out in three stages:

A. The first stage consisted in a medical evaluation of the occupationally exposed personnel through:
    1. Anthropometric evaluation
    2. Medical evaluation
    3. Sensitivity evaluation (Cornell questionaire / Pain Rating Scale: Visual Analogue Scale (VAS)
    4. Ergonomic job position evaluation (RULA method (Rapid Upper Limb Assessment and Angulus)
B. The second stage consisted on the creation of database to identify and follow-up the worker and the relevant medical recommendations were notified to the employee, the supervisor and manager.
C. The third stage was documented through the internal management procedure of probable occupational diseases risks at work (For its acronym in Spanish MIPRET), where the workers were interrogated through the medical consultation in their working hours to verify if it was possible to mitigate or eliminate the symptomatology Referred initially.

Delimitation: Skyworks Solutions de México, S de R.L.. de C.V.,Tape and Reel area, Bicycle reel inspection process. México, Mexicali, B.C.

RESULTS:

Antropometrics evaluations:

- We take a sample of one hundred workers corresponding to 10% of the total population of the second plant of the company mainly in inspection of reel with bicycle process.
- Antropometrics stations are placed with all respective instruments of measure.

- We obtein the percentile desired according to the anthropometric questionaire.
- The 52% of the analyzed personnel correspond to the female gender and only a 48 % to the male gender.

Sensibility and medical evaluations:

- The 90% of personnel analyzed, presents symphtoms related with works activities.
- The most frequent gender afect im muscularskeletor injuries is female in 90% of all valueted cases.
- The predominant age group among female employees is between the ages of 35 and 45.
- The work station with the highest incidence of upper limb musculoskeletal injuries is the inspection of reel with bicycle process. post with an incidence of 90%.

RULA And Angles evaluation:

- According to the objetis of RULA evaluation tomeasure the exposition of risks factors in workers which give rise to a high postural load and that can cause musculoskeletal disorders in the upper limbs of the body considering the position adopted, the duration, frequency of this and the forces exerted.
- In the work station of inspection of reel with bicycle process we obtaine an score of 6 giving us a high risk degree.
- Coinciding with the forced angles of a normal anatomy of the human body.

CONCLUSIONS:

Based on the used methodology in this research protocole (RULA and angulos evaluations) we determinated that exist a potential risk factor to generated a Works disease such as: rotator cuff syndrome, neck stiffness, quervain's tenosinovitis, Tendinitis of upper limbs, carpal tunnel syndrome, shoulder bursitis, in inspection of reel with bicycle, confirming with medical, senbility and antropometrics evaluations.

This diseases according to the generated stadistics area focused mainly to the female gender and to the age of thrirty five and fourty five people.

Which motivated the company to take short, medium and large corrective actions such as stratification of priorities in health, re located personnel, Restricting repetitive cumulative trauma activities and forced postures, as well as process engineering intervention through the automatization transition of a completely manual process and subsequent improvements to the same to the prevention of causal agents of musculoskeletal diseaseof upper limbsalways focused in ergonomy, Turning it in a works station where healthy workers, disable workers or personnel with an afection of upper limbs could perfom the work activities openly without any kind of restriction, that extence the productive activities of the processes.

- Automatization of inspection of reel with bicycle process.
- Re structure of lay out, furniture and equiptment.
- Rotation during the working day.
- Pauses to health.
- Calisthenics beging and to the end of work day.
- Training of news process and how to use the new furniture.

REFERENCES

http://www.stps.gob.mx/bp/secciones/dgsst/estadisticas/Nacional%202003-2012.pdf

https://www.researchgate.net/figure/275516613_fig1_Figure-1-Cornell-musculoskeletal-discomfort-questionnaire-female-version-Repro-duced

https://www.diba.cat/documents/467843/69764218/100517.pdf/7e8912f5-f474-40a7-a7c9-86fc96abeb10

http://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

http://www.fedelat.com/info/5-11-escala-visual-anloga.html

http://www.insht.es/Ergonomia2/Contenidos/Promocionales/Diseno%20del%20puesto/DTEAntropometriaDP.pdf

PROTOTYPE BRACELET FOR TAKING MEDICINES FOR PERSONS OF THE AGE THIRD

Cristóbal Ramón Morales Espinoza, Marisol Valenzuela Noriega, Jesús Raúl Campos Treviño, Alberto Ramírez Leyva, Jesús Iván Ruíz Ibarra

Departament of Industrial Engineering of the
Instituto Tecnológico de Los Mochis
Blvd. Juan de Dios Batiz y 20 de Noviembre.
Los Mochis, Sinaloa C.P. 81229

Corresponding author's e-mail:
Cristóbal Ramón Morales Espinoza: ing.cristobalmorales@gmail.com
Valenzuela Noriega Marisol : marisolnoriega6@gmail.com

RESUMEN: La toma de medicamentos es un tema muy delicado, ya que para que los tratamientos tengan resultados benéficos deben de llevar un control. Según German Enrique Silva; "La adherencia de un tratamiento médico se ha definido como el contexto en el cual el comportamiento de la persona coincide con las recomendaciones relacionadas con la salud."

En México existen cerca de 10.9 millones de personas consideradas como adultos mayores según un estudio realizado en 2015 por la INEGI, esto representa un 9.3% de la población total en el país, además, se estima que para el año 2050 crezca al 21.5% de la población total.

De acuerdo con lo anterior, debe considerarse que para un anciano realizar un tratamiento médico puede resultar en un mayor grado de dificultad que para un joven, ya que hay diferentes factores como el deterioro de la memoria con paso del tiempo y las distracciones que nos enfrentamos día a día.

PALABRAS CLAVE: Adultos mayores, memoria, toma de medicamentos, brazalete.

ABSTRACT: The ingestion of drugs is a very delicate topic, since for the treatments to be the beneficial results they must be in control. According to German Enrique Silva; "The adherence of a medical doctor has been defined as the context in which the person's behavior coincides with health-related recommendations."

In Mexico there are about 10.9 million people considered as elderly, according to a study by 2015 by the INEGI, this represents a 9.3% of the total population in the country, also estimated that for the year 2050 grow to 21.5% of the total population.

According to the above, it must be considered that for an elderly person to perform medical treatment may result in a greater degree of difficulty than for a young person, since there are different factors such as deterioration of memory with step Of the time and the distractions we face day by day.

KEYWORDS: Older adults, memory, medication, bracelet.

RELEVANCE FOR ERGONOMICS: The project is aware of the importance of taking drugs in sick people, especially the elderly, which is why it proposes a solution that may not cover 100% of the population, but it is expected that Make at least as much of the elderly population as possible.

1. INTRODUCTION

About 99% of older adults living in Mexico are in medical treatment that involves taking medications at different times of the day, and if you do not take the treatment to the letter you can bring problems for the patient such as:

* That the Treatment does not of the expected results.
* Side effects caused by the misuse of medicines.
* Manifestation of the disease that is avoided or controlled.
* Among other.

The initiative to create this prototype emerged by observing the daily behavior of an elderly person, as they suffer from different chronic diseases and therefore have to take medications to control each of them, and sometimes the same drug more Once a day. I am not sufficiently this problem, the person has problems of the eyes, reason why it has to always walk towards the place where the clock is, besides that in the occasions it loses the notion of time and it does not ingests its medicines in the time suitable . Failure to take medications at the right time has resulted in a mild manifestation of diseases that do not control, such as a change in blood pressure, low insulin production, decreased insulin secretion, and others. This is a problem that affects a large part of the adult population in Mexico

2. OBJECTIVE

Design the prototype of a useful tool that can solve the problems of the elderly related to the ingestion of drugs to control them.

3.METHODOLOGY

3.1-Watch

Its main function will be to take control of the time and of the actions that the prototype will carry out in general, that is to say, through this part the watch will be programmed to alert the elderly about the taking of their medicines, activating the vibration, the light Led and sound.

3.2-Extension

It will have a flexible and comfortable design so it does not hurt the user or it is uncomfortable, in addition it will include 10 circles of different colors with a different number.
Each number will have inside a small led light of the color corresponding to the circle, which will turn on when the watch emits the vibration and the sound, in this way the person will be able to associate the color of the light with a medicine.

4.RESULTS

When the research focused on the problem of the ingestion of drugs was identified, the factors that affect not complying with the prescribed recipe are identified, some of them are:

- Memory problems.
- Bad interpretations of the time on some watches.
- Memorize which medicine to take and its time.
- Performing activities that distract older adults.
- Among others.

The design of a prototype was created to remind them of the medications they should take and when they should be ingested, the design was shaped into a watch bracelet (Figure 1), which will be adjustable to cover most of the population (1), besides counting a series of numbers (0 to 9) of different colors to associate them with the drugs (2). Another characteristic is that when the time comes to ingest a medication the bracelet will emit a small vibration which will put the patient in a state of alert and a slight sound to give specifications on the drugs to be ingested, indicating with a small light the number and Color of medicine to be taken.

Figure 1.- Prototype bracelet for older adults

5. CONCLUSION

In conclusion, this prototype will be very useful for people with chronic conditions or older adults, since having different characteristics that alert people not to forget to ingest their medicines or not to confuse what is the corresponding to a certain time.

6. REFERENCES

- Virginia Palacios Expósito, Juan Carlos Morales Ruiz. (2011). Memoria en el anciano. Bogotá, Colombia: ISBN: 978-958-99855-0-2.
- Germán Enrique Silva, Esmeralda Galeano, Jaime Orlando Correa. (09/11/2014). Adherencia al tratamiento. Acta Medica Colombiana, Vol., 30 Nº 4, 268-273.
- http://www.inegi.org.mx/

MAXIMUM AND MINIMUM ROTATION ANGLES OF BODY SEGMENTS IN ART TASKS POSTURES

Patricia Eugenia Sortillón González[1], Enrique Javier de la Vega Bustillos[2]

[1]Departamento de Ingeniería Industrial
Universidad de Sonora
Avenida Rosales S/N CP 83000
Hermosillo, Sonora, México
Corresponding author's e-mail: psortillon@industrial.uson.mx

[2]Posgrados Instituto Tecnológico de Hermosillo
Instituto Tecnológico de Hermosillo
Avenida Tecnológico, Col. El Sahuaro
Hermosillo, Sonora, México
Corresponding author's e-mail: e_delavega@yahoo.com

Resumen: El propósito de este trabajo es obtener los valores máximos y mínimos de los ángulos de rotación de los segmentos corporales: cuello, tronco, brazo, antebrazo, mano, durante la ejecución de las tareas de pintura, escultura y grabado de 186 estudiantes de la licenciatura en Artes Plásticas de la Universidad de Sonora, en la ciudad de Hermosillo, Sonora México, como base para el análisis postural biomecánico.

Palabras clave: Ángulo, rotación, segmento
Abstract: The purpose of this work is to obtain the maximum, and minimum values of body segment rotation angles: neck, trunk, arm, underarm, hand, during the art tasks of 186 students of painting, sculpture and engraving at the Art School of Sonora University in Hermosillo, Sonora, México; as a basis to perform a biomechanical posture analysis.

Keywords: Angle, rotation, segment

Relevance to Ergonomics: This work provides a database of maximum and minimum rotation angles of body segments, that are expressed during the execution of tasks of a specific population: Plastic artists, which enables to perform biomechanical analysis over these tasks.

1. INTRODUCTION

In order to perform static and dynamic biomechanical analysis over the postures taken by the upper limbs, during the ejecution of art tasks, such painting, sculping and engraving, it is necessary to know the maximum and minimum rotation angles of neck, trunk, arm, forearm, hand. Several studies (Allen et al, 2002) point out diverse techniques for measuring body segments, ranging from standard goniometry(Latella D. et al, 2003) to three dimensional motion analysis systems (Magermans DJ,2005).

Most postural analysis consider just approximations of such angles, that in most cases, are not objective and quantitative values (Van Andel CJ et al, 2008), however, due to the fact that postural reviews and analysis requires to be performed in a fast and effective way, but mostly because there is not a formal biomechanical analysis.

A biomechanical approximation to perform a postural analysis potentially will lead to a more detailed information in regards to the posture, and also it will provide more information over any task under review.

This work provides the maximum and minimum values of rotation angles for five body segments, during the ejecution of art tasks: painting, sculpting and engraving, they were a total of 186 students who participate during sixteen weeks.

They were observed the following taks by area:

Painting: preparation of canvas, making the wood structure, painting any theme over canvas.

Sculping: preparation of ceramic mixes, making of molds, making of wood sculpture.

Engraving: Engraving of a wood surface, press of engraved designs.

The described tasks were selected considering the time cycle and the frequency of realization of all observed activities in all areas. All selected activities were registered and tasks fully described, as well as, various positions taken during the development of task. The observations were done for the right side of body under the sagittal plane. They were considered the tasks where a high frequency of load lifting was observed. The angles of body segments were measured against the vertical and measured counterclockwise. Participants were asked to take two rotational positions of each body segment with reference to sagittal plane, one of them was called maximum and the other one minimum. Maximum position was related to segment extensions and minimum for the opposite position.

2. OBJETIVES

There are two main objectives to persecute in this research:

Determine the average maximum and minimum segment rotation angles of body segments: neck, trunk, arm, forearm and hand.

Probe the normality of a data set of each rotation angle of body segment: neck, trunk, arm, forearm and hand.

3. METHODOLOGY

There was performed a transversal and exploratory study over sixteen weeks, with the collaboration of 186 students of plastic arts from first, three and fifth courses of painting (36%), sculpting (34.4%) and engraving(29.6%), all of them, from Art School at University of Sonora. They were a total of eleven groups of people who participate in this study.

3.1 Equipment and materials

The measurements of rotation angles were taken with a calibrated goniometer and a repeatability and reproducibility study was performed over the measurement system in order to verify that the system error, equipment error and inspector error were aleatory.

A 2.3 m by 3 m white screen, with a blue grill was placed behind the artist, and used as a support measurement device when was not possible to have free access to a measurement.

A Nikkon camera with a twenty pixels of resolution was used in some cases to take a photograph of a position that was difficult to verify and measure with goniometer. When the camera was used, a laser level was used to align it.

3.2 Measurements

Rotation angle was measured in degrees, it is important to clarify that the vertex of the different rotation angles is the segments joint. For each body segment were measured the maximum and minimum values, in all activities. A normality test (Kolmogorov-Smirnov) was performed over each set of a data. It was obtained the media and deviation for each body segment rotation angle.

4.RESULTS

Ten histograms were developed for each maximum and minimum segment rotation angle, one for the maximum value and the other for the minimum value, as shown in the following figures. There was also developed a Kolmogorov-Smirnov test for each maximum/minimum rotation angle of each body segment, as follows.

Figure 1 shows the histogram and Kolmogorov-Smirnov Test for the minimum rotation neck angle, where the mean is 115 degrees and the standard deviation is 0.02818 degrees.

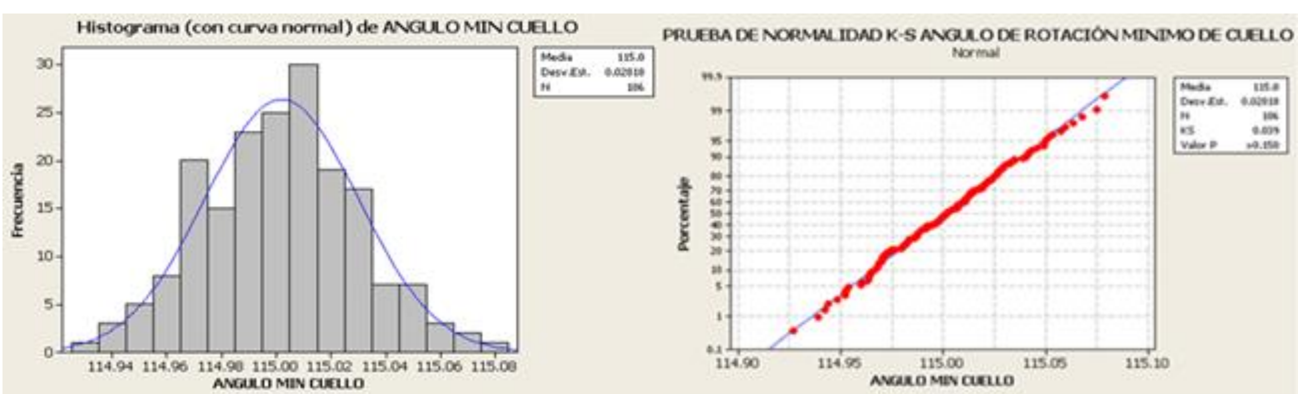


Figure 1. Minimum Rotation Neck Angle histogram and Kolmogorov-Smirnov Test

Figure 2 shows the histogram and the Kolmogorov-Smirnov Tet for the maximum rotation neck angle:

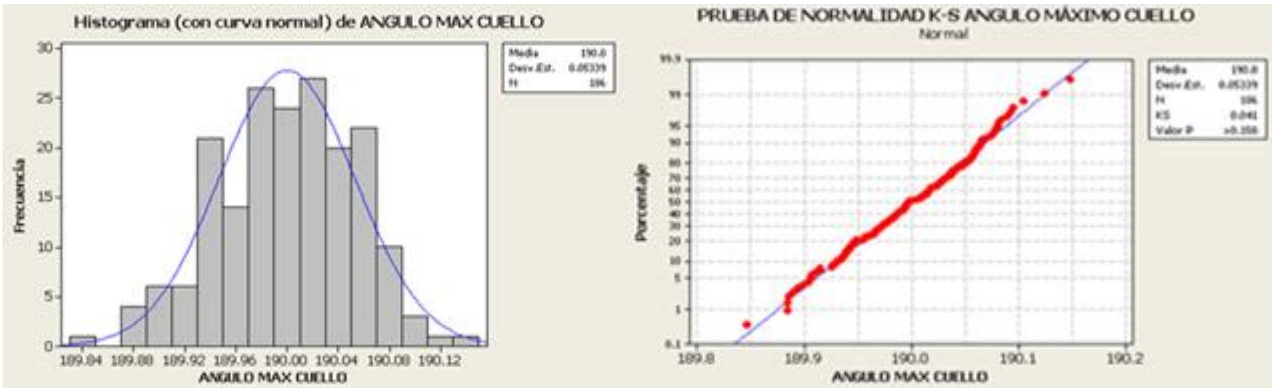


Figure 2. Maximum Rotation Neck Angle Histogram and Kolmogorov-Smirnov Test

We can notice that the mean is 190 degrees and the standard deviation is 0.05339 degrees.

Figure 3 shows maximum rotation arm angle histogram and Kolmogorov-Smirnov Test, where the mean is 175 degrees and the standard deviation is 0.06749 degrees.

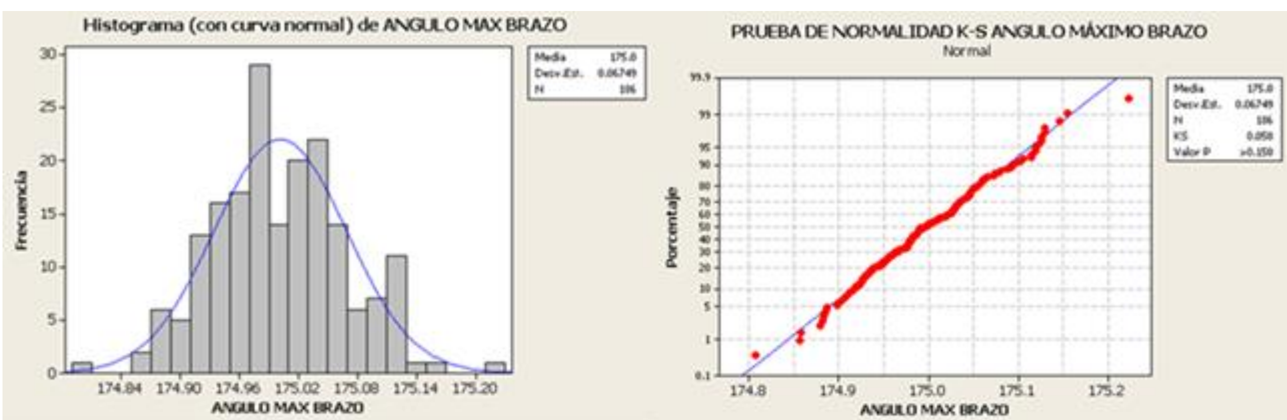


Figure 3. Maximum Rotation Arm Angle Histogram and Kolmogoro-Smirnov Test

Minimum rotation arm angle histogram and Kolmogorov-Smironov Test, is shown in Figure 4:

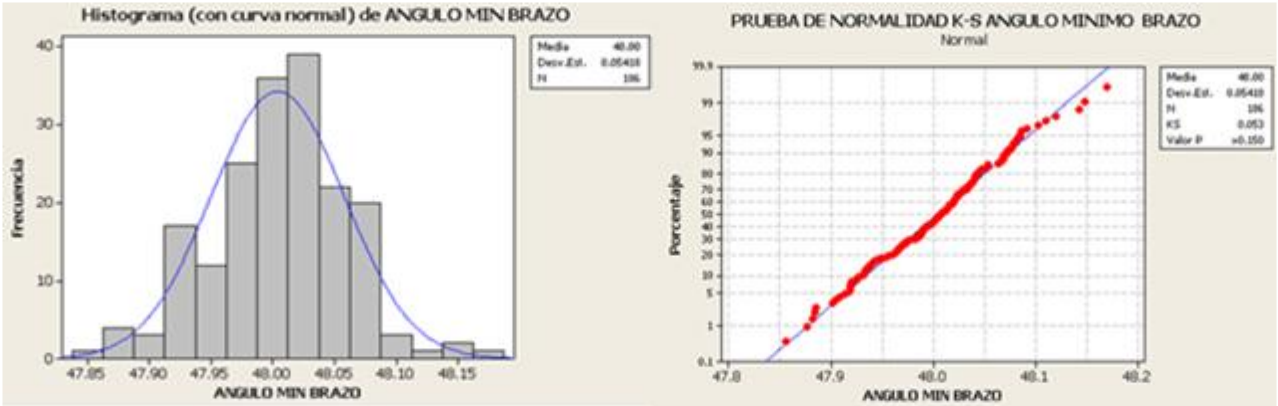


Figure 4. Minimum Rotation Arm Angle Histogram and Kolmogorov-Smirnov Test

For this rotation angle measurement, the mean is 48 degrees and the standard deviation 0.05418 degrees.

The maximum rotation underarm angle histogram and Kolmogorov-Smirnov Test is shown in Figure 5, where media is 175 degrees and standard deviation is 0.08090 degrees.

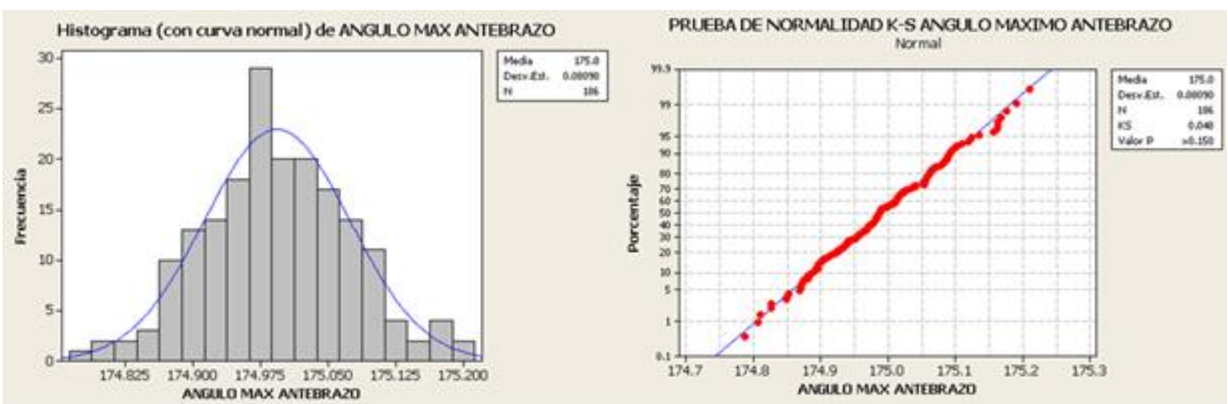


Figure 5. Maximum Rotation Underarm Angle Histogram and Kolmogorov-Smirnov Test

The minimum rotation underarm angle histogram and Kolmogov-Smirnow Test is shown in Figure 6 and it has been found a mean of 9.992 degrees and a standard deviation of 0.1003 degrees.

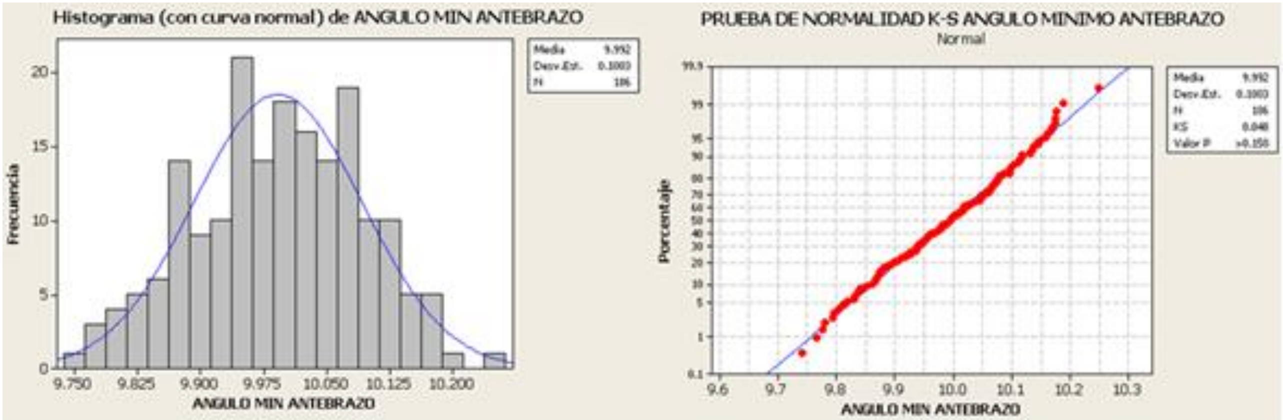


Figure 6. Minimum Rotation Underarm Angle Histogram and Kolmogorov-Smirnov Test

Figure 7 shows the maximum rotation hand angle histogram, where the mean is 135 degrees and the standard deviation is 0.1253 degrees.

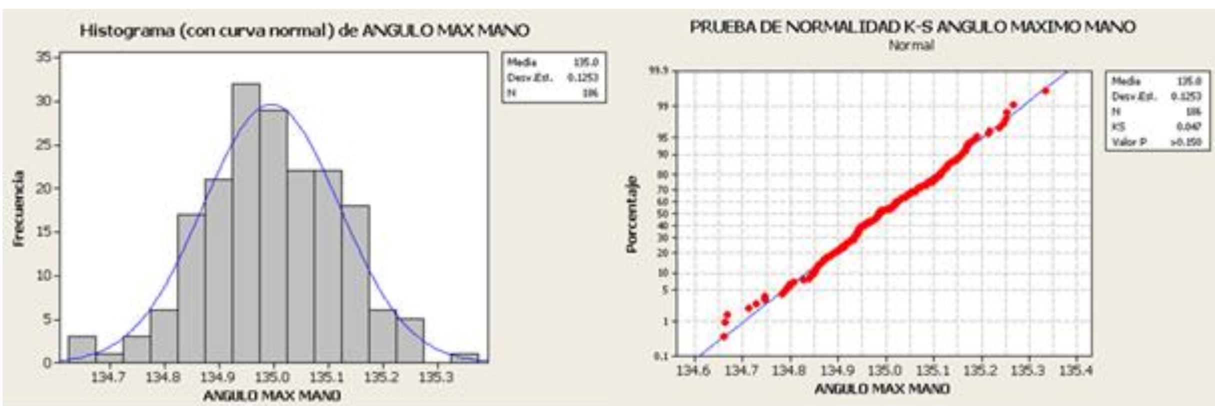


Figure 7. Maximum Rotation Hand Angle Histogram and Kolmogorov-Smirnov Test

Figure 8 shows the minimum rotation hand angle histogram and Kolmogorov-Smirnov Test:

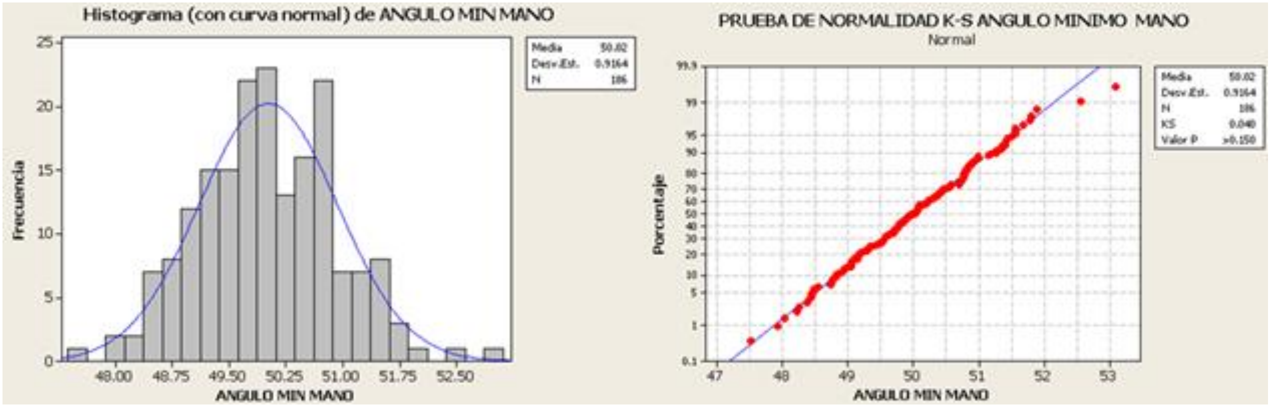


Figure 8. Minimum Rotation Hand Angle Histogram and Kolmogorov-Smirnov Test

It was found that the mean is 50.92 degrees and standard deviation 0.9164 degrees.

Figure 9 shows maximum rotation trunk Angle histogram and Kolmogorov-Smirnov Test, where the mean is 200 degrees and the standard deviation is 0.8756 degrees.

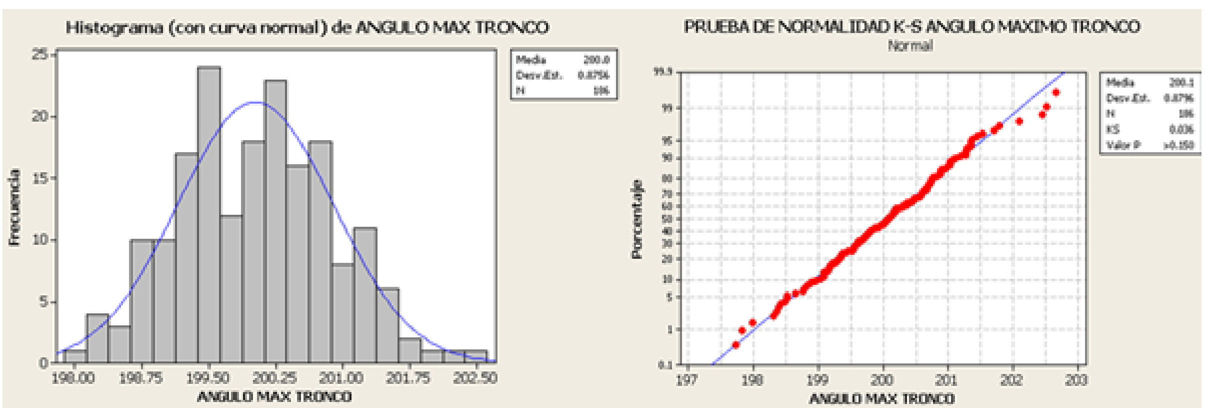


Figure 9. Maximum Rotation Trunk Angle Histogram and Kolmogorov-Smirnov Test

Figure 10 show the histogram for the minimum rotation trunk angle and the Kolmogorov-Smirnov Test for dataset.

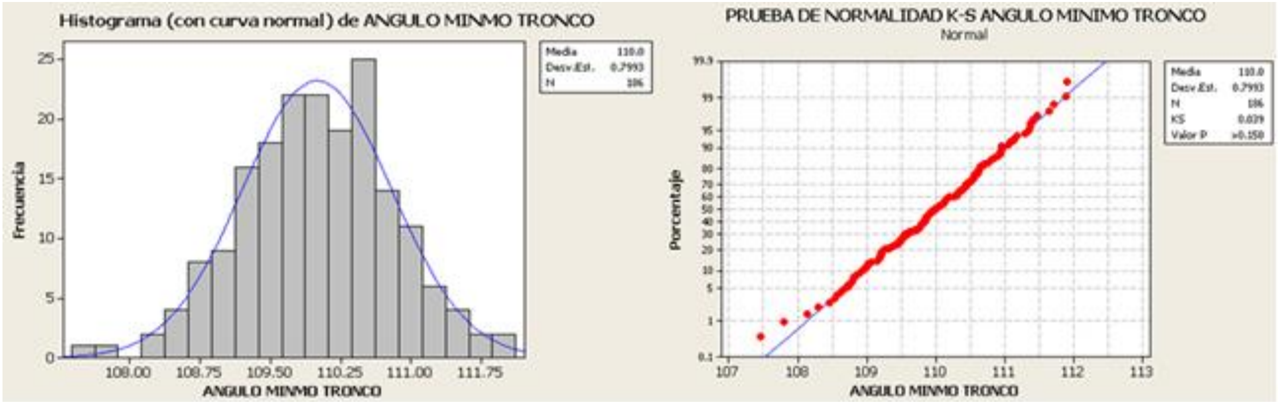


Figure 10. Minimum Rotation Trunk Angle Histogram and Kolmogorov-Smirnov Test

The mean for this data set is 110 degrees and the standard deviation is 0.7993 degrees.

5.CONCLUSIONS

The results obtained, suggest that angle values for a specific body segment are normally distributed, and we can notice that it happens between the three different tasks (painting, sculpiting and engraving) developed by artists. This can lead us to think that the procedure employed to obtain minimum and maximum rotation angles is a reliable quantitative method that provides a data set to perform a posture biomechanical analysis.

6. REFERENCES

Allen JL, James C, Snodgrass SJ. The effect of load on biomechanics during an overhead lift in the WorkHab *Functional Capacity Evaluation*. Work. 2012;43:487–96.

Latella D, Meriano C. Occupational Therapy Manual for Evaluation of Range of Motion and Muscle Strength. Clifton Park, NY: Thomson/Delmar Learning; 2003. pp. 1–10.

Magermans DJ, Chadwick EK, Veeger HE, van der Helm FC. Requirements for upper extremity motions during activities of daily living. Clin *Biomech* (Bristol, Avon) 2005;20:591–9.

Van Andel CJ, Wolterbeek N, Doorenbosch CA, Veeger DH, Harlaar J. Complete 3D kinematics of upper extremity functional tasks. *Gait Posture*. 2008;27:120–7.

Raiss P, Rettig O, Wolf S, Loew M, Kasten P. Range of motion of shoulder and elbow in activities of daily life in 3D motion analysis. *Z Orthop Unfall*. 2007;145:493–8.

RISK FACTORS IN THE DEBURRING PROCESS IN THE WORKCENTERS OF THE AEROSPACE COMPANY

Jonathan Rocha Castro, Mildrend Ivett Montoya Reyes, Dagoberto Valdés Juárez, Erick Humberto Moreno Portillo

Facultad de Ingeniería
Universidad Autónoma de Baja California
Blvd. Benito Juarez s/n
Mexicali, B.C.
Corresponding author's e-mail: JRocha@lmiaerospace.com

Resumen: El propósito del trabajo es identificar los factores de riesgos atribuibles al proceso de rebabeo en los centros de trabajo de una empresa aeroespacial a través del análisis del historial de servicios médicos y de entrevistar a los trabajadores para analizar y elaborar propuestas de mejora para reducirlos. En agosto del 2016 se aplicó el formato de encuesta de disconfort por región anatómica de la Universidad de Cornell, Nueva York, Estados Unidos y la técnica de análisis de posturas, con las cuales se determinó que no era la única molestia o fatiga que existía en tal actividad, por lo tanto, los principales riesgos atribuibles identificados fueron: posturas sostenidas, bipedestación prolongada, movimiento repetitivo y exposición a polvos.

Palabras clave: Industria aeroespacial, factores de riesgo, formato de Cornell, análisis de la postura, ergonomía participativa

Abstract: The purpose of this study is to identify the risk factors attributable to the deburring process in the workplaces of an aerospace company by analyzing the history of medical services and interviewing workers to analyze and elaborate improvement proposals to reduce the risk. In August of 2016, the anatomical region discomfort survey format of the University of Cornell, New York, USA and the posture analysis technique was applied, which was determined to be not the only discomfort or fatigue that existed in Such activity, therefore, the main attributable risks identified were: sustained postures, prolonged standing, repetitive movement and exposure to dust.

Relevance to Ergonomics: The participative ergonomics application as a tool to identify ergonomic opportunity areas for improvement in the deburring process to reduce fatigue and discomfort of the employee, as well to reduce the probability of a disability or the risk of suffering a musculoskeletal disorder injury and Increase worker productivity and efficiency.

1. INTRODUCTION

The company in which the study was made manufactures metal parts for the aviation industry, one of the processes used is the deburr operation in the work centers # 30 and # 37 in this process was reported cases of fatigue and discomfort or Some kind of discomfort in the upper limbs, tending in the unskilled arm with pain and numbness of the middle ring finger and thumb (radial nerve syndrome) in medical records, therefore, it is intended to identify the main risks attributable to this process to increase the comfort of the worker as well as his efficiency.

Figure #1 shows the behavior of the main occupational diseases from 2001 to 2013 at the national level, in which we can see the increase in muscular skeletal conditions.

Figure #1. Main Occupational diseases.

During the year 2015 the statistical report of the Mexican Social Security Institute (IMSS) reported that in Baja California, occupational diseases showed a 7.8% loss, above the national rate, which was 6.8%, and 69 Cases of Quervain Tenosynovitis (radial nerve injury) of which 61 cases were women, representing 88.4% of the total cases.

Analyzing the medical records, there were reported cases of discomfort or some kind of discomfort in the upper extremities, with tendency in the non-skillful arm with pain and numbness of the middle ring finger and thumb (radial nerve syndrome). However, applying the Cornell format and the posture analysis technique, the main attributable risks were determined: postures sustained in pronation, prolonged standing, repetitive movement and exposure to dusts.

2. OBJECTIVES

Identify attributable risk factors in the deburring process of work centers through the analysis of medical history and interview workers to analyze and elaborate improvement proposals to reduce them.

3. METHODOLOGY

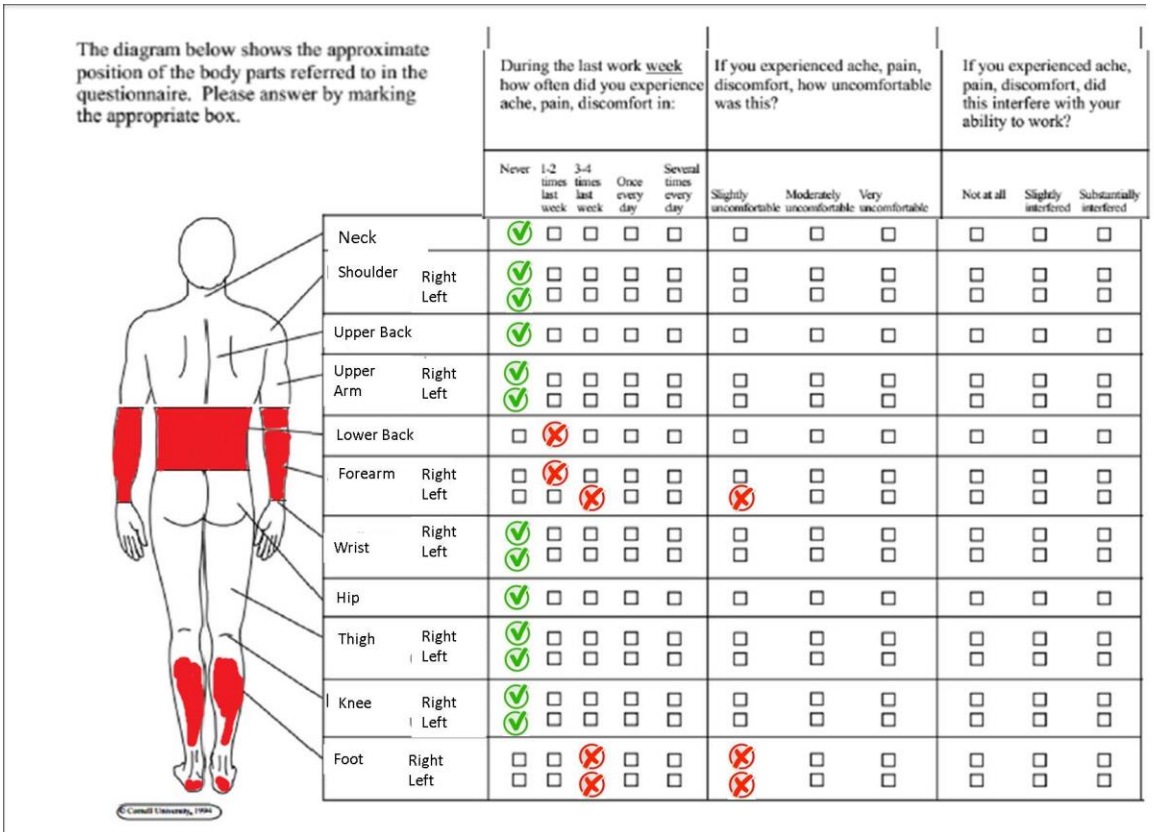
The study presented is descriptive, observational and cross-sectional. For the accomplishment of the investigation the following steps were carried out, view Figure #2:

Figura #2. Risk factors identification methodology.

a) Detection thru medical records.

Medical records of the nursing area were reviewed to identify cases with signs and symptoms of probable ergonomic risks. The deburring work centers are made up of 14 workers, of which 5 are men and 9 are women, with an average age of 39 years. In the records, 2 of the 14 workers in this area (14.2% of the population) had signs and symptoms related to ergonomic risk factors.

b) Employee interview.
   Subsequently 100% of the employees were interviewed in the scabbing area and the anatomical zone discomfort survey shown in Figure # 3 was applied.



The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.

		During the last work week how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
		Never	1-2 times last week	3-4 times last week	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Neck		✓										
Shoulder	Right	✓										
	Left	✓										
Upper Back		✓										
Upper Arm	Right	✓										
	Left	✓										
Lower Back			✗									
Forearm	Right		✗									
	Left			✗			✗					
Wrist	Right	✓										
	Left	✓										
Hip		✓										
Thigh	Right	✓										
	Left	✓										
Knee	Right	✓										
	Left	✓										
Foot	Right			✗			✗					
	Left			✗			✗					

© Cornell University, 1994

Figure #3. Cornell format, anatomical zone discomfort survey.

Figure #4 shows that 58% of the employees in the area showed some type of pain or discomfort in the upper limbs, Figure 5 and # 6 show that 91% reported discomfort for standing an also by the dust.

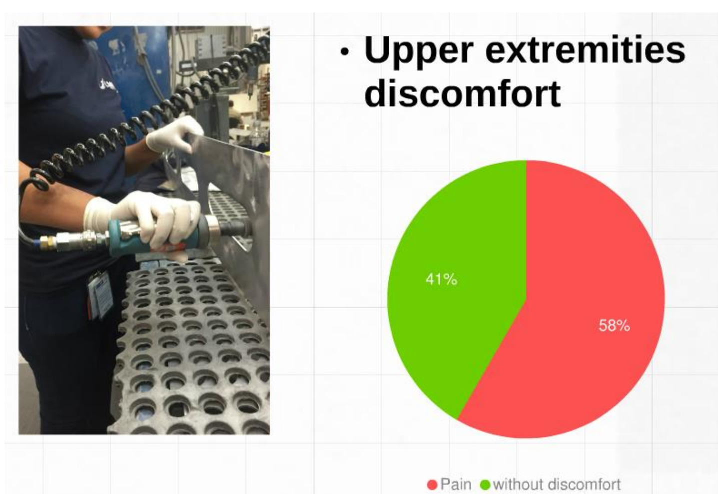


Figure #4. Main causes of discomfort in upper extremities.

Figure #5. Feet and leg discomfort.

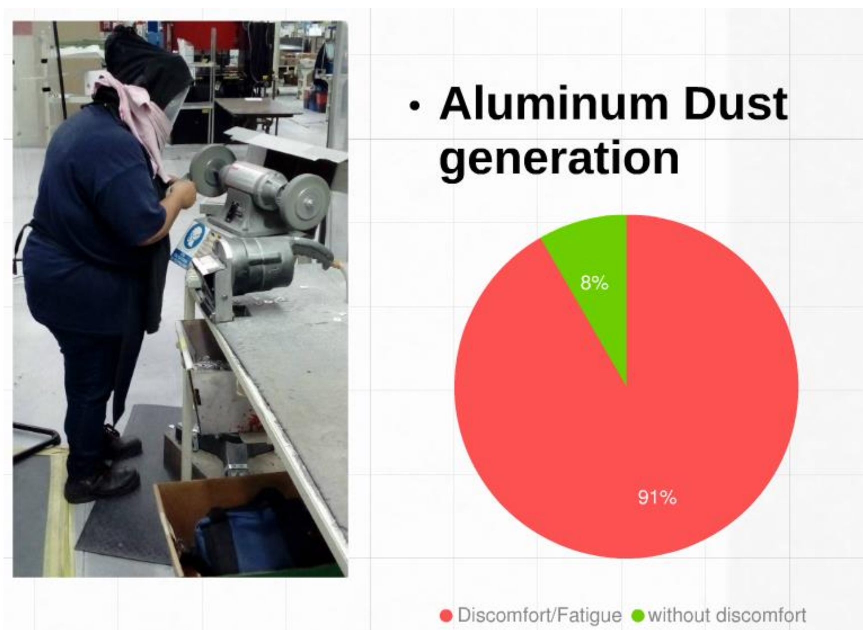


Figure. #6. Dust generation in deburring stations.

c) Attributable risk factors Analysis.
The work station and the activity of the worker were analyzed, an average of 320 small pieces per day were produced, about 40 orders with high mix and low volume. The employees noted discomfort in the left arm and in some cases numbness of the fingers extending through the forearm reaching the

epicondyle to the shoulder causing pain and fatigue. In addition, 91% reported discomfort due to the generation of aluminum dust.
The positions or movements of the elbow that can become forced are supination and pronation which are produced by changing tools or objects, from the elbow and are shown in figure # 7.

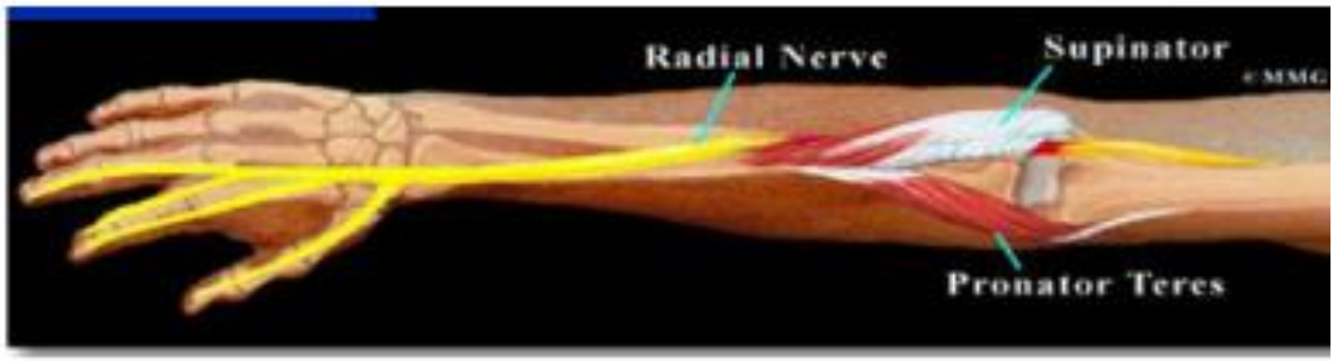


Figure # 7. Elbow movements that may become forced are supination and pronation.

The risk factors in the arms is the posture sustained in pronation with left hand flexion with left arm abduction, in wrists corresponds to the wrist movement and in extension, repetitive movement, right hand and vibrations and approximately stand 10 hours , thus presenting problems of prolonged standing.

d) Proposals for improvements
- Allow semi-employment with the help of a bank.
- Install rests feet and purchase anti-fatigue mats 1¨.
- The ideal profile for the process is a man; a training program will be established that allows rotating activities between the fast, medium and complex pieces of deburring stations, in order to reduce fatigue in the extremities, allowing both genders develop this activity.
- Extracting the dust generated efficiently from the operation will greatly help the comfort of the people in the area.
- Continuous evaluation of work centers and feedback in appropriate techniques such as stacking pieces that on the quality side is a practice not recommended and as with this study it was possible to see that it is also not a condition that helps the comfort of the operator. See figure # 8.

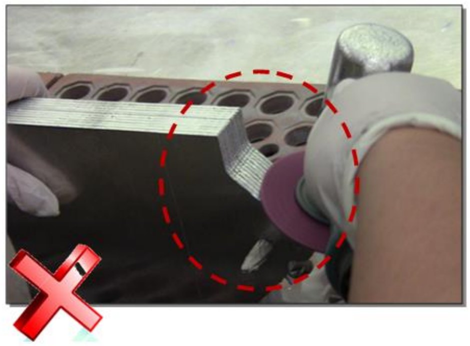


Figure # 8. Stacking pieces.

4. RESULTS

The personnel had the willingness and availability; it is why the application of participatory ergonomics is facilitated through this type of ergonomics to the employee that work directly in the process and by themselves suggests changes that may improve their working conditions.

In Figure # 9 and Figure # 10 you can see deburring operations and the improvement proposals given by the employees by themselves. It started with step 0 since the employees surveyed have poor eating habits which are an area of opportunity to improve. Working environmental aspects were considered, such as the dust generated by the deburring activity, the postures sustained with the arms and the prolonged standing.

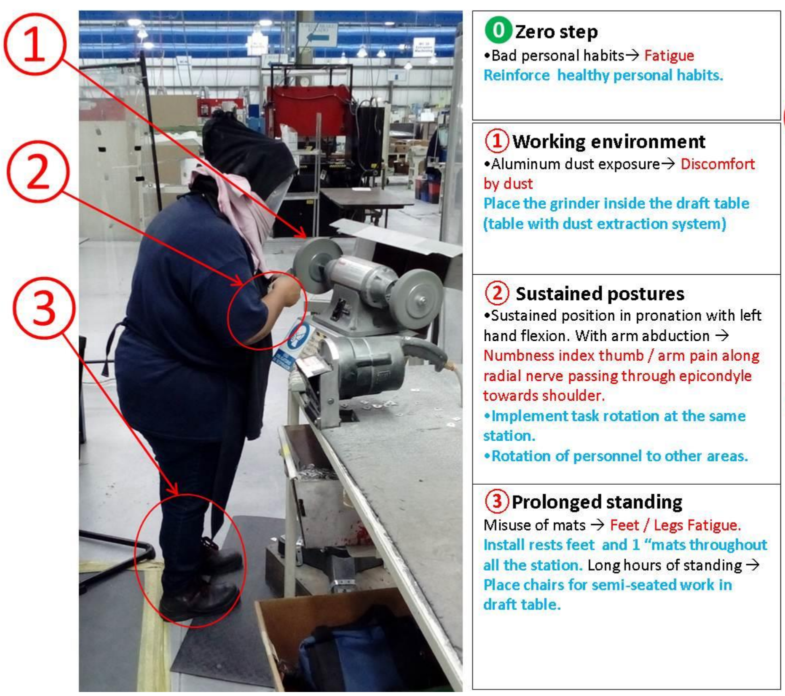


Figure # 9. Work center #30 deburring process.

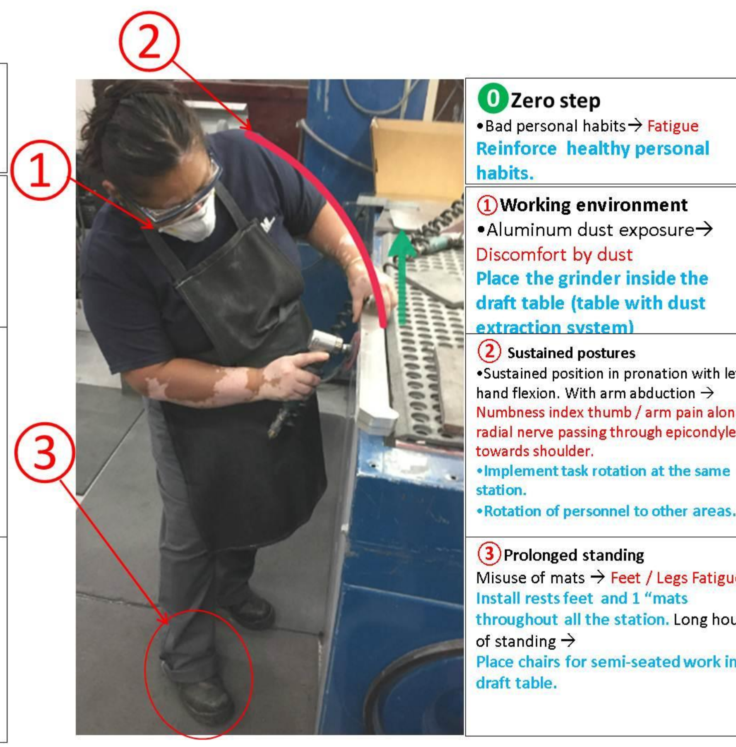


Figure # 10. Work center #37 deburring process.

5. CONCLUSIONS

The main ergonomic risk factors were identified: sustained postures, prolonged standing, repetitive movement and exposure to dusts. The use of the "zero step" was suggested through the suggestion of a correct diet, physical exercise, warm up before starting work, active breaks during the working day, use both hands and make annual medical examinations.

6. REFERENCES

Coordinación de Salud en el Trabajo, Memoria Estadística de Riesgo de Trabajo, 2013 y 2015. Recuperado el 3 de abril de 2017 de http://www.imss.gob.mx/conoce-al-imss/informes-estadisticas

Cornell University. Recuperado el 10 de octubre de 2017 de http://www.biotech.cornell.edu/cat/contact-us

Encuesta de disconfort por zona anatómica, Diplomado en especialización en Ergonomía y Salud Ocupacional con opción a certificación (2016)

ERGONOMIC RISK FOR PATIENT MOBILIZATION AND LUMBALGIA IN NURSING STAFF

Horacio Tovalín-Ahumada[1], Juan Carlos Álvarez-Rodríguez[1], Juan Alfredo Sánchez-Vázquez[1], Marylou Cárdenas-Turanzas[2], Marlene Rodríguez-Martínez[1]

[1]Especialización en Salud en el Trabajo,
FES Zaragoza, UNAM,
Batalla 5 de Mayo s.n.
Iztapalapa, Ciudad de México, 09110

[2]Department of Emergency Medicine,
UTHEALTH, Mc Govern School of Medicine, Houston.
6431 Fannin St, Houston, TX 77030, USA

Corresponding author's e-mail: saludtrabjadores.unam@gmail.com

Resumen: El objetivo de este estudio fue evaluar el riesgo ergonómico para la manipulación de pacientes y su asociación con la presencia de dolor lumbar en el personal de enfermería de un Hospital General Regional. Metodología: En esta investigación la muestra fue de 15 enfermeras de los diferentes servicios de un Hospital Regional. Metodología: Mediciones antropométricas de trabajadores: altura, peso; La ecuación de NIOSH: 5 ciclos de trabajo por trabajador fueron estudiados; Cuestionario MEEST-UNAM: reporte de molestias musculoesqueléticas en los últimos tres meses, Cuestionario POST-UNAM reporte de posturas forzadas. Resultados: el riesgo ergonómico durante la movilización del paciente fue alto para prácticamente todos, condición que en parte puede explicar que 14 de ellos reportaron eventos de dolor lumbar durante los últimos tres meses. Condiciones individuales como edad mayor de 34 años, altura inferior a 1,60 M y un IMC de 25 y más, interactuaron con la exposición a un alto riesgo ergonómico y el informe de dolor lumbar. Otras posturas frecuentemente mantenidas durante el día como agacharse, extender la espalda y el brazo y elevar el codo, junto con un alto riesgo durante la maniobra se relacionaron con la presencia de dolor lumbar. Conclusiones: la futura propuesta ergonómica para reducir el riesgo ergonómico de la manipulación de los pacientes debe tener en cuenta las características antropométricas de los individuos y la postura y los movimientos asociados con el manejo del paciente

Introduction: The objective of this study was to evaluate the ergonomic risk for the manipulation of patients and their association with the presence of low back pain in the nursing staff of a Regional General Hospital. Methodology: In this research the sample were 15 nurses from the different services of a Regional Hospital. Procedures: Anthropometric measurements of workers: height, weigth; The NIOSH lifting equation: 5 work cycles per worker were studied; MEEST-UNAM questionnaire: reports musculoskeletal discomfort in the past three months, POST-

UNAM questionnaire. Results: the ergonomic risk during patient mobilization is high for practically all workers, this condition may explain that 14 of them reported events of low back pain during the past three months. Individual conditions such as age greater than 34 years, height lower than 1.60 m and a BMI of 25 and more, interacted with the exposure to a high ergonomic risk and the report of low back pain. Other postures frequently maintained during the day as crouching, extending the back and arm and raising the elbow, along with a high risk during the maneuver were related to the presence of low back pain. Conclusions: future ergonomic proposal to reduce the ergonomic risk of the manipulation of patients should take into account the anthropometric characteristics of the individuals and posture and movements associated with the management of the patient

Key words: mobilization, patients, low back pain

Relevance to Ergonomics: The study applies an ergonomic method designed for standardized work and demonstrates its usefulness in the evaluation of risky maneuvers during patient care, as well as to identify individual and postural variables that increase the likelihood of presenting low back pain in this group of workers

1. INTRODUCTION

This work was carried out with nursing workers working in a regional hospital in Mexico City, who have in their multiple tasks manual manipulation of patients, to change sheets, transfer of the patient and transfer to another bed.

During these maneuvers of manipulation and the lifting of the patients, the workers adopt uncomfortable and forced postures and an important physical effort.

2. OBJECTIVE

The objective of this study is to evaluate the ergonomic risk for the manipulation of patients and their association with the presence of low back pain in the nursing staff of a Regional General Hospital.

This study makes an ergonomic risk assessment for the management of patients, together with the analysis of anthropometric and postural variables, related to the report of pain at the lumbar level.

3. METHODOLOGY

Type of study: Cross-sectional and Analytical

Population studied: In this research the sample were 15 nurses from the different services of a Regional Hospital. In the study participated the workers who had a seniority greater than six months, carry out cargo handling, belong to the night shift nursing group and have signed the letter of consent to participate in the study.

Variables:

• Independent variable: Ergonomic risk for patient manipulation, according to the NIOSH equation (IL Index)
• Dependent variable: Low back pain (report of back pain)
• Confounding variables: Age, Sex, Height, Body Mass Index (BMI), frequent forced postures at work.

Procedures:

• Anthropometric measurements of workers: height, weigth
• NIOSH lifting equation: 5 work cycles per worker were studied, taking measurements of grip heights (initial and final), horizontal distance, degrees of rotation, effective time of accomplishment of the task during a normal day (discounting rest time, food, transportation and other non-lifting tasks). According to the IL Index, if IL was between 1-3 a moderate risk was considered and if IL> 3 a high risk was considered.
• MEEST-UNAM questionnaire: reports musculoskeletal discomfort in the past three months, it was applied to all workers in the area
• POST-UNAM questionnaire: frequent repeated postures and movement for at least 2 hours of the day are identified, it was applied to all workers in the area.

4. RESULTS

From the 15 workers evaluated, according to the NIOSH equation, 12 had a High risk and 3 Moderate risk during the mobilization of the patients. Eleven women and four men participated, 80% of women and 100% of men were exposed to a high risk during the mobilization of patients.

From the 15 studied workers, 14 workers reported a back pain during the past three months.

According to the age group, the relationship between high risk and its relation to back pain was more frequent in the 34-50 age group (Table 1)

Table 1. Age Group, ergonomic risk and back pain

Age	Risk		Pain	
			Yes	No
21 - 33	High	N	0	1
		%	0.0	100.0
	Moderate	N	7	0
		%	100.0	0.0
34 - 50	High	N	**5**	**0**
		%	**100.0**	**0.0**
	Moderate	N	**2**	**0**
		%	**100.0**	**0.0**

In the group of workers whose height was lower than 1.60 centimeters, the high and moderate ergonomic risk were associated with back pain (Table 2).

Table 2. Height, ergonomic risk and back pain				
			Pain	
Heignt	Risk		Yes	No
Lower than 1.60 cm	High	N	**7**	**0**
		%	**100.0**	**0.0**
	Moderate	N	**2**	**0**
		%	**100.0**	**0.0**
1.60 cm or more	High	N	5	0
		%	100.0	0.0
	Moderate	N	0	1
		%	0%	100.0

The majority of workers had a BMI greater than 25 (13 workers), all workers with high BMI and high risk presented low back pain (Table 3)

Table 3. BMI, ergonomic risk and back pain				
			Pain	
BMI			Si	No
Less than 25	High	N	2	0
		%	100	0.0
	Moderate	N	--	--
		%	--	--
25 or more	High	N	**10**	**0**
		%	**100**	**0.0**
	Moderate	N	2	1
		%	66.7	33.3

Reported frequent work postures such as frequent bend the back, spread back, extending the arm, and raising the elbow were associated to a high ergonomic risk during patient mobilization, and these postures were related to reported back pain.

Table 4. Work posture, ergonomic risk and back pain						
Posture		Risk	Pain			Total
				Yes	No	
Bend the back	No	High	N	2	0	2
			%	100.0	0.0	100.0
	Yes	Moderate	N	2	1	3
			%	66.7	33.3	100.0
		High	N	**10**	**0**	**10**
			%	**100.0**	**0.0**	**100.0**
Spread back	No	Moderate	N	0	1	1
			%	0	100.0	100.0
		High	N	7	0	7
			%	100.0	0.0	100.0
	Yes	Moderate	N	**2**	**0**	**2**
			%	**100.0**	**0.0**	**100.0**
		High	N	**5**	**0**	**5**
			%	**100.0**	**0.0**	**100.0**
Extending the arm	No	Moderate	N	2	0	2
			%	100.0	0.0	100.0
		High	N	8	0	8
			%	100.0	0.0	100.0
	Yes	Moderate	N	0	1	1
			%	0.0	100.0	100.0
		High	N	**4**	**0**	**4**
			%	**100.0**	**0.0**	**100.0**
Raise the elbow	No	Moderate	N	1	1	2
			%	50.0	50.0	100.0
		High	N	6	0	6
			%	100.0	0.0	100.0
	Yes	Moderate	N	**1**	**0**	**1**
			%	**100.0**	**0.0**	**100.0**
		High	N	**6**	**0**	**6**
			%	**100.0**	**0.0**	**100.0**

5. DISCUSSION/CONCLUSIONS

According to the assessment of the ergonomic risks of the nursing staff studied using the NIOSH Equation, the ergonomic risk during patient mobilization is high for practically all, condition that in part may explain that 14 of them reported events of low back pain during the past three months.

Individual conditions such as age greater than 34 years, height lower than 1.60 m and a BMI of 25 and more, interacted with the exposure to a high ergonomic risk and the report of low back pain.

Other postures frequently maintained during the day as crouching, extending the back and arm and raising the elbow, along with a high risk during the maneuver were related to the presence of low back pain.

Future proposals to reduce the ergonomic risk of the manipulation of patients should take into account the anthropometric characteristics of the individuals and posture and movements associated with the management of the patient.

5. REFERENCES

Escalona, E. (2000). Factores de Riesgo ocupacionales y consideraciones de género en los estudios epidemiológicos de las lumbalgias. *Salud de los Trabajadores*, 9(1), 51 - 76.

Kee, D. S. (2007). Musculoskeletal disorders among nursing personnel in Korea. *International Journal of Industrial Ergonomics*, 37:207-212

ANALYSIS AND ERGONOMIC ADJUSTMENT OF THE PEDALBOARD MODEL BSB 60

Sergio Alberto Valenzuela Gómez[1], Obed Moacyr Mendoza Jiménez, John Alexander Rey Galindo

Center for Research in Ergonomics
Center of Art, Architecture and Design
University of Guadalajara
Independencia No. 5075
Huentitán el Bajo Guadalajara, México, C.P. 44100
alberto.valenzuela@alumnos.udg.mx; obed.mendoza@live.com.mx; john.reygalindo@gmail.com

Resumen: Existen productos especializados que demandan un conocimiento y capacitación previa por parte del usuario antes de utilizarlo; sin embargo, aun cuando pudieran contener instructivos de uso e instalación es necesario que el producto contenga información específica que facilite su comprensión en el proceso de instalación y de uso, tal es el caso de los pedales análogos para guitarra y el pedalboard que los contiene.

El objetivo de este trabajo es proponer un sistema de comunicación aplicado al pedalboard con el fin de facilitar la identificación e instalación de los pedales y demás componentes.

Como resultado de la propuesta los participantes lograron identificar los componentes del pedalboard y su instalación en el lugar correcto a pesar de que algunos no habían tenido la experiencia previa de interacción con el producto. Los participantes mencionaron que al utilizar la codificación por color, la plantilla con pictogramas y la señalización textual les resultó más fácil llevar a cabo la tarea solicitada.

Se espera que a partir de las implementaciones realizadas al pedalboard cualquier persona pueda utilizar este producto, a pesar de que esté dirigido a un determinado tipo de usuario.

Palabras clave: Ergonomía; usabilidad; pedalboard.

Abstract: There are specialized products that demand a prior knowledge and training by the user before using it; However, even if they may contain instructions for use and installation it is necessary that the product contains specific information that facilitates their understanding in the installation and use process, such as the analog pedals for guitar and the pedalboard that contains them.

The aim of this work is to propose a communication system applied to the pedalboard in order to facilitate the identification and installation of the pedals and other components.

As a result of the participants proposal they were able to identify the pedalboard components and their installation in the correct place from which some had not had previous experience of interaction with the product. Participants mentioned that using color coding and the template with the pictograms make it easier to carry out the requested task.

It is expected that from the implementations made to the pedalboard anyone use this product, although it is aimed at a particular type of user.

Key words: Ergonomics; Usability; Pedalboard.

CONTRIBUTION TO ERGONOMICS

The present work constitutes a small sample of the importance of the ergonomics within the analysis of improvement of products of use; through different tools that allow to understand not only that ergonomics is an intrinsic part of the design, but its importance encompasses both the physical factors and the cognitive factors in the interactions between user and product. In this sense contributes to the development of the field of design ergonomics.

1. INTRODUCTION

Usability is a concept that defines the quality of interaction between people and systems. If ergonomics and user-centered design are the means to create products that fit people, usability is how we measure that adaptation (Van Kuijk, 2015).

One of the most relevant aspects in the user's interaction with the product is the information that the product must have, so that it is easily understandable and simple to use. In this sense, there are some tools that allow us to specify the most relevant elements when defining the characteristics of the information of a product; an example is the ISO 9241-11 standard that explains how to identify the information that is required when specifying or evaluating usability in terms of user satisfaction and performance measures (UsabilityNet: International Standards, 2017).

There are specialized products that demand a prior knowledge and training by the user before using it; however, even if they may contain instructions for use and installation it is necessary that the product contains specific information that facilitates their understanding in the installation and use process, such as the analog pedals for guitar and the pedalboard that contains them.

The analog pedals for guitar are metal boxes of sizes that are allowed to transform the sound of the electric guitar when activated. The effect on the sound, depends on the type of pedal; however, in all cases, in terms of use they share a switch that activates or deactivates the effect and which is handled by the guitarist's foot. These pedals are used for the purity of their emitted sound and each of them consists of a single effect (Guachichulca, B. 2012).

The pedalboard is a box used to hold the electric guitar pedals. It is designed so that the guitarist can place his set of pedals in an orderly manner so that it becomes easier to interact with these when he is playing his instrument. Because it is a system composed of different pedals and cables that are interconnected with each other, the location of the latter and the use of pedalboard tends to become more complex. The lack of information makes it difficult to distinguish the components and identify their location and function, which can lead to poor interconnection of the cables on the pedals and poor distribution in the arrangement of the pedals on the pedal board.

2. OBJECTIVE

Propose a communication system applied to the pedalboard in order to facilitate the identification and installation of the pedals and other components.

3. METHODOLOGY

3.1 Delimitation

This is a cross-sectional descriptive study to understand the interaction between users and a product that is aimed to a specialized audience. In this study 11 people participated (7 men and 4 young women, students of the Center of Art, Architecture and Design of the University of Guadalajara). None of them had a relationship with each other and also reported not having had contact with any model of pedalboard before. Of the participants there was only one keyboard player, a drummer and a guitar player. The rest of the students mentioned that they did not know how to play any musical instrument.

3.2 Strategy

This research was divided in an initial pilot test with the three students who knew to play an instrument and two later phases in which ergonomic implementations were made to the pedalboard; In both phases four people with no experience in music.

Ergonomic implementations consisted of the placement of pictograms in the base of the pedalboard, color coding at the ends of the cables and inputs and textual signaling only at the inputs of the connectors. The purpose of the implementations was to facilitate, in terms of communication (with or without experience in the use of this product), the installation and connection of the wiring circuit normally performed by the guitarists.

The three implementations were tested by performing the following tasks:

Task 1. Placing pedal holding pads on the pedal board.

Figure 1. Placing holding pads

Task 2. Placing analogic pedals in the holding pads.

Figure 2. Placing pedals in the holding pads

Task 3. Cables connection.

Figure 3. Cables connection

in all three tasks, the BSB60 model Boss pedal and four guitar pedals (overdrive, delay, equalizer and wah) are used.

In each phase of the study, the same elements that are included in the pedalboard are used, which are:

Table 1. Description of the components used in the test

Element	Quantity	Figure
Holding pad	2	
Holding pad screw	8	
Power adapter	1	
Daisy chain cable (power supply for pedals)	1	
Short cable to connect pedals	5	
Cable cover to hide all connections	1	

Each of the phases of this study, including the test pilot, recorded video in order to identify what were the main flaws of the problems, in terms of communication, that participants had at the time of interacting with the Pedalboard.

In the pilot test participants worked without any color coding or pictogram for the installation.

In the first phase of implementation four people participated (without experience in music) and worked with color coding and pictograms that were designed from the observations made in the pilot test.

In the second phase of implementation, four people (not experienced in music) participated and worked with color coding, pictograms and textual signage only at the inputs of the connectors.

4. RESULTS

Pilot Test

Due to the previous experience of playing a musical instrument, participants of this pilot test were able to complete the first two tasks without difficulty; however, they had some complications with the cables connection and therefore this last activity was not completed by any of them.

The main interaction problem was found in the manipulation of the daisy chain cable and its location in the pedal inputs; In addition none of the participants could identify the cable cover and its function, so they did not use it and left the cables exposed.

First phase

At this phase pictograms and color code were added at the ends of the cables and the connection inputs, which fulfilled their objective, all the participants leaned on the images and correctly placed the holding pads.

Figure 4. First implementation to identy the place for the holding pads

Figure 5. Second implementation using pictograms

Three of the four participants couldn’t connect the cables correctly despite the implementation of color-coding.

Figure 6. Inputs with color-coding and textual labels

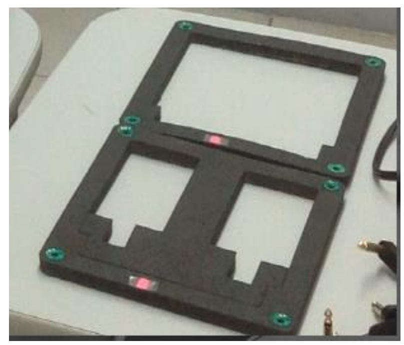


Figure 7. Holding pads with color-coding

Second phase.

Text signaling was implemented for the channel where the cables are hidden and in the inputs of the pedals and the cables to facilitate the connection in the series of the first ones. With these adaptations all the participants were able to place the elements and connections in the corresponding places and installation time were reduced.

Figure 8. Inputs and cables with color-coding (above). Holding pads with color-coding and cables cover with textual label (below).

5. CONCLUSIONS

The implementations in the pedalboard improved the identification of the components and their location in the right place despite participants never had had contact with any of the elements.

The students mentioned that color-coding and pictograms were easy to understand. Regarding the cable cover, after two modifications, participants reported difficulty in the identification of this part and they didn’t understand its function, so they decided not to use it. To solve this, new tests are proposed, but this time focusing only in the design of this part of the pedalboard.

It`s possible that the cable cover could be replaced. If it´s necessary to keep it, then in addition to color-coding, it will be necessary to add text describing the function of that element.

The main goal of a project like this it´s to make that every person can use this product, despite their experience using or playing a musical instrument like electric guitar.

6. REFERENCES

Van Kuijk, J., van Driel, L., & van Eijk, D. (2015). Usability in product development practice; an exploratory case study comparing four markets. *Applied ergonomics*, *47*, 308-323.

ISO, 1998. ISO 9241-11 Ergonomic Requirements for OfficeWork with Visual Display

UsabilityNet: International Standards. (2017). [online] Usabilitynet.org. Available at: http://www.usabilitynet.org/tools/r_international.htm [Accessed 18 Feb. 2017].

Terminals (VDTs) - Part 11: Guidance on Usability. Switzerland, International Organization for Standardization, Geneva.

Guachilchuca, B. (2012). Guía práctica de la guitarra eléctrica (Tesis de maestría). Universidad de Cuenca, Ecuador.

Naami, A. (2015). Desarrollo de un efecto de sonido controlado mediante un acelerómetro (Tesis de grado). Universidad Politécnica de Madrid, España.